Physics Department Self-Study and Strategic Plan
FY2010 to FY2017

Spring 2010

MONTANA STATE UNIVERSITY

Physics Department Self-Study and Strategic Plan: FY2010 to FY2017

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The external review team is being asked to address the following questions provided by the Guidelines for External Program Review, Office of the Provost (JA 10-30-08).

1. What are the strengths of the department? Please list any specific commendations.

2. What are your overall observations of the quality and the rigor of the academic programs?

3. How well does the curriculum represent the field in terms of breadth and currency? Does the curriculum evolve appropriately in response to changes in the field?

4. Please comment on the overall level of faculty productivity as it relates to the stated mission of the department.

5. What is your overall assessment of the quality of graduates produced by the programs in the department?

6. Please identify any weaknesses or unrealized opportunities and provide specific recommendations for action.

7. Please provide specific recommendations regarding any undersubscribed degree programs.

In addition, the Department asks that the review team address the following questions specific to the department?

1. Comment on the balance of research and teaching in the department. What are your observations and recommendations regarding faculty staffing for teaching and research, e.g. the relative strengths of our tenure-track, adjunct, and research faculty?

2. Comment on the breadth and balance of research fields in the department, including experiment and theory. What are your observations and recommendations regarding addition of faculty in existing research areas and in areas that are not currently represented by our department?

3. Comment on graduate student support and quality. What are your observations regarding the relative numbers and use of GTAs, GRAs, and fellowships?

4. Any general observations or concerns not addressed by the questions above?

Physics Department Self-Study and Strategic Plan: FY2010 to FY2017

Physics Department Mission Statement

The Department of Physics is committed to providing the highest quality of physics education to students in the Montana State University campus environment. Meeting this goal requires successful, nationally competitive research programs that contribute to the body of physics knowledge, improve science communication with the public, and forge links between fundamental knowledge and applied technology for the benefit of the people in the state of Montana.

1. Introduction and overview of the self-study

As we leave behind the Century of Physics and move boldly forward in the Century of Biology, the discipline of Physics continues to be intellectually vibrant. Exciting discoveries in the fundamental structure of matter and its behavior have deepened our understanding of the natural world, and they have expanded the knowledge base that will generate new technologies in the coming decades. These breakthroughs occur at all length scales from the astrophysical to the human to the microscopic. Increasingly, the boundaries between physics and other disciplines are being blurred, as physicists apply their creativity and analytical skills to address challenging problems in living systems, energy and the environment, communication and transportation, industry, and education.

Our students and faculty are actively engaged in these challenging, interdisciplinary problems. Research experience at the frontiers of knowledge advances our main goal, the education of creative and productive scientists for a complex, rapidly changing world. Our commitment to academic excellence is shared by all 30 tenure track, adjunct, and research faculty, our 20 post-doctoral and research scientists, and our 8 professional and technical staff, all of whom maintain a tradition of close contact with our 86 undergraduate majors and 61 graduate students. Our faculty have first-rate equipment, providing a stimulating environment for student research, located in a beautiful and serene mountain environment. An academic program in such an environment provides an enjoyable and rewarding experience for our students. (See Appendix I for the current Organization Chart for the Physics Department AY 2009-2010.)

The vision for Montana State University is to be the university of choice for those seeking a student-centered learning environment distinguished by innovation and discovery in a Rocky Mountain setting (Appendix 2: Campus Profile and Montana State University Five Year Vision FY09 to FY14). The Department of Physics plays a major role in contributing to the University's three-fold mission of instruction, research, and public service. As a provider of instruction in the most fundamental of the natural sciences, the Department serves a variety of student needs:

- Students desiring Core natural science credit are introduced to the concepts and methods of physics as well as its historical development and human impacts, while developing their analytical and communication skills.
- Students in professional fields such as engineering, architecture, and nursing acquire a basic knowledge of the physical world and problem-solving skills as a preparation for subsequent instruction in the professions
- Undergraduate physics majors are furnished with a comprehensive grasp of the concepts, theories, and analytical techniques of physics and are encouraged to develop their creativity by engaging in required capstone research projects under faculty direction while earning the B.S. degree.
- Graduate students receive an advanced education in both classical and modern physics, while strengthening their skills in problem solving, communication, creativity, and collaboration through directed research and study leading to the M.S. and Ph.D. degrees.

Research programs in the Department of Physics are currently focused in several areas: optical science and laser technology, condensed matter physics, gravitational physics, astrophysics, solar physics, and science education. Our programs in astrophysics and relativity are directed toward a fundamental understanding of the behavior of matter and energy on the astrophysical scale. Research on the physics of lasers and condensed matter systems - such as magnetic and dielectric materials, semiconductor and metal surfaces and thin films, laser materials and superconducting solids - enlarges the knowledge base on which future advances in technology are founded. Research in science education aims to improve the understanding of how students can best learn science in the schools, colleges, and universities. All of the Department's research activities enhance our instructional programs by involving students in capstone research problems and techniques at the frontiers of physical knowledge. Faculty working with the most advanced techniques on current topics carry their research experience into the classrooms at all levels.

Public and professional service is also an important component of the Department's role and scope, as mandated by Montana State University's heritage as a land grant institution. Profession-based service to the public, to local, state, and national agencies, and to professional organizations within the science community is encouraged for all faculty members. Special emphasis is given to activities that help improve the teaching of science in the public schools, or that advance the public understanding of science. The Department is also committed to forging links between fundamental knowledge and new technology, particularly in the areas of optical science and laser technology, an area in which significant collaborations with local industries are already taking place, and in the area of thin film coatings for advanced surface engineering.

The Department of Physics at MSU established a graduate program for physics in 1964, 45 years ago. During the ‘60s and 70’s the department grew to include approximately 14 faculty and 30 graduate students. Enrollments in the graduate program increased significantly in the early ‘80s as the department saw large numbers of students from Asian countries applying for graduate studies. The number of tenure-track faculty in the

department increased to 18 by AY84-85, where it has remained for the past 30 years. However, both graduate and undergraduate enrollments continued to grow and new research opportunities were plentiful. In 1992, under the direction of Professor John Hermanson, the department added a new track for growing its faculty, initiating an ambitious, far reaching growth in solar physics with the hiring of Dr. Loren Acton as a Research Professor. In the following 10 years, the number of Research Faculty grew to 10, while the number of tenure track faculty remained at approximately 18. The addition of research faculty in the areas of solar physics, relativity, and condensed matter physics, has allowed the department to continue growing its research and instructional program, and the associated graduate and undergraduate enrollments. Consequently, while the number of tenure-track lines in Physics has remained constant at 18 for 25 years, the research expenditures have grown by a factor of 7 since 1990, from $1.27M to $8.5M in 2004. The graduate enrollment has approximately doubled since the early 1980s. Today we stand as one of the stronger physics department in the country when compared on the basis of enrollments or research expenditures per faculty FTE. Yet we maintain this performance level with one of the lowest values of state support per faculty FTE. From an optimistic perspective, the Physics Department and Montana State University continue to provide an outstanding research and instructional experience at one of the lowest tuition rates in the country. From a forward-looking perspective, we must ask how much longer we will be able to maintain this quality of education for our students with the current levels of institutional support.

In the remaining sections of this self-study we look at the activities of our faculty and staff as the providers of the learning environment for our students (Section 2). We then discuss the undergraduate and graduate curricula, and the tools we have in place to assess the outcomes of those programs for our students (Section 3). We include in Section 3 the information addressing the specific criteria for program review established by the Board of Regents. We also address some aspects of outreach and service to the community consistent with the mission of the university as a land grant institution. In Section 4 we discuss the department's long-range plans and strategic goals for the next 7 years. While the following sections provide the detailed information necessary to fully understand the rationale, which motivates the long-range plans, we believe that a summary statement of the strategic goals at this point will establish a context for the discussion that follows.

Summary of the Physics Department's Strategic Goals for 2010 to 2017
(See Section IV for full discussion)

1. Increase undergraduate enrollments at all levels, both majors and non-majors, through increased efforts in recruitment and retention.

2. Increase the quality of and enrollment in our graduate program.

3. Strengthen our teaching program, particularly in the lower division courses, and the Physics Education Research program.

4. Capitalize on developing opportunities in solar physics with a proposal to locate the new National Solar Observatory headquarters at MSU.

5. Grow our faculty in a way that better allows us to achieve our mission, keeping a good balance between theory and experiment in existing programs, while considering growth in emerging research areas.

6. Improve working conditions and resources for our support staff.

7. Better utilize existing lab space and look for additional space to meet the needs of new faculty hires while also growing existing research programs.

8. Strengthen and grow those centers and programs in the department that enhance our research and instruction mission.

9. Develop new degree options in the Optical Sciences that will educate and train students for regional employment opportunities in the optics field.

10. Pursue development opportunities through donors in concert with the MSU Foundation and the College of Letters and Science.

2. Research Programs in Physics: Faculty and Staff

Montana State University has just completed a three-year self-study as part of the process for accreditation in the Northwest Commission on Colleges and Universities. We repeat here a portion of the cover letter from then-president Geoff Gamble that accompanied the self-study.

> "This emphasis on a research or creative experience for students is a cornerstone of the university's mission to integrate teaching with the discovery of knowledge. This commitment is vital to our efforts to enrich the traditional academic experience for undergraduate students by providing hands-on active learning opportunities. And the infrastructure for offering these experiences is the university's growing research enterprise, which has increased from $61 million in 2000 to an all-time high of $103 million in 2006. That same year, the Carnegie Foundation for the Advancement of Teaching classified MSU as one of 96 research universities with "very high research activity." MSU is the only research institution with this classification in the five-state region of Montana, Wyoming, Idaho, and North and South Dakota.
>
> For students, the growth in research has meant a significant increase in the number of opportunities available to them. In 2008, university research provided $7.96 million in undergraduate and graduate salaries,

> scholarships, and fellowships. To date, 49 MSU students have won the prestigious Barry M. Goldwater Scholarship, the nation's premier scholarship for undergraduates studying math, natural sciences, and engineering. MSU is currently ranked 11th in the nation for the number of Goldwaters earned, just behind Yale and MIT." *(Excerpt from the letter from the President in the 2009 Comprehensive Self Study Report for Montana State University. The entire 314 page report can be found at the following site: http://www.montana.edu/accreditation/selfstudy.html)*

Innovative instruction and world-class research are also hallmarks of the Department of Physics at MSU. Our faculty members are recognized around the globe for their research and creativity. The department's research facilities include state-of-the-art laboratories and equipment. Extensive external collaborations bring national and international experts to Bozeman and open opportunities for students to conduct research at other world-class laboratories. On campus we have ground stations that operate active satellite missions. Additional possibilities exist through interdisciplinary research programs with the departments of Chemistry and Biochemistry, Microbiology, and Electrical and Computer Engineering, and with the Center for Biofilm Engineering. Our graduates have an excellent record of finding employment in academia and industry, including high technology companies in the Bozeman area.

A. Evolution of the Research Programs in Physics

The Department's recognized excellence in teaching and research may be partly attributed to our decisions in the '80s and '90s to focus our efforts in a few well-defined areas: Laser Spectroscopy and Nonlinear Optics, Condensed Matter Physics and Surface Science, Relativity and Astrophysics, Solar Physics, and Physics Education. Each of these groups has two or more tenured faculty. Most groups have an effective support structure of weekly seminars, joint proposals, and shared ideas such that the adage about the whole being greater than the sum of its parts certainly applies here. We continue to be committed to the group concept in general, and to these groups in particular. In some cases, the focus of a group has evolved over the past several years as new research fields emerged on the scene and others waned. A particularly relevant example is the decline in surface science as a research topic on its own, and the evolution of a strong interest in characterizing and understanding the properties of novel oxide materials, such as the $La_xSr_{1-x}MnO_3$ perovskites, using the tools of surface science. Similarly, members of this group have begun studies in biophysics. We intend to pursue promising new directions within this group framework, but will also pay particular attention to the recommendations and commendations coming out of this self-study and external review process as a guide to our thinking about breadth as well as depth in our research programs.

Another important decision taken many years ago in the Department was to adopt a format of large lecture sections for lower division service courses. The format has proven to be highly beneficial to the department by releasing many of our more research-active faculty from heavy teaching loads. However, this approach does not

mean that our research active faculty are disconnected from lower division instruction. In fact, many of these same faculty members have won multiple teaching awards on campus connected with their teaching in large lecture sections, and they continue to ask for teaching assignments as instructors of the introductory engineering physics sequence. Student evaluations for these instructors are above the average for faculty in the department. The recognition received by the Physics Department members each year through campus-wide awards for distinction in teaching, research, and service amply demonstrates the success of our approach, and we remain committed to it.

The strength of our research programs, along with the expertise of our faculty, benefits the instructional program for our students in many ways. Some particular examples are mentioned here. With the implementation of Core 2.0, all undergraduates at MSU are required to complete a capstone research experience. In Physics, students are encouraged to join with a research group as early in their academic career as is practical, but typically at the beginning of their junior year. For three semesters these students are engaged with research groups in the department, working closely with graduate students, postdoctoral associates and research scientists in the lab, and culminating with oral, written and poster presentations about their work, presented in seminars and a campus-wide research celebration during April each year. Anecdotal information abounds concerning employment situations where this capstone research experience made the difference in earning a job offer. Another example of our research infrastructure benefitting students nationally is found in the two REU programs offered at MSU over the past 10 years, in Condensed Matter Physics and in Solar Physics. Together, these two programs have been bringing approximately 25 physics undergraduates to MSU each summer from around the country, and occasionally from outside the US. Those students spend 10 weeks in June – August, working closely with our research groups, while our own MSU physics majors typically participate in REU site programs at other laboratories and universities. Finally, we note that approximately one-third of our current faculty members have won the prestigious *Cox Faculty Award for Creative Scholarship and Teaching,* based on the faculty member's demonstrable union of superior research with excellence in upper division/graduate instruction.

B. Four Persistent Problems

The faculty leading our various research groups have discovered that success with growing research programs often leads to a shortage of resources, including space, graduate student assistants, and technical support staff. The faculty have been very successful in winning research grants, as we demonstrate later in this section, but find themselves short of graduate students to carry out the work, confined to research spaces that were already limiting the day we moved into the EPS complex in 1997, and wanting for financial support of technical personnel in the IT, electronics, and mechanical shops.

1. Space: With respect to the availability of research space, it is helpful to consider the condition of the department at the time of our move to the EPS complex (1997). The department research programs occupied most of the basement in the AJMJ

building, and a portion of the first floor. Faculty offices were distributed on the first and second floors. Instructional labs occupied (and still do) most of the space on the first floor of that building. Research expenditures at the time were approximately $2.8 M for the department. The move to EPS increased our research space by approximately 50%. In the period from 1997 to 2003 our research expenditures increased from $3 M to $7.9 M, our undergraduate enrollments increased by 25%, and our graduate enrollments increased by 10%. In 2003, a tremendous amount of effort was expended to find additional space for Physics within the EPS complex. Ultimately, some research programs (SSEL and MSGC) moved into Cobleigh Hall, graduate student flex space was created throughout the EPS complex, including Roberts Hall, with a portion of that being used by Physics students. Research expenditures, and the associated programs and student enrollments continued to increase until today we find ourselves again looking for additional space. Presently, our tenure track and research faculty occupy space in the EPS complex, including rooms in Cobleigh, and additional modular units in Faculty court. Research expenditures peaked at $8.5 M in 2004-2006, and currently stand at $6.3 M. Professor Rebane has equipment purchased on a new grant, but no place to set up the microscope. Research Professor Avci has new analytical equipment in ICAL, but lacks space to set it up. The department anticipates repeating a space audit similar to the audit performed in 2004, to determine where the department might reassign space and look for new space to grow. Discussions with the Dean of L&S may lead to a solution using space liberated in AJMJ with the move of some programs to new buildings erected on campus in the past year. That discussion and a solution is a part of our long range planning.

2. Graduate Student Support and Interests: Our graduate student enrollment stood at 61 in Fall 2009, with 22 students on graduate teaching assistantships (GTA), and the balance on research assistantships (GRA) (35), scholarships (3), or self-supporting (1). That results in approximately 3.6 graduate students per tenure-track FTE. We do not include research faculty in this calculation so that we can compare ourselves to data provided through the “Midwest” Physics Chairs, a group of approximately 35 Physics Department chairs that meet annually to exchange data related to department management. In that group, we rank above the average of 2.8 graduate students per FTE, about 9th out of 35. On the basis of that comparison, our faculty should be able to recruit and mentor about 10-12 additional students (4.0/FTE) if the research space and financial support were available. The number of GTAs awarded by the college to the department is based on the number of lab sections offered and the amount of grading help required by faculty. Only an increase in undergraduate enrollments would justify additional GTA support. Thus, a growth in the graduate program requires both more research space and additional GRA support through grants and contracts. Also, a look at the distribution of graduate students among research groups (See organization chart in Appendix 1 and Grad Students per Group) shows that a better balance of student interests is needed to spread the mentoring load among the faculty. The anticipated new faculty hire in Gravitational Physics in Fall 2010 will reduce the load on faculty in that group. Also, including the 5 Research Faculty in solar physics reduces the current advising load on solar faculty to 2.1/FTE. Targeted recruiting is needed to bring in students with interests in CMP, Optics, and Physics Education

Research. These ideas have guided our thinking in setting our strategic goals for the coming years.

3. Return of F&A to Departments and PIs: In the 1990's, a new policy was instituted by the then Vice-president for Research to return a portion of the F&A (known as Indirect Costs or IDCs in some departments) overhead charges collected in the Office of Sponsored Programs (OSP) to the colleges, departments, and PIs. The fact that campuses in the state were even allowed to retain these indirect costs on campus to reinvest in research programs was a major step forward, and a credit to the state and university administrators who made it possible. On the MSU campus we entered a period where 10% of the collected F&A charges was returned to the PIs, 10% to the college deans, and 30% was returned to the departments, leaving 50% for the VPR. In the current economic climate, with increased fixed costs and reduced revenue in the VPR's office, it was decided in Fall 2008 to change the policy for distribution of returned F&A. With the current policy, implemented in Fall 2009, a portion of the collected F&A is returned to the departments, and no amount is returned directly to the PIs. Further, the amount returned to the departments has been reduced, and depends on a combination of current fixed costs in the VPR's office, and the amount of research expenditures in the department during the previous fiscal year. For Physics, the amount returned would be insufficient to cover our commitments to our technical staff (see below), so the VPR has continued to help the department meet our fixed costs for salaries and benefits while we look for another solution. The department head is currently discussing with faculty members an appropriate model for returning to the PIs a portion of the department's share of returned F&A. In addition, under the current policy the VPR is now assuming most of the startup costs for new faculty hires. The next section describes our current situation with respect to supporting our technical staff using returned F&A.

4. Technical Support: Maintaining a healthy research program requires strong technical and administrative support. Since the earliest days of the Physics Department at MSU, we have maintained a mechanical shop with one skilled machinist, and an electronics shop with a technician capable of both design and repair of electronic instrumentation. Both shops have been staffed with additional student laborers as needed. With the growth of the computer-dominated office and lab, the department hired an IT manager. These three individuals are essential to our department research operations. In addition, with increased research expenditures, the department has found it necessary to have a full-time fiscal manager, and part-time travel administrative associate. These four individuals have significant responsibilities in the department, and supervise their own assistants. Over the past 10 years the Department has reclassified these individual positions from classified to professional, enabling salaries more appropriate to the skill levels of the individual in each position, and reducing turnover. For several years, the support of these individuals was split between the instructional budget (70%) and the department research budget fed by returned F&A (see section above). It is appropriate for the technical positions to have a major portion of their support through the state instructional budget because of the strong role the research program plays in student education. Support for the Fiscal Manager and Travel

Coordinator comes entirely from research overhead. However, with continuing cuts in the instructional budget in these tough economic times, there is increasing pressure to move more and more of the technical support off of the instructional budget and onto the department's returned F&A. At the same time, increased debt payments on new buildings and other fixed costs have placed additional pressure on the office of the Vice President for Research to retain collected F&A charges, leading to reduced return of F&A to the departments on campus. In the physics department we have asked individual PIs to help pay for technical support by charging a 1% fee on all direct costs of awarded grants, with approval from OSP. However, a better long-term solution for the department is to move the support of technical personnel related to research back to the instructional budget where it more appropriately belongs. In these uncertain economic times, it is not wise to have such a large portion of our technical staff salaries dependent on returned F&A, a policy that could change, for example, with ongoing changes in the upper administration. We have made this realignment of technical staff salaries one of our strategic goals for the coming years.

C. Research Expenditures

The Department of Physics has been a leader on campus in research expenditures through the Office of Sponsored Programs (OSP) for many years, and thus an extremely valuable resource for the University. Our research expenditures in FY'09 were over $6 M, generating approximately $1.1 M in F&A, while our departmental state instructional budget was $1.7 M. These numbers reflect the fact that although the nominal F&A rate for MSU is 42.5%, the effective return rate for Physics in FY09 was 23.5% because we use a modified total direct cost method in which some budget categories are exempt from facilities and administrative charges. The table below shows that research expenditures in Physics have ranked in the top 2 out of 15 departments in the College of Letters and Science for the past six years. In the same period our research expenditures have ranked in the top 4 out of more than 50 departments across campus at MSU

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Year	Physics	Rank CLS	Rank MSU
FY'04	$8,563,442	#1	#1
FY'05	$8,172,489	#1	#2
FY'06	$8,468,739	#1	#3
FY'07	$8,047,159	#1	#2
FY'08	$6,309,097	#2	#4
FY'09	$6,011,089	#2	#4

Appendix 3 contains a table with research and other sponsored program expenditures for FY 2009, showing the Physics Department as #4 in total expenditures. Research expenditures through OSP in the College of Letters and Science for the past 14 years are shown in Appendix 4. The Physics Department has been the top department in OSP expenditures since 1997, being #2 for the past two years behind the Department of Chemistry and Biochemistry. Such a record is a remarkable commendation for our faculty, who continue to win grants with top-rated science programs. Such a success

rate has placed us 5th out of 30 departments reporting such data at the annual Midwest Physics Chairs meeting for FY'08. This measure of success would not be possible without high quality graduate and undergraduate students, skilled technical staff, and strong administrative support.

D. Research Groups, Goals and Strategies

We present here a synopsis of the research programs for each of the groups in the department. We describe for each group: (1) the research interests and activities, (2) the research expenditures for that group in FY09, (3) the number of graduate students currently in the group, (4) the group goals and strategies in the coming years, and (5) the faculty members in that group as shown in the Organization Chart (Appendix 1) with their individual interests. Appendix 5 lists the publications and research grants reported by each faculty member for CY 2009 as part of their annual reporting in the Faculty Activity Database (FAD). We also provide a brief description of four research programs associated with the department: SSEL, Spectrum Lab, MSGC, and ICAL. We end this section with a list of current emeritus faculty and current support staff with job descriptions. Appendix 6 contains curriculum vitae provided by all tenure-track, research, adjunct, and research-active emeritus faculty currently in the department.

1. Astrophysics, Relativity and Cosmology (ARC)

Research Activities: The ARC group studies extreme astrophysical phenomena such as black holes, the big bang, and neutron stars, and uses them to further our understanding of fundamental physics. The incredible conditions that occur in these astrophysical environments far exceed those attainable in any earthbound laboratory. Their research involves many branches of physics, including general relativity, particle physics, fluid dynamics, magnetohydrodynamics and plasma physics. Current research in the ARC group focuses on two areas: gravitational wave astronomy and neutron star interiors. Other areas of study include determining the size and shape of the universe, investigating quantum effects in strong gravitational fields, and energy extraction from rotating black holes. Neutron stars are excellent laboratories for studying matter in extreme environments - a teaspoon of neutron star material has a mass of several hundred million tons. The ARC group studies the role of magnetic fields, superfluidity and crustal rigidity in neutron stars, and how these factors may be related to star quakes and spin glitches. Gravitational wave astronomy is an exciting new area of research that is poised to open a new window on the Universe. The ARC group is investigating how the space-based LISA gravitational wave detector and the ground based LIGO detectors can be used to study violent astrophysical events such as the collision of two black holes.

Group research expenditures in FY2009: 5 grants for $395,497

Graduate Students in this group: 15

Goals and strategies in coming years: Complete the hire of a new faculty member in the area of gravitational physics. Identify one or two fascinating research areas of physics that would serve to broaden our investigations into fundamental physics as a department. Areas to consider include observational astronomy or subatomic physics. The goal would be to identify an area with good potential for attracting both graduate student interest and a healthy level of funding.

Faculty Members:

Professor Neil Cornish: Research is focused on the interface between general relativity, astrophysics and early universe cosmology. Neil is particularly interested in using cosmological observations - such as the detailed measurements of the microwave background radiation provided by the Wilkinson Microwave Anisotropy Probe (WMAP)- to study the size and shape of the Universe, and other fundamental issues connected with quantum gravity. His main area of research is the newly emerging field of Gravitational Wave Astronomy. Neil's group is exploring how the Laser Interferometer Space Antenna (LISA) can be used to study violent astrophysical events such as the collision of two black holes through the gravitational waves they stir up. They have developed a LISA Simulator that models the operation of the detector, and allows them to study how the observatory will operate long before it is launched in 2012.

Professor Bennett Link: Dr. Link's research uses neutron stars as laboratories with which to study matter at densities currently inaccessible in terrestrial laboratories. Aspects of neutron stars that are studied observationally include spin evolution, thermal evolution, radii and masses. These data can be used to probe the exotic neutron star interior. Bennett's research focuses on theoretical study of the neutron star interior and the development of diagnostic probes with which to constrain the properties and dynamics of the super strong neutron star crust and the quantum liquid it contains. Recently he has been studying neutron star "wobble" (precession), which seriously challenges current models of the neutron star interior. Bennett has also been studying timing noise (quasi-random spin fluctuations) in neutron stars, the possibility that some young neutron stars can produce observable high-energy neutrinos, and the thermal evolution of neutron stars.

Professor Sachiko Tsuruta: Professor Tsuruta is involved with the astrophysics research group in various theoretical problems of high energy, plasma, relativistic, particle and nuclear astrophysics, with particular emphasis on studies of dense matter in neutron stars and ultrahot plasmas around supermassive black holes. Professor Tsuruta's current research includes detailed calculations of neutron star cooling and heating with superfluid particles, pion and kaon condensates, quarks, and strong magnetic fields; implications of the results of these calculations to the problem of detectability of these stars; and construction of viable models of a central power house in active galactic nuclei (AGN). This central engine is considered to be responsible for the enormous amount of energy produced in quasars and strong radio galaxies.

Research Professor Ron Hellings: Research is focused on two general problems.
(1) *Tests of relativistic theories of gravity using solar system data*. A century of optical transit circle observations of the right ascensions and declinations of the planets, plus several decades of radar and planetary spacecraft range data from earth to the planets are fit to a relativistic model of solar system dynamics. In the process, the values of certain theory-dependent parameters (the so-called Parameterized Post-Newtonian, or PPN, parameters) are solved for. The observed values of these parameters allow one to discriminate between competing theories of gravity.
(2) *Low Frequency (LF) gravitational wave astronomy.* Beginning with searches using spacecraft radio tracking data and pulsar timing data, Prof. Hellings has worked on the direct detection of gravitational waves. This has included designing a dedicated space mission, OMEGA, which would have had the sensitivity to see gravitational waves from known astronomical sources and from massive black hole events at cosmological distances from the earth. Most recently, the work has centered on developing data processing and data analysis algorithms for the proposed LISA mission.

2. Condensed Matter Physics

Research Activities: The department pursues an exceptionally broad spectrum of fundamental and applied research in condensed matter physics. The topics include defect characterization, ferroelectrics and piezoelectrics, fuel cells, interfacial growth, magnetism (bulk and thin film), nanotechnology, phase transitions, spintronics, superconductivity, structural studies using x-ray and neutron diffraction, and specimen synthesis including single-crystal and thin-film growth. State-of-the art experimental facilities at MSU enable measurements to temperatures as low as 0.3 K. We are leaders in the measurement of thermal expansion, using a novel device developed at MSU that is capable of detecting sub-angstrom length changes of specimens to study phase transitions and critical phenomena with superb resolution. The Ion Beams Laboratory conducts experiments on thin films and buried solid-solid interfaces to reveal fundamental properties and growth mechanics of importance for fuel cells and electronic devices. Ceramics for fuel cells are fabricated and tested for their electrical properties. The spectroscopy group investigates defects in advanced materials at the atomic level using a host of techniques such as EPR, ENDOR and optical spectroscopy, with the goal of engineering new properties for novel applications in photonics and information technology. The Center of Bio-Inspired Nanomaterials utilizes biological molecules as templates for the synthesis of nanoparticles with unusual physical properties; this interdisciplinary effort thrives on close collaboration among biologists, chemists, and physicists at MSU. Some experiments are also conducted at facilities such as the High Magnetic Field Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, and Pacific Northwest National Laboratory.

Group research expenditures in FY2009: 15 grants for $1,150,941

Graduate students in this group: 18

Goals and strategies in coming years: The main goals for the condensed matter physics faculty are to broaden and deepen the education of students in materials related physics endeavors to promote student success. Our detailed strategy to achieve this goal is as follows:

- Strengthen our commitment to a new thrust direction initiated with the hire of a new faculty member in condensed matter theory in January 2009.
- Expand the departmental expertise in emerging areas of condensed matter physics with a tenure-track faculty hire in exotic materials, materials far from thermodynamic equilibrium, or materials in extreme environments.
- Diversify the funding portfolio to include small group funding support in addition to the individual researcher support.

The successful outcome of this strategy will be an increased ability to attract a larger number of qualified graduate and undergraduate students to condensed matter physics and to expose and involve students to a broader spectrum of modern-day research topics.

Faculty Members:

Professor Yves Idzerda: Professor Idzerda is currently interested in the physics of reduced dimensionality systems, especially in their interfacial and nanostructured behavior. His groups' recent interests have been in the oxide materials including half-metallic ferromagnets, multi-ferroics, and components of solid oxide fuel cells. This includes research on ultra-thin film and interface magnetism of itinerant electron magnetic systems and in novel characterization techniques that have strong magnetic contrast. Part of his research includes magnetic nanoclusters developed in protein cages and exploiting polarized X-rays to obtain unique knowledge of the behavior of magnetic thin films and surfaces. Some of his research is performed at the MSU Nano-materials X-ray Characterization Facility located at beamline U4B of the National Synchrotron Light Source (NSLS) where he is the Spokesperson for this effort.

Associate Professor Galina Malovichko: Professor Malovichko performs experimental research to investigate extrinsic and intrinsic defects in ferroelectrics, non-linear optical materials, electro and acousto-optical crystals for advanced applications in optoelectronics, photonics, and telecommunications. The group uses techniques such as Electron Paramagnetic Resonance (EPR) and Electron Nuclear DOuble Resonance (ENDOR).

Professor John Neumeier: Professor Neumeier's group studies the physical properties of novel condensed matter materials, such as high temperature superconductors, low-dimensional materials, and manganese oxides that exhibit colossal magneto-resistance. Many of the experiments focus on the study of phase transitions and the connection between structure and physical properties. They also measure magnetic properties and other thermodynamic properties, such as heat capacity. This research program is focused on fundamental, rather than applied physics. Much of the work involves the growth and characterization of bulk materials in polycrystalline and single-crystal form,

which allows control of the samples used in the experiments and the ultimate in flexibility. They have a NEC optical image furnace for growing very large single crystals and a number of conventional furnaces. They have developed new techniques for measuring the thermal expansion of solids using capacitive dilatometry and their own design of a novel thermal expansion cell constructed of fused silica (quartz). Experiments are conducted in the temperature range from 0.3 K to 1000 K.

Professor Richard Smith: Professor Smith uses MeV ion backscattering/channeling and electron spectroscopies to determine the atomic structure at solid surfaces and at solid-solid interfaces. The emphasis of this research is on epitaxial growth and the formation of alloys at metal-metal interfaces. Ion beam techniques are also used to measure the oxidation rates and thermal stability of metal surfaces on current collectors in solid oxide fuel cell (SOFC) stacks, and to characterize improved anodes for SOFCs.

Assistant Professor Anton Vorontsov: Professor Vorontsov's research area is theoretical condensed matter with a focus on correlated many-body (collective) effects such as superconductivity and superfluidity. In many new materials superconductivity appears close to or together with magnetism, and in this research he studies how magnetic fields, impurities and fluctuations influence superconducting properties.

Research Professor Recep Avci: Professor Avci studies fundamental and applied aspects of condensed matter, including biomaterials, surfaces and interfaces, with a wide variety of spectroscopic and microscopic techniques. Current interests include the detection, localization and quantification of receptor-ligand interactions between outer membrane proteins and adhesins associated with bacteria, and understanding at the molecular level the interactions of these adhesins with the environment. A second area of focus is the application of laser-assisted secondary ion mass-spectroscopy (LASIMS) in the mobilization of trace radionuclides (such as Cs, Co and Sr) by pulsed laser irradiation and its use in homeland defense applications. Professor Avci has considerable experience with a variety of techniques including atomic and chemical force microscopy, time-of-flight secondary ion mass spectroscopy, photoemission and Auger electron spectroscopy, scanning electron microscopy and X-ray microanalysis, powder X-ray diffraction (including thin-film diffraction and reflectivity), small spot X-ray fluorescence spectroscopy using synchrotron radiation, high-resolution vibrational and electronic electron energy loss spectroscopy, spin-polarized inverse-photoemission spectroscopy, and coincidence and nuclear-emission spectroscopy. He also serves as Director of the Imaging and Chemical Analysis Laboratory (see below)

3. Optical Physics

Research Activities: The optical physics and laser spectroscopy laboratories include lasers ranging from the ultrastable (sub-kHz linewidths) to the ultrafast (femtosecond pulses). The research efforts of optical science and laser faculty members range from fundamental investigations of optical physics to development of commercial photonics devices. Research areas include: spectral hole burning phenomena combined with

holography, materials science, and devices; ultra-fast holography and spectroscopy; advanced 3D imaging systems; Raman lasers; diode laser frequency control and noise characterization; ultra-stable optical lasers and cavities; and applying advanced laser and non-linear optics technologies to remote sensing and medical applications. The Spectrum Lab and the Optical Technology Center (OpTeC) foster collaborations with the Departments of Chemistry and Biochemistry, and Electrical and Computer Engineering and with local optics industries. These local collaborations, along with close ties to several national and international laboratories and companies, enhance our fundamental and applied research efforts and offer outstanding employment opportunities for our graduates. These programs have supplied many employees to local industries.

Group research expenditures in FY2009: 11 grants for $438,989

Graduate students in this group: 10

Goals and strategies in coming years: Optical Science and Laser Physics are vibrant areas locally, nationally, and internationally. Goals in this area include 1) maintaining strong connections to optics companies and new startups, 2) educating students for the local economy, 3) continuing research at the front lines of optics, and 4) hiring for the future. The path to those goals includes maintaining the extensive collegial transfer of technology between the optics research groups and implementing the Masters Degree in Optical Science and Laser Technology. There are opportunities to expand activities in biophysics research, where we are already using genetic engineering and local synthesis to improve fluorescent proteins and chromophores and have established collaboration with chemistry and neurobiology. Themes of remote laser sensing, coherent light-matter interactions, solid state materials for quantum memories and quantum information processing, and fundamental developments in these areas are important.

Faculty Members:

Professor Randy Babbitt: Research interests include remote sensing, RF photonics, microwave signal processing, laser and photonic component development, and spectral-spatial holography. Spatial-spectral holography combines the spatial storage and processing attributes of volume holography with spectral storage and processing attributes of persistent spectral hole burning. Spatial-spectral holographic (SSH) phenomena encompass optical coherent transients, photon echoes, and time-domain spectral hole burning. The SSH materials' ability to record optical signals with bandwidths up to 100 GHz with resolutions on the order of tens of kHz enables advanced microwave signal processing. The SSH research has required development of novel lasers and photonic components, which have had the side benefit of opening up new areas of remote sensing. Remote sensing research interests includes feature specific imaging, high precision laser radar, and remote gas sensing in the mid-IR, specifically for the detection of effluents from clandestine drug labs and other hazardous chemical detection.

Professor John Carlsten: Research interest over several decades has primarily been in non-linear optics and quantum optics, with emphasis on the stimulated Raman effect and cw Raman laser. Experiments in the high power pulsed regime and later in the low power cw regime led to the development of frequency agile diode lasers and high finesse cavities that are now finding applications to optical sensing. Recent collaboration with Professor Kevin Repasky and Professor Joe Shaw of the Department of Electrical and Computer Engineering have led to LIDAR applications involving these diode lasers and cavities. One current area of interest in this collaboration is LIDAR detection of aerosols in the atmosphere, important for the understanding of cloud formation. A confocal cavity is being used to separate signals of the aerosols from the Rayleigh scattering in this two-color experiment. In another application, LIDAR DIAL is being used to monitor water vapor in the atmosphere. In this case compact diode amplifiers are being used to construct compact systems that are deployable in multiple sites. Another LIDAR application of the group involves scattering of laser light from the wing beats of honeybees trained for explosive detection and land mine location. Finally recent interest in global climate change has led to the development of LIDAR monitoring of CO_2 in connection with CO_2 sequestration with the ZERT program at MSU. For this program both free space above-ground systems and fiber optic, below-ground systems are being developed.

Professor Rufus Cone: Professor Cone's research group studies optical, dynamical, and magnetic properties of solids using a variety of nonlinear optical spectroscopic methods, many new materials, and a variety of lasers. Recent focus areas are:

- Fundamental understanding of dynamic and static contributions to optical lineshapes and level structure in rare-earth-doped optical materials, including effects of inhomogeneity and disorder;
- Design, development, and characterization of materials for practical optical signal processing and quantum information science;
- 1.5 micron wavelength devices using fiber communication infrastructure like optical amplifiers, high bandwidth modulators, diode lasers, and modelocked fiber lasers, and including laser development;
- Laser frequency stabilization using rare-earth-doped materials as frequency references;
- Relation of rare earth ion levels to host band states in crystals, impacting signal processing, laser materials, scintillators, and optical display phosphors;
- Compositionally-tuned solid state laser materials for resonant remote sensing and other applications;
- Developing new methods for analysis of laser crystals and crystal quality.

Professor Aleks Rebane: Research interests include: Nonlinear optics, ultrafast time-space holography, spectroscopy of organic materials, and biomedical photonics. Professor Rebane’s goals include:

- Develop new optical methods for biophysics research using fluorescent proteins. In particular, by combining quantitative multi-photon spectroscopy with genetic

engineering develop better fluorescent protein probes for functional biological imaging and microscopy,

- Interdisciplinary study of biological chromophores in collaboration with chemistry and neurobiology.
- New methods to diagnose and treat deep tissue solid cancer tumors in collaboration with microbiology and local biotech startups.
- Continue work with core program of AFOSR in femtosecond nonlinear spectroscopy of photonic materials;
- Physical principles of coherent light-matter interactions; solid state materials for quantum memories and quantum information processing.

Research Professor Alan Craig: Photonics and Nano-photonics, computing device applications for nanoparticle spectroscopy.

Assistant Research Professor Mikhail Drobijev: The research of Dr. Drobijev (Drobizhev in scientific publications) is concentrated on nonlinear optics of organic molecules and biophotonics. Current project investigates the molecular biophysics of fluorescent proteins (Green Fluorescent Protein, GFP, and other members of the family). In collaboration with Dr. Thomas Hughes (Cell Biology and Neuroscience Dept., MSU) we study two-photon absorption properties of a large variety of fluorescent proteins. In collaboration with Dr. Patrik Callis (Chemistry and Biochemistry Dept. MSU) we perform quantum-mechanical modeling and calculations of the effect of protein surrounding on the optical properties of the chromophore group (e.g. through Stark effect). This information would enable us to create considerably improved new genetically-encoded fluorescent probes for two-photon laser scanning microscopy and better understand photophysics of fluorescent proteins.

Research Scientist Charles Thiel: Dr. Thiel's research interests focus on fundamental and applied photonic materials research as well as integrated fiber-optic device development at 1.5 microns for signal processing, quantum information science, and laser applications. This includes solid-state materials research (single crystals, bulk glasses, and optical fibers) using a wide range of optical techniques to probe nano-scale interactions that influence macroscopic optical properties. Dr. Thiel has worked on projects in collaboration with several corporate partners, including S2 Corp. and Scientific Materials Corp. (a Division of FLIR), on laser materials research as well as spatial-spectral holography materials and device development, transferring expertise gained in fundamental scientific studies to these industrial partners to aid in the development of commercial products. Dr. Thiel's recent work has focused on understanding quantum decoherence processes in optical materials and developing quantitative models to guide material design and optimization.

4. Physics and Astronomy Education Research

Research Activities**:** The Physics and Astronomy Education Group endeavors to improve teaching and learning at all levels. Graduate Students may pursue a Ph.D. in physics with a principal research focus on science education. Students whose primary research is in other areas may pursue a minor in science education. Members in this group have extensive expertise in: improving learning in large lecture courses; research driven curriculum development; WWW-based instructional strategies; K-12 teacher education and authentic student assessment strategies and project evaluation. Working in this group prepares students for continuing research in the growing number of physics education groups across the country, teaching at two and four year colleges and universities and for careers in educational material development.

Currently one graduate student is investigating the understanding of gravity by non-science majors in Phys 101 Mysteries of the Sky, a general astronomy course, and plans to develop a questionnaire that will gauge the level of understanding these types of students have about gravity as compared to the expert view on the subject. Eventually she will also develop a set of tools to better teach concepts related to gravity. Other research includes a long-term study about how grading incentives affect student tendencies to block vote in large classroom settings. An undergraduate student is studying gender issues in the classroom, looking for trends in performance on the Force Concept Inventory tool with respect to gender in a Physics I course (with calculus). Another study is looking at the impact on student understanding of basic astronomy concepts when an online homework system was added to Physics 101. The only change made to the course was the addition of an online homework system, worth 10% of the overall course grade. The instructor, lectures, and overall structure of the course remain unchanged.

Group research expenditures in FY2009: 3 grants for $86,847

Graduate students in this group: 1

Goals and strategies in coming years: Future goals for the Physics and Astronomy Education Group include attracting more graduate students to the research group (at least 3 more students within the next 5 years) and continuing to seek NSF and NASA support. Proposals to study student understanding with respect to gender and among Native American students in STEM disciplines have been submitted without success within the last 4 years. We have been successful with several internal grants from the Teaching and Learning Committee at MSU Bozeman. We will continue to attend and present results at the AAPT conferences each year.

Faculty Members:

Associate Professor Jeff Adams: Professor Adams has served as the Assistant Vice-Provost for Undergraduate Education in Academic Affairs since 2001. In his administrative role, Dr. Adams' motivation continues to be his desire to help students be

successful. Professor Adams continues to teach courses in the department (mostly PHYS 206) because it provides an opportunity to experiment with new techniques and technologies, which he can then share with other faculty across campus. Dr. Adams' creative activities now focus on textbook writing with the current focus on the texts for PHYS 205 and 206.

Professor Greg Francis: Professor Francis is first and foremost a teacher, and has enjoyed teaching throughout his graduate and post-doctoral career. He joined the Physics Education Research Group at the University of Washington-Seattle in 1990, learning the "science" of effective physics teaching. Since coming to Montana State University 1992, Greg has continued to experiment with active learning approaches in large introductory classes, and has focused on textbook development. Dr. Francis has won every teaching award given on the campus of Montana State University, and is often referred to as a teacher for the teachers.

Adjunct Assistant Professor Carla Riedel: Dr. Riedel's teaching interests include modern physics (quantum mechanics, special relativity, particle physics), and mathematical and computational physics. She enjoys teaching at both the undergraduate and graduate level, and is especially concerned with issues relating to the continuity and completeness of the undergraduate curriculum. Dr. Riedel's research interests in experimental subatomic physics focus on spin and isospin phenomena in light nuclei (e.g. hydrogen and helium), primarily at the intersection of high-energy particle physics and conventional nuclear physics. The broad goal of her experimental program is to characterize the strong interaction in a well-understood nuclear medium. She is currently a member of several international collaborations conducting experiments at TRIUMF (Vancouver, British Columbia), BNL (Ridge, New York), and LANL (Los Alamos, New Mexico). Her work involves experimental design, particle detection, data acquisition, data analysis, and theoretical modeling.

Adjunct Assistant Professor Shannon Willoughby: Dr. Willoughby's research focuses on how students learn (and don't learn!) physics and astronomy. A recent one-year study involved using different grading incentives for clicker questions in Physics 101 (Astronomy). Student learning groups in each section of astronomy were recorded several times during the first semester of the project. The goal was to see if the nature of the conversations differed between sections. A secondary goal was to see if gender differences within groups colored the conversations in any measurable way. This study was done in conjunction with a professor in Cell Biology. The data are being analyzed together to see if there are differences between how learning occurs in biology versus physics. Another project involves using planetarium software in Physics 101 as opposed to more traditional methods using a globe to measure the effect this software has on student understanding of the apparent nightly and seasonal motions of the night sky. Students are tested on the ideas and classes in which the software was used will be compared to classes in which more traditional methods were used to discuss the ideas.

5. Solar Physics

Research Activities: The Solar Physics group conducts diverse research aimed at understanding the Sun as a star and as the source of space weather. The MSU group is internationally known for theoretical and computational research in magnetohydrodynamics and radiation transfer, for collaborative studies with a worldwide cadre of observers and theorists, and for the group's central role in several space missions. The TRACE mission images the solar transition region and corona with unprecedented spatial resolution. The RHESSI mission studies solar flares with innovative combinations of X-ray and gamma-ray imaging and spectroscopy. MSU's involvement in the Hinode (Solar-B) mission benefits from the group's extensive experience with X-ray imaging during the Japan/US/UK Yohkoh mission, and expertise with ground-based instrumentation for magnetic field measurements and theoretical studies of solar magnetic fields. The AIA telescopes will extend the high-resolution heritage of TRACE to NASA's first "Living with a Star" mission, the Solar Dynamics Observatory, whose scientific scope extends from the interior of the Sun to the outer reaches of its corona. MOSES, a novel rocket borne ultraviolet imaging spectrograph designed and built at MSU, was launched in February 2010, and paves the way for future development of space based solar instrumentation in Montana.

Group research expenditures in FY2009: 22 grants for $1,348,822

Graduate students in this group: 17

Goals and strategies in coming years: Develop a proposal to locate the new headquarters of the National Solar Observatory at Montana State University. This will involve construction of a new building to house 60 NSO scientists, and recruiting several additional faculty to perform research in solar physics and optical instrumentation development. The group will also propose to host a future meeting of the Solar Physics Division at MSU-Bozeman. The group will recruit additional research faculty in solar physics.

Faculty Members:

Associate Professor Charles Kankelborg: Professor Kankelborg's group has many research interests, including: solar corona, the transition region and chromosphere; coronal heating and X-ray bright points; force-free magnetic fields; ultraviolet optics; and space instrumentation. Current projects in his group include: the Multi-Order Solar Extreme-Ultraviolet Spectrograph (MOSES), the Interface Region Imaging spectrograph **(**IRIS), and field line ("fluxon") modeling of force free magnetic fields.

Professor Dana Longcope: Research interests in Professor Longcope's group fall into two general areas: (1) Magnetohydrodynamics, including equilibria and stability, singularities and current sheet formation, magnetic reconnection, and turbulence; and (2) solar physics topics including magnetic structure of the corona, microflaring and

coronal activity, magnetic field generation and emergence, and flares and particle acceleration.

Assistant Professor Jiong Qiu: Professor Qiu's group is working on several research projects, including: magnetic reconnection in solar eruptions, small-scale active region energy release events, particle acceleration in flare environment, dynamics of solar flares and active regions, evolution of solar magnetic fields, and earthshine measurements of global atmospheric change.

Assistant Research Professor Bob Leamon: Professor Leamon's research interests and skills are primarily in data analysis and observation, although his interests extend further than just the Sun. The over-arching theme of his recent research has been the correlation of interplanetary phenomena with their solar sources. This is true on both large scales with coronal mass ejections and their interplanetary manifestations, and to the small-scale tracking and forecasting of the quiet solar wind. His most recent efforts are focused on how the nascent solar wind accelerates in the solar corona and even below. Dr. Leamon also maintains an active interest in the dissipation magnetic fluctuations in the corona, solar wind and heliosphere. He will be a contributor to the Solar Probe Plus and Solar Orbiter missions.

Research Professor Loren Acton: Dr. Acton oversees the solar physics group, which carries on an active research program under NASA support. They are actively involved in day-to-day operation and scientific utilization of the Japan/US/UK Yohkoh mission for studies of high-energy solar physics. This satellite carries a solar x-ray telescope, prepared under the leadership of Dr. Acton, for the study of high-energy processes, such as solar flares, on the sun. The primary emission of the extremely hot outer atmosphere of the sun, the solar corona, is at x-ray wavelengths. The extended duration and high-resolution x-ray imagery from Yohkoh are being analyzed in an effort to learn why the sun has a corona at all and why it varies in intensity so strongly in response to the 11-year sunspot cycle. Dr. Acton is also a co-investigator on the NASA Transition Region and Coronal Explorer (TRACE) mission. This battery of 4 ultraviolet telescopes has provided new and detailed observations of the thin and dynamic interface region at the base of the corona. This region is also the source of much of the ionizing radiation that determines the properties of the upper atmosphere of the earth such as the ionosphere and ozone layer.

Research Professor Dick Canfield: Professor Canfield's research interests include: solar magnetism, topology of coronal fields, magnetic helicity and the solar dynamo, solar flares as characterized through the Max Millennium program and the RHESSI High Energy Solar Spectroscopic Imager, solar coronal mass ejections and sigmoids as precursors of coronal mass ejections, and solar eruptions and their interplanetary consequences.

Research Professor David Klumpar: Professor Klumpar serves as the director of the Space Science and Engineering Laboratory (SSEL; see below). His research interests include (1) the aurora and ionosphere, including particle acceleration, ion energization

and heating; (2) space weather, including geospace response to solar activity and the Living with a Star program; and (3) space instrumentation. Dr. Klumpar and his team have managed, designed, fabricated, and tested student projects such as the Montana EaRth Orbiting Pico Explorer (MEROPE), a miniature cube-shaped satellite to measure earth's energetic charged particle radiation.

Research Professor Piet Martens: Professor Martens is a solar physicist with experience in theoretical modeling, data analysis, automated feature recognition**,** and space instrumentation. Research interests include long-term solar activity in the context of the Sun-Earth connection, coronal loops, solar flares, filament eruptions and particle acceleration, and dynamos in the context of the solar-stellar connection. He has been involved with several solar missions, including Yohkoh, SoHO, TRACE, Hinode**,** and SDO**.**

Associate Research Professor David McKenzie: Professor McKenzie's work focuses on observations and analysis of solar flares and the structures which produce them; the behavior of magnetic fields during flares; and the heating of stellar coronae. For these studies, he primarily uses ultraviolet and X-ray observations from telescopes orbiting the Earth. David works with graduate students, faculty at MSU, and partners at other institutions, to operate NASA's TRACE satellite and the X-Ray Telescope on the JAXA/NASA/UK Hinode satellite. Professor McKenzie is also heavily involved in education & public outreach projects related to solar and space science.

6. Programs and Centers Associated with the Physics Department

Spectrum Laboratory: The Spectrum Lab was established in 1999 and is a photonics research center under the Deans of the Colleges of Engineering and Letters and Science. The threefold mission of Spectrum Lab is: (1) To perform advanced research and development on MSU grown photonic technologies; (2) To establish and maintain university-corporate partnerships to effect the transfer of these technologies into Montana companies; (3) To provide enhanced educational and employment opportunities for Montana undergraduate and graduate students, enabling our students to perform team-oriented, goal-driven, time critical research and development. Teams of research scientists and students in Spectrum Lab and from science and engineering departments across the campus collaborate on research including photonic signal processing, LIDAR, quantum computing, laser development and stabilization, and optical material engineering and characterization. Spectrum Lab is currently under the direction of Professor Randy Babbitt. More information on Spectrum Lab can be found at http://www.spectrum.montana.edu/

Annual Operating Budget for FY2009: $1.55 M

Imaging and Chemical analysis Laboratory (ICAL): ICAL is a user oriented facility that supports basic and applied research and education in all science and engineering disciplines at MSU. The laboratory provides access to state of the art equipment, as well as professional expertise and individual training to government and academic institutions and the private sector. Laboratory instrumentation is dedicated to the characterization of materials through high-resolution imaging and spectroscopy. ICAL promotes interdisciplinary collaboration between the research, educational and industrial fields. ICAL operates under the direction of Research Professor Recep Avci. For more information see http://www.physics.montana.edu/ical/home/index.asp

Annual Operating Budget for FY2009: $268,274

Space Science and Engineering Lab (SSEL): The Space Science and Engineering Laboratory at Montana State University is an interdisciplinary center of expertise with faculty, staff and facilities for space research and space technologies. The laboratory enables students and faculty in the science and engineering disciplines to conduct space science research through the development of space hardware instrumentation. SSEL was started under the auspices of the Physics Department at MSU in November, 2000. SSEL strengthens existing programs at MSU in solar-terrestrial physics, microelectronics, optical mechanisms, composite and ultra-light structures, bio-films and remote sensing. SSEL operates under the directions of Research Professor David Klumpar. For more information see http://ssel.montana.edu/home/

Annual Operating Budget for FY2009: $266,249

Montana Space Grant Consortium (MSGC): The Montana Space Grant Consortium was established in 1991 as a component of NASA's National Space Grant College and Fellowship Program. The Montana program is one of a national network of 52 Consortia, working to strengthen aerospace research and education in the United States. Members of the Montana Space Grant Consortium consist of institutions of higher education, business, industry and non-profit organizations. The Consortium works with these affiliates and through government and public outreach, to promote a strong science, math and technology base in the state. MSGC embraces the goals and objectives established by the National Space Grant Program. To achieve these goals, MSGC awards fellowships and scholarships to students pursuing aeronautical or space related studies and also awards stipends to undergraduate students pursuing space-related research at all member campuses. The Consortium has a yearly competition for research initiation and educational enhancement grants for faculty, and carries out additional undergraduate student research, K-12 teacher enhancement, and pre-college and public outreach programs through its central office. Another national and state goal is the inclusion of members of underrepresented groups in space-related research and education programs. To meet this goal, the Consortium makes every effort to encourage and attract participation by qualified students from the state's female and

minority populations. All seven of Montana's tribal colleges are members of the Consortium. MSGC operates under the direction of Dr. Angela Des Jardins. For more information see http://spacegrant.montana.edu/

Annual Operating Budget for FY2009:

7. Emeritus Faculty

Drumheller, John E., Ph.D., Colorado, 1962. Solid state physics; electron spin resonance; magnetism.

Hermanson, John C., Ph.D., Chicago, 1966. Surface physics theory.

Kirkpatrick, Larry, Ph.D., MIT, 1968. AAPT officer. Science Education.

Lapeyre, Gerald J., Ph.D., Missouri – Columbia, 1962. Solid state and surface physics; photoemission; electron energy loss.

Schmidt, V. Hugo, Ph.D., Washington, 1961. Solid state physics; nuclear magnetic resonance; alternate energy.

Swenson, Robert, Ph.D., Lehigh, 1961. Statistical physics.

Wheeler, Gerald, Ph.D., SUNY-Stony Brook, 1972. AAAS officer. Science education. Experimental nuclear physics.

8. Physics Department Support Staff

Sarah Barutha, Department Manager

The Physics Department Manager is in charge of the day-to-day operating activities of the Physics department that enables those involved in the academic and research missions to do their jobs. The department manager is the personnel administrator and performs those tasks on the department level as well as being the department liaison with the university human resources department.

Jerry DiMarco, Instructional Lab supervisor

The instructional lab supervisor is responsible for:

- All aspects of lecture demonstration equipment, including acquisition, repair, maintenance, setup and take down.
- All aspects of instructional lab equipment for introductory courses, including setup and take down, repair, maintenance, and acquisition.
- Scheduling all uses of the AJM instructional lab rooms.
- AV equipment and materials for the department.

- Liquid nitrogen supply for the EPS complex.
- Supervision of student labor assistant for instructional lab equipment.

Jeremy Gay, Information Technology Manager

The IT Manager is the resident department IT guru. The departmental computing environment is a mix of different hardware and software platforms, which calls for a flexible approach to systems management, troubleshooting and support. The IT Manager strives to provide innovative IT solutions within an excellent computing environment for the department. Duties of the IT Manager include:

- Manage Physics department server systems.
- Network and email account management.
- Department web site webmaster
- Web CRM database management.
- Desktop support for Windows, Apple and Linux operating systems.
- Windows, Linux, Apple systems integration.
- Physics domain network management and administration.
- Physics computer lab management.
- Systems research and analysis.
- IT systems training and consultation.
- Coordinating the purchase of department hardware and software.

William "Bo" Glaspey, Electronics shop supervisor

The electronics shop supervisor is responsible for:

- Assisting researchers and students in the implementation of electronics design and prototype development.
- Assisting researchers and students in resolving equipment failures.
- Providing expertise in computer control and automation of lab measurements.
- Providing computer aided design (CAD) expertise in ORCAD Schematic Capture and Circuit Layout software.
- Maintaining inventory of common electronic components used by the Physics Department.
- Serving as a resource for upper level lab-based courses, instrumentation and electronic needs.
- Supervising researchers and students while using the shop facilities.

Sherry Heis, Fiscal Manager

The Fiscal Manager is responsible for:

- Providing reporting, analyses and financial expertise to the department head and faculty with grant funding.
- Instituting accounting and management practices to ensure compliance with relevant laws and regulations.
- Providing day-to-day oversight of the department budget.
- Managing the department's accounting, purchasing and student personnel functions.

Margaret Jarrett, Administrative Assistant and Graduate Program Coordinator

The Administrative Assistant and Graduate Program Coordinator is responsible for serving as the general department liaison. The AA/GPC manages all aspects of the inquiries, applications and admissions process for the graduate program in Physics, including all recruiting activities for the program. The AA/GPC maintains all graduate and undergraduate student files, forms, and other paperwork, and provides general support for faculty and students. The AA/GPC supervises student labor in the department office and assists with general provision and distribution of department supplies.

Brian Kay, Travel Coordinator

The Travel Coordinator serves as an assistant to the Fiscal Manager and is responsible for all department travel related paperwork.

Glenda Winslow, MSGC Program Coordinator

The Program Coordinator (PC) for the Montana Space Grant Consortium oversee the financial aspect of the program, including tracking expenses, balancing accounts, allocating charges, paying invoices, etc. The PC is also responsible for awarding subcontracts, scholarships, fellowships, and generally dealing with the distribution of all of our funding. The PC supports the Director in the annual call for proposals and compiles reviews in preparation for the review panel meeting. The PC duties include tracking students who have received a significant award from the Consortium.

Norm Williams, Machine Shop supervisor

The shop supervisor provides technical design support to all department programs and to experimental research projects, including:

- Machining small quantities of prototype hardware with complex geometry using both manual and computer controlled machines.
- Consulting with faculty and/or researchers determining feasibility of project, design parameters, material selection and cost estimates.
- Providing a resource for knowledge about the properties of and the techniques for working with many different materials including titanium, inconel, magnesium, stainless steel, copper, tantalum, and ceramics such as aluminum oxide, ule, and zerodur.

3. Academic Programs: Undergraduate, Graduate, and Assessment

A. Undergraduate Program: B.S. in Physics

The undergraduate physics curriculum is designed with considerable flexibility in order to accommodate the variety of interests, plans, and needs of majors. At the same time, it provides a broad and thorough understanding of the fundamental ideas and concepts

related to the physical world surrounding us. Using this broad base, which stresses fundamentals, undergraduates may enter graduate work in one of the pure or applied sciences or one of the non-sciences such as education, business administration, law, journalism, or philosophy. They may also choose to go directly into jobs in education, industry, government, or business.

Professional Option

Intended primarily as preparation for graduate work in one of the physical sciences, the professional option provides a sound background in the fundamentals of physics and mathematics. The program requirements have sufficient breadth and depth to qualify the student for any graduate program in the country. In AY2009-2010, 77% of our undergraduate majors selected this option.

Interdisciplinary Option

This option requires a minimum of 16 credits in the declared area and is designed for those who desire a firm background in mathematics and physics coupled with a concentration in another discipline such as chemistry, biology, computer science, engineering, or technical writing. Each student choosing this option will work out a specific program with an advisor and the participating department. In AY2009-2010, 15% of our undergraduate majors chose this option.

Teaching Option

This option is intended primarily as preparation for secondary school teachers. Teaching options require a teaching minor from the Department of Education. In AY2009-2010, 8% of our undergraduate majors selected this option.

Undergraduate Research Participation

An integral component of all undergraduate major programs in physics is participation in undergraduate research. Faculty members work closely with students in identifying and addressing important problems in particular sub-fields, depending on student interests. Although a minimum of 3 credits of undergraduate research is required for graduation, many students extend this experience and work in research labs throughout the year, including summers. Students from other majors who demonstrate interest and ability are also welcome to participate in undergraduate research projects in physics.

Senior Project

The senior project is designed to give a student the opportunity to develop, over two or more semesters, skills that are necessary for work in a professional scientific environment. The student will collaborate with a mentor on a project that is of interest to the student, is either experimental or theoretical in nature, has a defined objective, and is primarily based on the student's own work. This work normally will be presented in PHYS 406C, Capstone Presentations. It could be an extension of background or historical work completed by the student in PHYS 470 or 489, but must also include at least 2 credits of 490 completed before taking PHYS406C. In PHYS 406C students will be required to complete: (1) an APS-style abstract, (2) an APS-style 10-minute oral presentation, (3) a poster at the Student Research Celebration in April of spring

semester, and (4) an 8-10 page written research report, based on their prior research. Specific examples of past senior projects include:

- Laser development for specific applications
- Conducting spectroscopy or surface measurements of materials
- Extending or applying recent theories of quantum information theory
- Theoretical work in astrophysics, gravitation
- Analysis and interpretation of astronomical data
- Oxidation resistance of coatings for SOFC interconnects

Capstone Experience

Students in the professional and interdisciplinary options will complete senior projects that integrate their physics knowledge and problem solving skills. Students will complete these projects during a minimum of two credits of PHYS 470 or PHYS 490 and present their results in oral and written forms in PHYS 406 - Capstone Presentations. Guidelines for these senior projects are provided by the departmental advisors. The capstone experience for those in the Physics Teaching Option is EDSD 410 - Student Teaching. Each student in this option will submit a written report from the supervising teacher and a written self-assessment.

Departmental Honors in Physics

When appropriate, majors should consider the opportunities afforded by the departmental honors program. This program has the following requirements:

- A minimum 3.5 grade-point average (GPA) in physics; 3.0 GPA overall.
- A minimum of four credits of undergraduate research credit.
- An acceptable, bound senior thesis, and an oral defense of the thesis.
- Participation in a physics seminar for one semester in either the junior or senior year.

Sound Advising

An important part of achieving a high-quality undergraduate education is receiving sound advice regarding choices among course offerings, research opportunities, enrichment activities, and award and scholarship opportunities. Faculty members in the department are selected to serve as advisors for an entering freshman class, and continue as the class advisor for the duration of those students' time in the department. Advisors are a resource for the students in all academic matters. Furthermore, the faculty members in all research groups are strongly committed to enriching the undergraduate experience by providing opportunities for undergraduates to fully participate in cutting-edge research projects working alongside faculty and graduate students. One example of helpful advising is the layout of courses over a four-year period for each option in a concise flowchart showing required and elective physics and mathematics courses, and prerequisites for courses. These snapshots are an aid allowing students to grasp the bigger picture of their university experience. See Appendix 7 for the Professional Option flowchart. Curriculum tabs and course catalog descriptions for the various options in Physics are provided in Appendices 8 and 9, respectively.

B. Graduate Programs: M.S. and Ph.D. in Physics

The Department of Physics offers graduate work leading to the Master of Science and Doctor of Philosophy degrees. The M.S. program offers two options: Plan A (thesis required), and Plan B (without thesis). Graduate program general requirements are described in Appendix 10. The two M.S. options provide our students with multiple career opportunities. Students continuing on to the Ph.D. will generally complete the 30 credits of course work required for the Plan B M.S. degree, and so obtain an M.S. en route to the more advanced degree. The Plan B degree provides graduate level instruction in the core areas of Classical Mechanics, Quantum Mechanics, Electromagnetic Theory and Mathematics, and thus is a wise choice for students wishing to teach at private schools or community colleges, or making a career change. The Plan A M.S. degree, with required thesis, is the choice of many of our students who choose to leave with the M.S. to work in industry, specifically, many of the small high tech companies in the Bozeman area.

The Ph.D. degree in Physics is the terminal degree in the field, requiring additional graduate course work beyond the M.S. degree, a total of 40 credits. The program includes specialized course work in the student's selected field, and a dissertation based on an independent research project carried out under the mentoring of a research advisor. The Ph.D. is a research-based degree that indicates a capability of recognizing a problem, formulating a substantive program of research, and ultimately arriving at and presenting a solution. The student is expected to demonstrate oral and written skills for disseminating the results of the thesis. Passing the oral and written portions of the comprehensive examination demonstrates both breadth and depth of knowledge in the field of physics. The Ph.D. degree is typically required for research and management positions in industry and faculty positions in a university. Typically, Ph.D. students will begin their careers with a postdoctoral research position where they explore new fields or further investigate the subject of their graduate thesis work. Statistics for employment of new Ph.D. recipients in industry, national labs, and universities can be found at the web site of the American Institute of Physics. The time to degree for Ph.D. students after completing the B.S. degree is about 6.5 years at institutions in the Unites States. The average time to degree for students at Montana State University is about 6 years. Additional information on degree requirements for Graduate Programs in Physics is provided in Appendix 10. Course descriptions for graduate courses offered in the department are listed in Appendix 9.

C. Concerns Needing Attention in the Graduate Program:

1. Tuition waivers and the 6-credit rule: At Montana State University, tuition and fees are not routinely waived by the university for all new graduate students. Yet, to be competitive in recruiting the top graduate students available each year the Physics department must offer tuition and fee waivers as part of the total financial aid package. This is an extremely difficult financial burden on department budgets at MSU. In subsequent years, when students become research assistants for a faculty member, to remain competitive and retain these students the individual PIs must find ways to pay

for the tuition and fee waivers from their research grants. While it is possible to include non-resident tuition and fee waivers in research grants, such full waivers are not a part of the department instructional budget for teaching assistants. One approach to solving this problem is to have graduate students take only 6 credits in their first 12 months at MSU. In this way, they are considered only half time students, and so can establish residency in their first year as a graduate student. In subsequent years, the department only needs to provide resident tuition and fee waivers, something that is closer to the actual budget allotment for GTAs. While this approach appears on the surface to be a solution to a budget problem, it does represent a barrier to recruitment since potential graduate students are told that they will only be able to take two classes rather than three classes during their first year at MSU. In effect, this extends their time in course work by one semester, delaying the start of research toward their dissertation. Two years ago, an attempt was made in the Division of Graduate Education to provide all GTAs and GRAs with needed tuition waivers. However, the budget allocation to DGE for such waivers was insufficient and we reverted to the prior status. In the opinion of this department, it would be helpful toward improving graduate recruiting for the state to provide adequate funding to cover tuition waivers for 9 credits of course work during the first two or three years for students in the graduate program. Giving residency status to first-year graduate students upon arrival would be a step in the right direction.

2. Inadequate graduate student stipends: In AY2009-2010, the 9-month stipend for first-year graduate students is $14,450. Once students have passed the comprehensive exam, the stipend is increased to $15,750. In our comparison group of 35 Physics departments who participate in the Midwest Physics Chairs, our stipend was approximately $2,240 below the average stipend and we ranked 29th out of 31, near the bottom of the list for departments who reported data. The problem is even greater because the GTA budget provided to Physics by the College is only about two-thirds of the amount offered to incoming students, and we must make up the difference through vacancy savings or use of F&A charges returned to the department. One portion of our long-term planning is to continue efforts to at least reach the mean stipend of this group of physics departments. Increasing our GTA stipend by $2240 for our budgeted 22 GTAs would require increasing our instructional budget by approximately $50,000 per year. The Dean of our college has recognized this impediment to graduate recruitment in Physics and agreed to increase our total GTA budget by $15,000 over a period of three years. We greatly appreciate this financial support from the college, and will continue looking for other means to further increase the stipend, for example through scholarships or other types of donations.

3. Excessive time to degree and improved advising strategies: For many years in the department we have had an unwritten policy where every graduate student that needed financial support in the form of a stipend was awarded either a GTA or GRA if at all possible. Generally, this has not been a problem because there were sufficient research grants and GTA appointments available. If we came up short on such support, there were sufficient departmental funds available through returned F&A to support a few additional students. The total financial aid package for one graduate student for 9 months with a waiver for resident tuition, insurance and fees is

approximately $22,000. The number of GTAs currently allotted to the department is 22 based on the number of introductory laboratory sections offered and the number of graders needed in our larger introductory courses. Problems with a shortage of student support arise for several different reasons: (1) The stipend from the college is only about two-thirds of what we pay to students to have a competitive program; (2) some research programs have insufficient funds to support a student on a GRA so those students are awarded GTAs when possible; (3) some students just take longer to identify a thesis problem and make headway on solving it; and (4) occasionally a student just "hangs around", not making adequate progress toward completing the degree, but clearly interested in physics. This last category of student is the one who needs our help the most, either in the form of some exit strategy earlier in his/her career, or perhaps by simply recognizing the problem earlier and getting good direction from the research advisor. The Dean of the college has helped us to begin addressing the first problem, and we encourage faculty to continue submitting proposals to help address the second. For the third and fourth situations listed above we implemented two new policies in Spring 2010, as described in our Graduate Manual. (Appendix 10) First, we now require graduate students to have at least one meeting annually with their graduate committee beginning with the spring semester of their fourth year in the program, and continuing on to the dissertation defense. These one-hour progress reports allow the student to get feedback from the committee earlier in their student career, often at the point where the student is struggling to define the thesis problem. Details regarding who must attend the meeting and the reporting that must be made to the Department Head are provided in the Graduate Manual. The graduate students strongly supported this concept, asking for advice earlier in their student career, and even helped to write the policy. The second policy, which will be implemented beginning in Fall 2010, is that no student will be awarded support as a GTA after their eighth year in the program, except for unusual circumstances. As mentioned in the manual, we hope that the first of these two policies will eliminate the need to implement the second. Although 8 years sounds like an unusually long time to degree, one needs to remember that the average time to degree nationally in Physics is about 6.5 years, with a broad distribution, so cutting GTA support off at 8 years should cover those students on the long-time side of this curve. Eliminating even one GTA appointment for a "senior" student who is struggling with the research component of a graduate education will save the department $22,000. While all students are subject to the mandatory annual meetings, it is still left to the individual research advisor to determine the time limits, if any, for GRA support in his/her program.

D. Enrollments, Degree Completion, and Student Credit Hours Taught

1. Key Performance Indicators (KPI) data addressing the BOR criteria: The KPI data for the Physics department are shown in Appendix 11 for FY2000 through FY2009. Definitions for the labels in various rows in that table are also provided. As pointed out earlier, expenditures for instruction are about one-fourth the amount of our research expenditures ($1.7 M, excluding benefits, vs. $6.0 M through OSP). The university collects approximately $1.2 M in F&A associated with the OSP expenditures.

As noted in the KPI footnote, benefits were moved from central management to departments part way though FY09. Some points to notice from these data follow:

- GTAs supported have been about 28 for several years (14 FTE because GTAs are half time appointments); however, support is budgeted typically for only 22, placing additional demands on the other areas of the department budget, e.g. returned F&A, vacancy savings.
- Approximately 83% of the department student credit hours (SCH) are at the lower division, in service and core science classes for non-majors.
- Approximately 60% of the lower division SCHs are taught by tenure-track faculty, the balance being taught by one or both of our two adjunct faculty.
- Expenditures per student FTE (1 FTE = 30 SCH) is approximately $6,000 and the student-teacher ratio is about 24 FTE/Faculty FTE.
- The number of majors (upper and lower division) has increased from about 60 in FY01 to about 75 in FY09, 25% in 8 years. The number of majors in Fall 2009 was 86, exceeding the **BOR Criteria 2d** in the MSU Guidelines for external review.
- The number of B.S. degrees has increased from an average of about 9 in FY01 to an average of 16 for the past three years, an increase of 78%, exceeding the **BOR Criteria 2a** in the MSU Guidelines.
- The number of graduate degrees (M.S. and Ph.D.) has stayed relatively constant for the past 10 years. The distribution between M.S. and Ph.D. degrees fluctuates significantly, but has averaged to about 8 M.S. and 4 Ph.D. degrees per year over the past several years, exceeding the **BOR Criteria 2b and 2c** in the MSU Guidelines for external review.
- The percentage of women in our program in Spring 2010 is approximately 25% at the undergraduate level and 21% at the graduate level.

2. Delaware Study of Instructional Costs and Productivity*:* The University of Delaware's Office of Institutional Research and Planning conducts two national studies of academic productivity and costs. MSU participates in both studies. These studies allow for comparisons at the departmental level with peer departments in similar universities across the country. Since departments of physics are rather uniquely defined, it is possible to make comparisons directly with other physics departments within the reported Delaware data. The FY08 study includes data from 196 schools across the country. Results of the study are provided in Appendix 12, which gives first, a general description of the report format, followed by definitions used in the report. In the appendix we then show the peer comparisons, both relative to the national benchmark and relative to other departments at MSU for the past 6 years. We then show graphs comparing the costs and productivity for departments across the MSU campus. We list here some points to be taken from the data:

- Physics is just below the MSU mean for instructional expenditures per SCH, which itself is at only 73% of the benchmark (mean for all schools). We spend less than the average physics department nationally. The comparison is even

- 98% of our instructional expenditures are on personnel, which leaves almost nothing to cut other than positions when budgets are reduced.

- The instructional expenditures per SCH on operations and capital are only 22%, while the MSU department mean is 53% of the benchmark. We spend very little on operations and capital.

- Research expenditures per FTE in Physics are at 262% of the Delaware benchmark, that is, approximately 2.6 times the average physics department in the study. The MSU mean is 186%, still nearly twice the mean for the study group.

- Physics Department SCH taught per instructional FTE (all instructors) is 101%, equal to the average Physics department in the study.

Overall, the data from the Delaware Study are consistent with the data collected by the Midwest Physics Chairs group. The MSU Physics Department is a very productive research-oriented department, with a relatively large number of undergraduate majors per tenure-track FTE, an above average number of graduate students per tenure-track FTE, and a well below average amount of instructional support from the state of Montana.

E. Assessment of Instructional Programs:

1. Departmental Assessment Plan and Reports:

> "In summer 2004, on the recommendation of the Assessment and Outcomes Committee, MSU adopted its new Student Outcomes Assessment Policy. This policy is designed to foster the integration of formal program assessment into the evolution of departmental curricula and instructional practices. The policy emphasizes faculty participation and the need to document the use of assessment data in the decision-making process. An Assessment Guide for department heads provides more detail on the process."
> (From the MSU Web page for assessment plans and reports:
> http://www.montana.edu/wwwprov/assessment/assessmentplans.htm)

Assessment for course work in the Physics Department began in 2004 and is carried out by the Undergraduate Curriculum Committee with oversight by the Department Head. Assessment plans were submitted (Spring 2004) and subsequently revised (Spring 2007 and Spring 2009). Assessment reports have been submitted annually since Spring 2006. A copy of the current Departmental Assessment Plan 2009 – 2011 is included as Appendix 13. A copy of the most recent Departmental Assessment Report

for Spring 2009 is included as Appendix 14. Both the plan and the report describe the mechanisms for feedback in program assessment. These include student feedback through the Society for Physics Students, the Student-Faculty Lunch at the end of spring semester, and senior exit surveys collected in individual meetings with the Department Head. Feedback mechanisms from outside constituencies include: Student Awards and student performance based on GPAs and graduation statistics. Evaluation of teaching is accomplished through in-class student evaluation of courses at the end of each semester, faculty mentoring of new hires in the department, and faculty comment during promotion and tenure reviews. Additional assessment of student preparation occurs by means of surveys or pre-tests in most classes at the start of a semester. Syllabi for each class are kept in a binder in the front office to assist faculty members who are teaching a course for the first time, or for students and faculty to examine course content during the advising period.

The departmental Undergraduate Committee carried out a substantial review of the undergraduate curriculum in AY2008-2009. Recommendations for improvements through course realignment and the introduction of a new Modern Physics course in the junior year were brought to the faculty for discussion. Those changes that were approved by the faculty will be implemented beginning in Fall 2010, and are described in the Spring 2009 report in Appendix 14. Updated flow charts were prepared for all options, showing the normal sequence of required math and physics courses as well as a listing of available elective courses. These flow charts, an example of which is shown in Appendix 7 of this self-study, are excellent tools for advisors and students. It was determined that the five undergraduate faculty advisors (one for each class) should meet briefly at the beginning of each advising period in each semester to review the latest campus-wide policies, special course offerings, and other aspects of advising that will result in more uniform information being given to majors throughout the Physics curriculum.

A major initiative from the Office of the Commissioner of Higher Education was implemented in 2007 (2009 for the Physics department), to make the transfer process more efficient for students moving from one campus to another within the state of Montana. Referred to as the Transferability Initiative, a system of common course numbers was established by faculty from within each discipline wherein equivalent courses being taught on the various Montana campuses will have the same rubric and course number. The new rubric for Physics is PHSX, and will be implemented in Fall 2010. Courses were assigned new numbers as well to minimize the potential for confusion when comparing a post-initiative course with a pre-initiative course. One valuable outcome from the initiative process is that all courses will eventually have expected student outcomes listed on the web so that advisors and instructors across the state can assess their own courses in terms of the statewide expectations. Writing those outcomes for the new PHSX courses will continue in AY2010-2011.

The web page for MSU assessment plans provided in the appendix is:
http://www.montana.edu/wwwprov/assessment/assessmentplans.htm

The web page for the Transfer Initiative in the OCHE is:
http://mus.edu/transfer/index2.asp

2. Student surveys regarding physics courses and career paths: Keeping track of alumni is an extremely difficult task as any university foundation or alumni office will attest. At MSU, Senior Surveys concerning the academic program are collected on line from graduating seniors, with an approximate return rate of 30%. Department specific information is provided to the department at the recommendation of the Dean of CLS. The data are provided for our use but are not analyzed centrally. Survey results for AY08-09 were provided in June 2009 for the following questions:

- What would you tell a friend about your experiences in physics courses?
- What specific suggestions do you have to improve the teaching of physics courses?
- Which of the following physics courses have you taken at MSU?

Much of this information is anecdotal, and is helpful to the Department, but difficulty to quantify and summarize. It is available for review to the external review committee for this self-study.

Two other questions offered in the Senior Survey were:

- Rate the relevance of your physics courses in terms of your overall education?
  Responses on a scale of 5:Very relevant to 1:Not at all relevant were as follows: (5) 31 (4) 36 (3) 31 (2) 22 (1) 10

- Overall, how would you rate the value of your physics courses?
  Responses on a scale of 5:Very Positive to 1:Very Negative were as follows: (5) 43 (4) 44) (3) 26) (2) 14 (1) 5

Respondents to the questions above had been enrolled primarily in the astronomy (101), college physics (205-206), and engineering physics (211-212) courses. They were generally very positive about their physics courses and felt that the courses were relevant to their overall education.

The Career, Internship & Student Employment Services Office at MSU conducts a survey to determine placement rates and salary survey information from recent MSU graduates. A 65% response rate was obtained for the 2225 graduates in the 2008 Career Destinations Survey. Selected pages from that report are shown in Appendix 15. The web site for the complete report is given below. For the 9 B.S. graduates in the Professional Option, 8 responded to the survey. Of the 8 respondents, 2 were employed full time in the field, 4 indicated continuing education, and 2 indicated continuing education and employment. The mean reported salary was $60,000. Of the 9 M.S. degree recipients, 4 responded to the survey. One respondent was employed full time not in the field, one was unemployed, and 2 indicated continuing education and

employment. No salary information was provided. Of the 5 Ph.D. recipients, 2 responded to the survey. Both respondents were employed full time in the field with an average salary of $50,000.

The department recognizes the difficulty of maintaining contact with department alumni, but is still interested in pursuing this form of assessment. As mentioned in our Spring 2009 Departmental Assessment Report, documenting the awards won by our students is one type of feedback on the merits of our program. In addition, students are polled at the exit interview as to their future plans for work, or further studies in graduate school, but there is little in the way of follow-up information. The Physics department has begun some planning to improve the establishing of post-graduate contacts. Members of our office staff and interested graduate students are working with the Alumni foundation to utilize tools already in place, and to avoid "reinventing the wheel". So far, this has only resulted in establishing a department web page for alumni, but we hope to follow what many other departments across the country are doing to make and maintain contact with Physics alumni. Utilizing social networking websites has been discussed, but no organized effort has been made yet in this arena.

The web page for results of the Senior Survey is located at:
http://www.montana.edu/wwwprov/assessment/surveys/

The web page for results of the Career Destinations survey is located at:
http://www.montana.edu/careers/

3. Student, Staff and Faculty Awards, and Faculty Service As discussed in our Departmental Assessment Plan (Appendix 13) one means of evaluating the success of the department is through acknowledgement of student excellence in the form of awards given by the department, college, university, and national organizations. In addition, the excellence of our faculty is acknowledged through invitations to speak at national and international conferences, and invitations to participate on review panels, advisory boards, and various program organizing committees. For this purpose, we present here an abbreviated list of local and national student award winners. The number of invited presentations given by our faculty can be found in the individual CVs provided in Appendix 6. We provide in Appendix 16 a list of faculty members and the national (off campus) service they provided in CY2009, as self reported in the 2009 Faculty Activity Database. A complete list of student, staff and faculty award winners is maintained in the department office and available for review. The short list presented here is for current faculty and students unless stated otherwise.

National Faculty Awards:

NSF CAREER Awards (Longcope, Qiu, Vorontsov)
PECASE (Longcope, Kankelborg)
APS Fellows (Carlsten, Cone, Idzerda along with 6 Emeritus Faculty)
AVS Fellows (2)

MSU Faculty Awards:

Regents Professor (1)
CLS Distinguished Professor (1)
President's Excellence in Teaching Award (2)
Ross Provost's Award for Excellence in Teaching (2)
Phi Kappa Phi Fridley Distinguished Teaching Award (2)
Cox Family Faculty Award for Creative Scholarship and Teaching (5)
MSU Wiley Outstanding Research Award (10)
MSU Meritorious Science/Technology Award (2)
Provost's Award for Undergraduate Research/Creative Mentoring (2)
CLS Meritorious Research or Creativity Award (4)
MSU Alumni and Chamber of Commerce Awards for Excellence (7)

Student Awards:

Barry M. Goldwarer Scholarships (17 since 1994, including most recent in 2010)
NSF Graduate Student Fellowships awarded to MSU undergraduate students,
5 in past 20 years; last one in 1998
MSU Alumni and Chamber of Commerce Excellence Awards
25 since 1983 including 9 in the past 10 years.

F. Mentoring Programs for Students and Faculty:

The Physics Department faculty and staff work with students and new faculty members to create opportunities for mentoring. We recognize that learning good classroom teaching skills is not a part of the typical Ph.D. program in Physics. Some of these programs and their status of implementation are discussed here.

Mentoring of New Faculty: The Departmental assessment plan includes the utilization of faculty mentors for new faculty members. Under this plan, new faculty are referred to experienced instructors in the department to help the new member in teaching and adjusting to the campus workplace. Typically, the mentors will be selected from the search committee that worked during the hiring process with that new faculty member, or from among one of our teaching experts in the Physics Education group. Up to this point, the degree of interaction between the new hire and the faculty mentor has been left to the individuals involved. New faculty are encouraged to take advantage of teaching-related campus workshops conducted by the Teaching-Learning Committee. The department also helps new faculty members by recommending them for participation in national workshops such as the Workshop for New Faculty in Physics and Astronomy at the American Center for Physics in College Park, Maryland. This workshop is sponsored by the American Association of Physics Teachers, the American Physical Society, and the American Astronomical Society and is funded by the National

Science Foundation's Division of Undergraduate Education. The department provides travel support for the faculty member to attend the workshop.

Mentoring of new undergraduate students through SPS: The group of undergraduate Physics majors in our Society of Physics Students has discussed the idea of pairing up freshman majors with senior majors as an aid for new students. This idea emerged from exit interviews with the seniors and discussion in the Undergraduate Curriculum Committee. Senior students often know more than faculty advisors about various courses offered on campus, shortcuts through the administrative procedures, and other useful timesaving tips. This mentoring approach is still being discussed and has not been fully implemented as of spring 2009.

Mentors and Protégés (MAP): A group of first- and second-year graduate students have investigated national mentoring programs organized to help graduate students adjust to life and academics in graduate school. They looked at programs such as MentorNet, and the New Mexico State University ADVANCE mentoring program. These students started the Mentors and Protégés (MAP) program locally, based on the NMSU model. It is designed to pair first-year graduate students with senior level graduate students who can offer guidance, advice, and commiseration over all the issues that face students when they arrive at MSU, and as they progress through their first years of graduate school. Mentoring interactions may address questions about choosing an advisor, how to start studying for the comprehensive exams, or just listening while novices talk about difficult homework assignments. http://www.physics.montana.edu/grad/map/map.htm

Women in Physics group luncheons: A group of women graduate students, with assistance from staff in the department office, have organized monthly luncheons to discuss topics related to gender equity in the workplace. The group generally has an organized program and occasionally invites speakers for the lunch period. Most recently, the group provided a candidate evaluation tool for the search committee working on our selection of a new faculty member in the area of gravitational physics. Discussion in this group format led eventually to the formation of the Mentors and Protégés (MAP) program described above. The department has helped to defray expenses with the luncheon whenever possible.

4. Physics Department Strategic Goals for 2010 to 2017

Looking back over the relatively good economic times of the past decade, we recognize that even in the good times it can be challenging to continue to grow one of the strongest departments on the MSU campus in an environment of balancing departmental needs with the very limited instructional support for higher education. Looking forward then at what could be a multi-year period of budget cuts before the state economy begins to rebound, the Department of Physics will take the approach of emphasizing growth in those areas of our program that require relatively little additional support for capital equipment, personnel, or space acquisition. We have set goals which are mostly revenue neutral or revenue producing (e.g. through increased enrollments), and in this way will strategically grow certain research programs in the department, while maintaining other existing programs. As we emerge from these challenging economic times we expect to be poised to take advantage of new resources as they become available for strategically increasing faculty FTE, graduate student enrollment, support personnel and infrastructure. To this end, with the insight provided by the preceding pages of this self-study of our research programs, academic curriculum, and assessment plan, the Physics Department will:

1. **Increase undergraduate enrollments at all levels, both majors and non-majors, through increased efforts in recruitment and retention**, while simultaneously improving the quality of the program with an updated curriculum, expanded research opportunities, and better advising. By averaging at 5 undergraduate majors per tenure-track FTE, our faculty members already rank highly with respect to our peer institutions in this respect. Among the Midwest Physics Chairs group, we rank 3rd out of 32 by this metric. Among our peers in the Delaware Study we rank at 126% of the mean, and 7th of 33 departments on the MSU campus. To continue growing our undergraduate enrollment while offering a strong research environment for capstone projects we will need to increase our faculty FTE, and the associated research space needed for undergraduate projects. Our Fall 2009 undergraduate enrollment was 86 students. It is an achievable and reasonable goal to have 100 majors by 2017 with the addition of two tenure-track faculty (total of 20 FTE) and with the necessary associated research space. The increase in FTE is justified on the basis of a need for research mentors associated with our emphasis on undergraduate research efforts and the campus mandate of a capstone research experience. From the perspective of this specific goal, the research specialty of these two faculty can be open.

2. **Increase the quality of and enrollment in our graduate program**. As our faculty continue to spend greater fractions of their time with teaching, advising, proposal development, outreach, and service at the campus and national levels, the job of getting the research done falls more and more on the graduate students and postdoctoral associates. At the same time our faculty are increasing the breadth and intensity of their research interests. Such growth in the research programs necessitates a growth in our graduate enrollments. We anticipate some

increase in the number of GTAs awarded to the department as our enrollment in lower division courses in creases. In Fall 2009, our graduate student enrollment was 61. With increased research expenditures through additional successful grant proposals, and only modest increases in state support for Graduate Teaching Assistants, we will grow our graduate enrollment to approximately 72 students, or 4 students per tenure-track faculty (currently at 18 FTE). With 20 faculty members in the department we could support approximately 80 graduate students. With 4 graduate students per tenure-track faculty, we would rank approximately 4th of 32 in the Midwest Department Chairs group; currently we rank 9th of 32 at 3.4 graduate students per tenure-track FTE. To achieve this graduate enrollment with well-qualified students spread uniformly among the various research faculty, it will be important to target particular disciplines in our recruiting and admissions process. Specifically, we need to attract more students in optical physics and condensed matter physics. The graduate recruiting committee will need to investigate various recruiting strategies to attract more students to apply for our program. This may include department-sponsored travel to give free colloquia at universities throughout the Northwest region, and continued participation in the campus-wide graduate recruiting weekends.

3. **Strengthen our teaching program, particularly in the lower division courses, and the Physics Education Research program**. Through retirement and horizontal moves on campus, we lost two tenure-track positions in the area of Physics Education (Adams, Kirkpatrick). These individuals carried a large fraction of our lower division student credit hours, and represented a significant component of our program in PER. In the past year, Prof. Adams had one M.S. and one Ph.D. student complete and successfully defend dissertations. However, the department is currently struggling to meet the needs of our graduate students interested in PER. These needs come not only from students wishing to do research in PER, but also from students in other research areas who want to improve their teaching abilities and be more aware of successful teaching strategies. The teaching duties associated with those lost positions are currently being handled by two, nearly full-time adjuncts. However, the lost research component of the two faculty lines in PER has not been restored. Dr. Shannon Willoughby has managed to continue PER investigations related to clicker technology while teaching 3 large lower division classes each semester (~1800 SCHs per semester). Dr. Riedel has taught 7-8 credits of upper division and graduate courses in AY2009-2010. Several of our tenure-track faculty have also taught the large enrollment astronomy and engineering physics courses. The faculty in the department have already had some discussion about possible scenarios for continuing the PER program, for example with the hire of an experienced tenure-track faculty member in PER, or the implementation of long-term contracts for our two adjuncts, and the addition of GTAs who could conduct research in teaching as part of their teaching assignments. That discussion will continue, informed by the outcome of the pending external review, as we determine student and faculty interest in the PER program.

4. **Capitalize on developing opportunities in solar physics**. Montana State University will submit a proposal to AURA for consolidating and locating the new headquarters of the National Solar Observatory (NSO) at MSU-Bozeman. The timing is excellent to propose MSU as a headquarters location that provides an optimal management focus in the context of strong science programs in solar and optical research, for the Advanced Technology Solar Telescope, currently under construction in Hawaii. The department will work with MSU administration to put together our strongest possible proposal to be submitted in December, 2010. We expect the proposal to include the promise of faculty and technical support in Physics and the optical sciences, working through the colleges of Engineering and Letters & Science. Other opportunities will be sought out in the area of gravitational wave astronomy with the addition of a new faculty member in Fall 2010. That search is nearing completion in Spring 2010.

5. **Grow our faculty in a way that better allows us to achieve our mission** to the State of Montana, specifically through strategic hires that improve our balance between theory and experiment, between research and teaching, while simultaneously watching for opportunities to hire in new areas of physics that will both attract graduate students and research support from federal agencies. Such growth could include hires of either research or tenure-track faculty, or both. The previous planning goals have mentioned the addition of a faculty member in gravitational physics, with that search currently under way, and the possible addition of faculty members in PER and solar physics. In addition, anticipated growth in undergraduate and graduate enrollments, as well as maintaining a competitive program capable of attracting today's graduate students in emerging research areas such as energy production and advanced materials properties, will certainly require us to consider the addition of new research and tenure-track faculty during the next 7-10 years.

6. **Improve working conditions and resources for our support staff**. Upper administration continues to increase the workload of our administrative staff while failing to offer incentives through salary increases, or assistance through new positions. This is to be expected in tight economic times, but departments must look for ways to recruit and retain top-quality support staff in the midst of these frustrating situations. Furthermore, upper administration may occasionally not recognize when attempts to cut costs in one office place additional work loads on subordinate offices, resulting in no net savings when considering the larger, university-wide picture. Additional classified or student labor positions at the department level would lead to restored, or hopefully improved services for students, improving student retention, and thus paying for themselves with additional tuition dollars. Additional support staff needs in Physics include:

    (1) In the past year, during a change of personnel in the Fiscal Manager position, a part-time classified accounting tech position was eliminated and replaced with part-time student labor. Recovering this part-time

(2) Our lecture demonstration and introductory lab management has been handled for several decades by a single person with occasional student labor assistance. However, with growing enrollments and the move to a new building (EPS) in 1997, we currently have lectures and instructional labs taking place in two different buildings (EPS and AJM). As enrollments in our lower division courses increase even more, there will be a need to add one full-time person for this service capacity. It is likely that revenue from increased enrollments would be sufficient to pay for the additional staff position. Under the current staffing situation, there is no time available for repair of lab and demonstration equipment, or development of new labs and demonstrations. For example, the benefits of incorporating the latest technology into our introductory labs, while growing student enrollments, is creating a need to add a second computerized lab room, with associated equipment needs and lab development time.

(3) We are aware of discussions on campus that might lead to a reduction in the amount of technical services provided for campus users through the Technical Services shop in EPS. Already, the physics department machinist is seeing additional requests to provide assistance for student projects in some engineering departments, and he does not have time to meet those needs while also satisfying the shop needs of our own department. At this point we are concerned about the impact on our mechanical shop services if the Technical Services resource in EPS is eliminated or reduced in scope. It is critical for our student and faculty research programs to maintain the existing shop services in the Physics Department.

7. **Better utilize existing lab space and look for additional space** to meet the needs of new faculty hires while also growing existing research programs. Increased student enrollments looking for the associated research experiences will put pressure on existing groups to increase their lab space that is used by students. The current situation is that some of our optics groups have inadequate space to set up new equipment without shutting down other productive funded research projects. The ICAL facility is limited by space restrictions in its ability to expand the services offered to the campus community and to off-campus users. The reality that all departments in EPS are looking for additional research space means that Physics may have to look for additional space outside EPS, e.g. in the AJM Johnson building where space may become available as a result of programs in that building moving to other locations on campus.

8. **Strengthen and grow those centers and programs that enhance our research and instruction mission**, specifically, the Space Science and Engineering laboratory (SSEL), the Montana Space Grant Consortium (MSGC), Spectrum Laboratory, and the Interface and Chemical Analysis laboratory (ICAL). These programs offer our students incredible opportunities for research in areas ranging from space science, to applied optics, to advanced properties of nanostructures, to biophysics. However, many of these programs are facing critical shortages of space and support for program directors, or changes in program leadership. The Department will work with these program directors to resolve these issues. Specifically, the SSEL program has had several remarkable achievements in the past year, earning space for the Explorer 1P student satellite project on an upcoming NASA launch, coordinating the two MISSE-6a student projects to study materials degradation in the environment of the International Space Station, and development of the SpaceBuoy satellite project. SSEL provides invaluable training for students interested in space instrumentation, coming from a variety of department on campus including all areas of STEM. The department will work with Dave Klumpar, director of SSEL, to find ways to keep this program going in the coming years. Similarly, Spectrum Lab offers physics and engineering students a variety of research and development experiences, and the department will work with the Spectrum Lab Director, currently Randy Babbitt, to keep this connection with Physics strong. Students and research scientists from a variety of departments on campus use the ICAL analytical facility. Research is performed in ICAL to meet the needs of many research grants, and also to obtain data for proposal development. The Physics Department will work with Dr. Recep Avci, director of ICAL, and the Office of the VPR to find adequate financial support and expansion space to meet the needs of ICAL. MSGC is under the very capable directorship of Dr. Angela DesJardins, and offers multiple research experiences for Physics students through MSGC/NASA sponsored programs such as Borealis. The department is ready to work with Dr. DesJardins however necessary to maintain this student resource.

9. **Develop new degree options in the Optical Sciences** that will educate and train students interested in joining the growing number of companies doing research and development in optical instrumentation and materials in the Gallatin Valley. Such developments will likely include a new option for our majors at the undergraduate level, and an M.S. degree at the graduate level, and will take advantage of related research interests among faculty in the physics and engineering departments on campus. This goal has already been discussed by the faculty and is likely to be put in place within two years, or less.

10. **Pursue development opportunities through donors** by coordinating our fundraising efforts with those of the MSU Foundation and the College of Letters and Science. The department will continue its efforts to identify potential donors who might be interested in supporting an endowed chair in physics. Other opportunities might include named Professorships, supplements to academic

year salary for fixed terms such as with the Regent's Professorship or CLS Distinguished Professor awards, support for visiting scientists, student support for scholarships, travel grants to attend national conferences, or lab equipment. The department will expand its effort at web page development to better inform and connect with alumni of the department.

Appendix 1: Organization Chart - Physics department: AY2009-2010

ORGANIZATION CHART -- PHYSICS DEPARTMENT –2009-2010

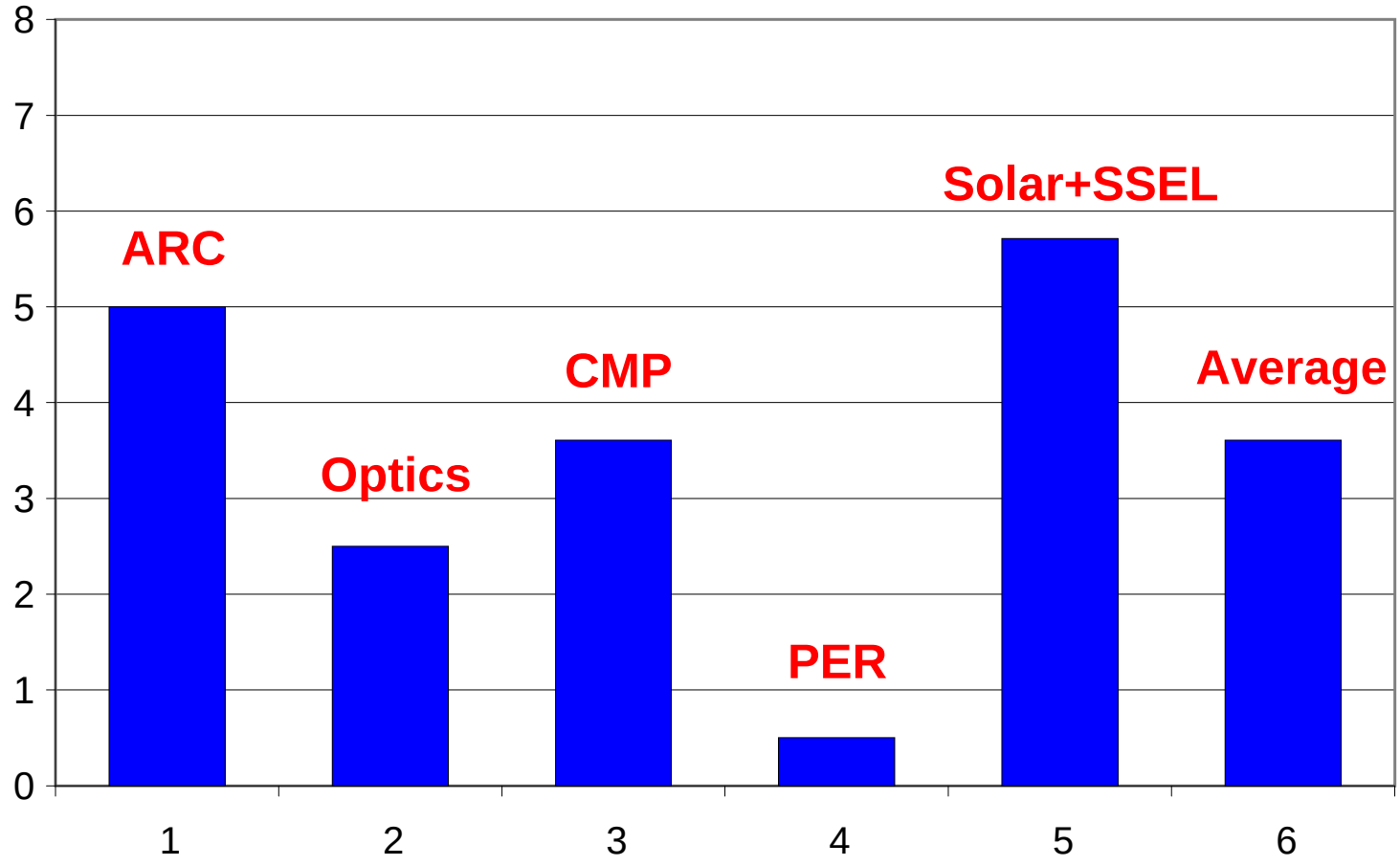
DEPARTMENT HEAD – Richard J. Smith
DEPARTMENT MANAGER – Sarah Barutha

Departmental Office Assistants	Instructional Labs and Shop Supervisors	Physics Teaching	Astrophysics, Relativity, and Cosmology	Solar Physics & SSEL	Condensed Matter	Optical Physics	
Program Asst. M Jarrett Fiscal Manager S Heis Acct. Tech. B Kay Information Tech Support J Gay Student Labor K Clark	Instruc.Lab Supervisor J DiMarco Student Labor M Ruiz Electronics Engineer W Glaspey Student Labor C Harne Instrument Maker/ Designer N Williams	Tenureable 1 J Adams 2 G Francis Emeritus 3 L Kirkpatrick Adj/Asst. Prof. 4 C Riedel 5 S Willoughby Grads 2 K Williamson	Tenureable 1 N Cornish 2 S Tsuruta 3 B Link Res. Prof. 4 R Hellings MSGC Director 5 A Des Jardins MSGC Dep Dir 5 R Larimer Program Coord. 5 G Winslow Grads 1 M Adams 1 P Baker 1 V Corbin 1 J Key 1 L Sampson 1 P Schladensky 2 D Bambeck 2 N Beisenkhanova** 2 M Freed** 2 T Gelbord 2 A Liebmann 2 M Unver 3 S Price 4 R Collins 4 J Plowman	Tenureable. 1 D Longcope 2 C Kankelborg 3 J Qiu Res. Prof. 4 L Acton 5 D Canfield 6 D Klumpar 7 P Martens Res. Assoc. Prof. 8 D .McKenzie Res. Sci. 6 L Springer 8 A Takeda 8 K Yoshimura Postdocs 3 J Cheng 8 J Shin Res. Assoc. 6 E Mosleh 6 K Mashburn Grads 1 S Brannon 1 S Guidoni 1 A.Malanushenko 1 L Tarr 2 H Courrier 2 L Fox 2 J Plovanic 2 T Rust 3 W Liu 3 C Lowder** 3 G Lowe 3 J Rice** 5 M Kazachenko 7 A Munoz 7 J Scott 8 A Kobelski 8 S Savage	Tenureable 1 R Smith 2 Y Idzerda 3 J Neumeier 4 G Malovichko 5 A Vorontsov Research.Prof. 6 R Avci Emeritus 7 J.Drumheller 8 J Hermanson 9 G Lapeyre 10 H Schmidt Res. Sci. 4 V Grachov 6 J Suo Postdocs 2 P Rugheimer 2 A Lussier 2 E Negusse Res. Assoc. 6 N Equall 6 L Loetterle 6 L Kellerman Grads 1 N Childs 1 C Key 1 M. Kopczyk 1 M Lerch 2 B Anderson 2 H Bhatkar 2 A Christian** 2 J.Holroyd 2 H Li 2 A McClure 2 V Pool 3 R Bollinger 3 M Shchemelinin** 3 B White 4 J Jorgensen 6 M.Deliorman 10 L Lediaev 10 C-L Tsai	Tenureable 1 J. Carlsten 2 R Cone 3 R.Babbitt 4 A.Rebane Res. Prof. 5 A Craig Res. Asst. Prof. 6 M Drobijev Res. Sci. 2/3 C Thiel Res Assoc 6 E Beuerman Grads 1 E Amouzou** 1 E Casey** 1 W Johnson 1 B Todt 1 G Wicks** 3 E Curtis 4 B Davis** 4 N Makarov 5 R Scott	

3/27/10

** First year grads

Grad Students per FTE by Research Group



Appendix 2: Montana State University Five Year Vision FY09 to FY14

Montana State University-Bozeman's Five-year Vision
Voluntary System of Accountability (College Portrait)
Quick Facts
Key Performance Indicators
Delaware Studies
Common Data Set
Student Data
National Survey of Student Engagement
Retention Studies (MSU access only)
Faculty and Staff Data
Budget and Finance Data
Committees/Shared Governance
Miscellaneous Data
About the Office of Planning & Analysis

Contact Us

Office of Planning and Analysis
Montana State University
PO Box 172435
Bozeman, MT 59717-2435

Tel: (406) 994-2341
Fax: (406) 994-1893

Email:
facts@montana.edu

CAMPUS PROFILE

Enrollment
(Fall 2009)

12,764 total
10,840 undergrads
1,924 grad students

Student Body Profile
(Fall 2009)

46% female
54% male
63% Montana residents
33% out-of-state residents
394 (3%) international students (from more than 71 countries)

Faculty -- Instructional
(Fall 2009)

569 full-time
239 part-time
16:1 student-faculty ratio

Estimated yearly costs for freshmen
(2009-10)

Montana resident
Tuition and fees, $5,988

Non-resident
Tuition and fees, $17,650

Financial Aid
(2009-10)

Approximately 64% of undergraduates received aid, with an average total award of over $4,760 from all aid sources.

Interesting Facts

In 2008-09 MSU awarded 2,374 degrees.

MSU faculty are nationally competitive with their ideas and garnered $98 million for their research and creative projects in fiscal year 2009.

Return to regular view
Text-only

Updated: 2/17/2010

Didn't Find it? Please use our **contact list** or our **site index**.

Montana State University Five Year Vision, FY 09 to FY 14

Montana State University Vision Statement:

Montana State University will be the university of choice for those seeking a student-centered learning environment distinguished by innovation and discovery in a Rocky Mountain setting.

Montana State University Mission Statement:

The mission of Montana State University is:

- To provide a challenging and richly diverse learning environment in which the entire university community is fully engaged in supporting student success.
- To provide an environment that promotes the exploration, discovery, and dissemination of new knowledge.
- To provide a collegial environment for faculty and students in which discovery and learning are closely integrated and highly valued.
- To serve the people and communities of Montana by sharing our expertise and collaborating with others to improve the lives and prosperity of Montanans.

In accomplishing our mission, we remain committed to the wise stewardship of resources through meaningful assessment and public accountability.

Montana State University Five Year Outlook

If we are successful, what will MSU be like in five years?

Montana State University is a geographically dispersed institution that provides programs in every county and reservation in Montana. The faculty, staff, and students in the MSU community have developed, and the Strategic Planning Committee maintains, a description of what the institution will be like in five years.

The description is divided into six different but often overlapping areas: 1) Student Body, 2) Faculty and Staff, 3) Curriculum, 4) Research and Creativity, 5) Partnerships and Outreach, and 6) Physical, Technical, Financial and Service Infrastructure. In places, the description includes specific numerical goals. In other places changes to or extensions of current policies and practices are indicated. The description is not all encompassing, but it does represent a fairly general, comprehensive view of what a successful Bozeman campus will look like five years from now.

I. Student Body

A. Montana State University will increase enrollment to approximately 13,000 students.

B. As MSU achieves national prominence, and as the number of Montana high school students declines, we will attract a greater number and proportion of non-resident students.

C. The student body will be more diverse than it is today. For example, the number of Native American students enrolled will increase.

D. The number of international students will increase.

E. Incoming freshmen will be better prepared than they are today. The number of freshmen with 3.60 and higher high school GPAs will increase. The percentage of Montana University System Honors Scholarship recipients who choose MSU will increase.

F. The Fall-to-Fall retention rate of our incoming freshmen students will increase, which will ultimately lead to an increase in graduation rates.

G. Student engagement at MSU will continue to increase, leading to increased student retention and stronger alumni affinity upon graduation.

H. MSU will continue to offer need- and merit-based financial awards. Grants, scholarships, and waivers will increase.

II. Faculty and Staff

A. MSU will have a strong sense of campus community and improve its competitive status as an employer, evidenced by lower classified and professional staff turnover rates and by larger applicant pools for those positions. To improve its competitive status as an employer, MSU will implement family-friendly policies within its control and promote family-friendly policies in the MUS and state.

B. MSU will offer competitive faculty and staff compensation packages that narrow the gaps between current MSU salaries and the appropriate markets. Because we compete nationally for faculty and administrators and statewide for many staff positions, the appropriate markets will vary across positions.

C. There will be an increase in the number of named professorships and in the number of endowed chairs.

D. Faculty and staff will have increased access to professional development programs and international exchanges. For faculty this will include sabbaticals, BEST awards, and short professional leaves. The University also will have implemented a staff training and development program for the purposes of improving the quality of support services, providing career growth opportunities, and improving employee recruitment and retention.

E. As the University experiences growth in its enrollment, research FTE, facilities, and volume of advanced technology applications, there will be a corresponding level of growth in tenure track faculty and professional/staff positions that provide all essential support services.

F. The faculty will have a global perspective on their disciplines and will be active participants in the international development of their fields. The University will increasingly attract a strong and diverse faculty drawn from the best educators, scholars, and researchers throughout the world.

G. MSU is committed to increasing the number and proportion of members of underrepresented groups among our vice presidents, deans, directors, department heads, and other administrators.

H. We will continue to enhance our efforts to recruit a diverse pool of applicants to MSU staff and faculty positions, resulting in an increase in the diversity of our applicant pools and an increase in women and minorities among our employees.

I. MSU will continue its commitment to shared governance.

III. Curriculum

A. MSU will be nationally recognized as a leader in the integration of learning and discovery at the undergraduate level.

B. MSU will have graduate programs that are internationally recognized for excellence.

C. The number of doctoral degrees awarded will increase.

D. MSU will be recognized for its commitment to the teacher-scholar model in which students are taught by distinguished faculty.

E. There will be increased opportunities for interdisciplinary courses and programs and encouragement of team teaching across all disciplinary boundaries.

F. Over the next five years MSU will grow, student composition will shift, learning goals will change, and new research opportunities will become available. To lead the process and shape the future, MSU anticipates the realignment of several departments and centers and the creation of new interdisciplinary majors and centers.

G. Students will have increasing opportunities to participate in international experiences and participation in education abroad programs will increase. Additional opportunities will be offered for students to learn critical languages and take internationally focused courses.

H. MSU will increase the number of graduates citing an internship or cooperative education experience. The yield on “internship-to-employment” conversions (internship opportunities leading to full-time employment with the same organization) will increase.

I. Undergraduate research or creative experiences, now required, will continue to improve in depth and quality. This will include greater participation in one-on-one or small group research projects with faculty, interdisciplinary undergraduate research seminars, increasing numbers of funded research positions for undergraduates, and more students involved in undergraduate research that exceeds the basic academic requirements.

J. There will be a vibrant (and financially sustainable) series of evening, weekend, distance, and Summer Session course offerings for MSU's regular student body and for others including place-bound students.

K. MSU will systematically invest in informational and instructional technologies that support and enhance the rapidly evolving formal and informal teaching and distance learning needs of our diverse faculty and student body.

L. MSU will continue to advance the goals of Indian Education for All across the university.

M. MSU will be actively engaged in supporting the efficient and effective delivery of two-year programming to meet the developmental needs of four-year students and the workforce needs in the local community.

IV. Research and Creativity

A. We will grow our annual Office of Sponsored Programs expenditures at a level that equals or exceeds the annual growth in federal Research and Development funding. We will increase the number of competitively awarded, large, multi-PI, interdisciplinary grants. We will expand our portfolio of funded research projects involving faculty in a larger number of disciplines.

B. We will continue to grow a powerful research/creativity enterprise that spans the range of basic, applied, developmental and commercialized research. MSU will increase its technology transfer enterprise and through these efforts enhance the Montana economy.

C. There will be a demonstrable increase in the involvement of graduate and undergraduate students in grants and contracts activity.

D. MSU will enhance its IT infrastructure to better support research and scholarship.

E. MSU will have deployed a second data center to meet the computing and data storage needs of faculty in support of their academic activities and to provide redundancy and improve availability and security.

V. Partnerships, Outreach, and Alumni

A. The four campus MSU family will be more integrated in its array of program offerings, outreach, and business services.

B. We will continue to build strategic partnerships with the K-12 system and with campuses and other organizations outside MSU, which will include service learning and collaborative learning experiences for students.

C. We will increase the number of strategic partnerships with local and state businesses. Such partnerships will include sponsored research agreements, subcontracts to companies, Small Business Innovation Research awards and Small Business Technology Transfer awards, companies assisted by MSU, testing agreements, and intellectual property agreements, as well as educational partnerships like internships and service learning opportunities.

D. MSU faculty and staff will directly contribute to outreach by disseminating the knowledge base and new discoveries available on campus and at our research centers to citizens, communities, and organizations throughout Montana, documenting the positive impacts of this work.

E. The MSU County Extension offices will serve as a portal to and from the entire University.

F. MSU will enhance partnerships with agricultural and natural resources organizations to ensure collaborative, quality, and dynamic programs in support of these important sectors of the state economy.

G. MSU will increase its service and development assistance to state, local, and non-profit agencies through increased University-based partnerships that will help these agencies to foster principles of good governance, promote government efficiency, reduce the potential for conflict and litigation, and increase a sense of civic literacy and citizenship.

H. The alumni population will be actively engaged in a meaningful and lasting relationship with Montana State University.

I. MSU will have raised the endowment and begun a major campaign that focuses on funds for scholarships, endowed chairs, and other academic goals.

J. MSU will develop expanded international partnerships in key countries and regions in order to provide study abroad and exchange opportunities for students and faculty, to increase international diversity on the MSU campus, and to promote international research collaboration.

VI. Physical, Technological, Financial and Service Infrastructure

A. MSU will maintain integrated processes for capital and land use planning that support and complement the University's Mission and Five Year Vision.

B. MSU will have developed and implemented comprehensive sustainability protocols to continually enhance campus character, function, and environmental stewardship.

C. MSU will continue to manage the condition of our facilities within accepted national benchmarks.

D. MSU will have implemented a business-continuity plan for its primary administrative information systems, enabling critical business processes to occur in the event of a major disaster.

E. MSU will have enabled gigabit data communications in most of the primary academic and research buildings on the main campus and will have extended the capability to the desktops, classrooms, and laboratories as needed.

F. MSU will improve the efficiency and effectiveness of institutional and IT systems through improved business processes, incorporating client service principles, quality assurance principles and increased use of appropriate technological resources.

G. MSU will ensure the confidentiality, integrity, and availability of information resources through the efficient use of technology, secure data stewardship, policy enforcement, and training for the MSU community to raise their security awareness, skills, and capabilities.

Appendix 3: OSP FY09 Research Expenditures

MONTANA STATE UNIVERSITY

RESEARCH AND OTHER SPONSORED PROGRAMS

FISCAL YEAR 2009 EXPENDITURES BY COLLEGES AND DEPARTMENTS

College of Agriculture	
Dean's Office	$187,694
Agricultural Economics and Economics	$1,122,659
Agricultural Education	$2,348
Animal and Range Sciences	$1,943,922
Plant Sciences and Plant Pathology	$2,551,822
Land Resources and Environmental Sciences	$4,718,335
Research Stations	$452,192
Veterinary Molecular Biology	$7,849,682
TOTAL	**$18,828,654**

College of Arts and Architecture	
Dean's Office	$137,208
Architecture	$130,080
School of Film & Photography	$127,621
Shakespeare in the Parks	$42,345
KUSM	$1,424,749
TOTAL	**$1,862,003**

College of Business	
Dean's Office	$74,599
TOTAL	**$74,599**

College of Education, Health and Human Development	
Dean's Office	$1,990,532
Education	$1,236,714
Health and Human Development	$3,332,956
TOTAL	**$6,560,202**

College of Engineering	
Dean's Office	$108,176
Chemical Engineering	$1,790,568
Civil Engineering	$714,709
Computer Science	$427,908
Electrical and Computer Engineering	$2,728,449
Industrial and Mechanical Engineering	$1,276,465
Center for Biofilm Engineering	$2,811,792
MT. Manufacturing Extension Ctr.	$1,947,930
Western Transportation Institute	$8,066,950
TOTAL	**$19,872,947**

College of Letters and Science	
Cell Biology and Neuroscience	$2,658,700
Chemistry and Biochemistry	$9,951,032
Earth Science	$738,774
Ecology	$2,634,292
English	$10,271
History and Philosophy	$303,183
Mathematical Sciences	$248,209
Microbiology	$1,403,397
Modern Languages	$43,027
Native American Studies	$25,984
Physics	$6,011,089
Political Science	$206,710
Psychology	$69,277
Sociology	$148,460
TOTAL	**$24,452,405**

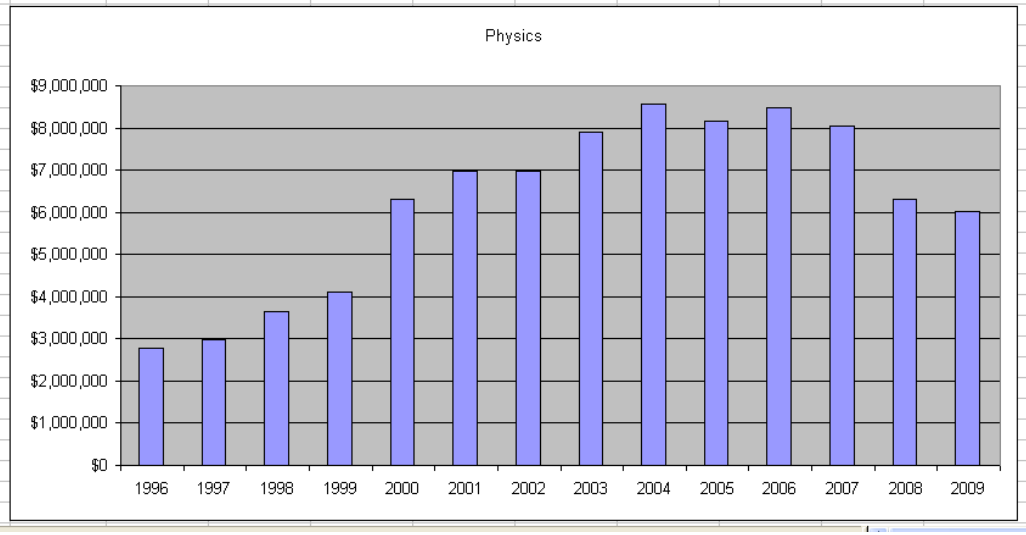
College of Nursing	
Nursing	$1,543,186
Area Health Education Center (AHEC)	$714,235
TOTAL	**$2,257,421**

University Programs	
Animal Resource Center	$11,559
Athletics & ASMSU	$126,409
Big Sky Institute	$1,313,329
Center for Community Involvement	$45,604
Division of Graduate Studies	$15,241
Division of Health Sciences:	
American Indian Research Opportunities (AIRO)	$424,671
Office of Rural Health	$567,523
WWAMI	$1,589,634
EPSCoR Programs	$4,032,728
Extended University	$311,467
Extension Service	$1,309,271
Fire Training School	$50,794
INBRE	$3,196,296
International Programs	$514,500
Library	$10,500
Montana Water Resources Center	$594,252
MSU TechLink	$3,584,711
Museum of the Rockies	$1,713,627
Special Projects	$4,552,004
Student Affairs (ABC)	$395,144
Student Health	$89,574
Undergrad Scholars	$74,622
TOTAL	**$24,523,460**

GRAND TOTAL $98,431,691

Appendix 4: OSP Yearly Expenditures 98-07 CLS

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1							Research Expenditures through OSP								
2															
3		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
4															
5	CLS Dean's Office	$27,540	$63,474	$309,660	$381,184	$291,563	$90,223	$738,361	$2,124,945	$2,756,234	$8,554	----------			$3,196,296
6	Biology	$2,269,950	$2,977,057	$3,593,746	$3,871,983	$3,390,393	$0	$0	----------	----------	----------	----------			
7	Cell Biology and Neuroscience			----------	----------	----------	$1,788,356	$1,047,900	$2,579,886	$3,097,890	$7,228,510	$7,045,160	$4,567,886	$2,971,493	$2,658,700
8	Center for Computational Biology			----------	----------	----------	----------	$1,315,618	----------	----------	----------	----------			
9	Chemistry and Biochemistry	$3,591,178	$2,579,452	$3,088,704	$3,058,147	$3,997,528	$4,247,609	$5,164,051	$4,625,357	$4,712,517	$5,420,175	$4,507,667	$7,766,617	$10,692,959	$9,951,032
10	Earth Sciences	$674,782	$632,913	$677,990	$519,723	$380,600	$466,096	$859,039	$579,446	$402,360	$796,239	$1,260,199	$1,196,770	$961,830	$738,774
11	Ecology	$0	$0	$0	$0	$0	$2,301,606	$2,439,796	$2,514,960	$2,096,683	$2,117,801	$2,124,872	$2,283,409	$2,613,111	$2,634,292
12	English	$0	$0	$0	$0	$0	$12,690	$3,200	$428	----------	$12,217	$7,693	$25,407	$4,373	$10,271
13	History and Philosophy	$57,979	$4,836	$13,876	$28,263	$12,488	$459	$91,904	$65,825	$171,071	$269,530	$305,630	$317,293	$346,018	$303,183
14	Mathematical Sciences	$1,319,852	$986,829	$942,342	$615,318	$216,986	$327,310	$342,968	$402,126	$633,895	$604,937	$406,454	$257,277	$132,218	$248,209
15	Microbiology	$1,685,803	$2,324,503	$3,098,818	$2,836,015	$3,121,000	$3,228,594	$3,264,436	$3,257,475	$3,116,994	$2,473,158	$2,865,299	$2,166,435	$2,088,288	$1,403,397
16	Modern Languages														$43,027
17	Native American Studies	$154,615	$183,889	$138,305	$163,057	$159,039	$62,993	$7,043	$10,212	----------	----------	----------		$8,619	$25,984
18	Physics	$2,778,032	$2,980,190	$3,636,568	$4,121,182	$6,309,318	$6,973,405	$6,971,034	$7,894,451	$8,563,442	$8,172,489	$8,468,739	$8,047,159	$6,309,097	$6,011,089
19	Political Science			----------	----------	----------	----------	----------	----------	----------	----------	$274,047	$351,240	$214,196	$206,710
20	Psychology	$39,065	$21,942	$33,438	-$1,011	$15,002	$5,035	$22,146	$97,949	$78,976	$51,410	$20,278	$47,914	$71,902	$69,277
21	Sociology	$44,198	$37,721	$8,023	$48,543	$11,840	$23,029	$36,468	$15,185	$45,060	$37,772	$110,925	$108,113	$89,003	$148,460
22															
23	**Letters and Science TOTAL**	**$12,642,994**	**$12,792,806**	**$15,541,470**	**$15,642,404**	**$17,905,757**	**$19,527,405**	**$22,303,964**	**$24,168,245**	**$25,675,122**	**$27,192,792**	**$27,396,963**	**$27,135,520**	**$26,503,107**	**$27,648,701**
24															
25	**MSU GRAND TOTAL**	**$38,681,240**	**$41,604,061**	**$51,995,455**	**$49,732,406**	**$61,031,150**	**$61,023,155**	**$66,030,291**	**$82,353,323**	**$87,964,958**	**$98,475,262**	**$103,048,866**	**$102,116,323**	**$96,150,553**	**$98,431,691**



Appendix 5: Publications and grants by faculty member for CY 2009

Appendix 5: Publications and grants by faculty member for CY 2009
(As reported by faculty in Faculty Activity Data Base for CY2009)

1. Active Grants in CY2009: Title, Agency, Amount, Duration

Babbitt, W. R.

Exploiting Non-Traditional Signals Using a Photonics Based Signal Processor, ONR, $1,101,000, 3 years

Broadband Analog to Digital Conversion and Spectral Analysis using Spatial-Spectral Holography, Navy SPAWAR/TST, $1,165,001, 3 years (with R.L. Cone)

Quantum Information Science Research and Technical, ARO, $763,694, 3.5 years

Methamphetamine Detection and Health Effects, UM/ CDC, $68, 777, 2 years

Next Generation LADAR for Long Range, High Precision NASA Applications, NASA/ MSGC, $27,677, 2 years

Compact, Low-Cost Remote Sensing of Meth Labs, NSF STTR with Bridger Photonics, $150,168, 2 years

Carlsten, J. L.

ZERT ERI Phase V, DOE, $102,131, 21 months (with K. Repasky)

Bee Lidar, DOD, $75,127, 18 months (with K. Repasky)

Fiber CO2 sensor, DOE, $160,310, 3 years (with K. Repasky)

Raman Lasers, NSF, $390,600, 1 year (with K. Repasky)

Cone, R.L.

Maximum coherence in optical transitions in rare earth ion-activated solids, NSF, $110,250, 1 year (with Aleksander Rebane, Krishna Rupavatharam, Charles W. Thiel)

Broadband Analog to Digital Conversion and Spectral Analysis using Spatial-Spectral Holography (See Babbitt, W.R.)

Photonics-enabled Radio-Frequency Arbitrary Waveform Generation, S2 Corporation, $11,185, 1 year (with C. Thiel)

High-Resolution Wide-Bandwidth Optical Arbitrary Waveform Generation Over Extended Time Apertures, S2 Corporation, $32,063, 1 year (with C. Thiel)

High-Resolution Wide-Bandwidth Optical Arbitrary Waveform Generation Over Extended Time Apertures, S2 Corporation, $224,994 (with C. Thiel)

Cornish, N. J.

LISA Data Analysis Development, NASA, $338,646, 3 years

Gravitational Wave Astronomy with SPOT, NASA, $45,000, 3 years (with J. Key, T. Littenberg)

Searches for Transient Gravitational Waves, NSF, $98,358, 3 years

Idzerda, Y.U.

NIRT: Exploiting Protein Cage Dynamics and Engineering Active Nanostructures, NSF, $1,000,000, 4 years (with T. Douglas, B. Bothner, M. Young)

Regenerative SOFC Development for Aerospace Technology Platforms, NASA, $1,500,000 with match, 3 years (with Des Jardins, Sofie, Smith, Shaw, Gannon)

Characterization of Multi-ferroic Interface Structures, ARO, $506,398, 3 years

Synchrotron Investigations of LSCF Cathode Degradation, DOE, $450,000, 3 years

DURIP: Interfacial Engineering of Multiferroic Multilayers, ARO, $146,480, 1 year

Kankelborg, C.C.

Multi-Order Solar Extreme UV Spectrograph (MOSES), NASA, $1,056,501, 3 years

Interface Region Imaging Spectrograph (IRIS)-MSU Bridge Phase, Lockheed Martin, $55,785, 1 month (with Klumpar and Springer)

IRIS-MSU Phase B, $791,517, 7 months (with Springer)

Rocket Scientists, NASA EPO, $10,304, supplement to MOSES

Longcope, D.W.

Quantitative Measurements of Magnetic Reconnection, NASA, $323,039, 4 years (with McKenzie)

Solar Flare Forecasting Using Topological Energy Models, NASA, $386,185, 4 years (with Barnes)

SHINE: Driving Solar MHD simulations, NSF, $217,496, 5 years

Malovychko, G.

Multifrequency spectroscopy of rare-earth and transition ions in optical materials, NSF, $342,000, 3 years (with Grachov)

McKenzie, D.

TRACE MO&DA Extension, NASA/LMSAL, $79,940, 6 months

REU Solar Physics Program at MSU, NSF, $682,000, 5 years (with Martens, Canfield)

AIA for Solar Dynamics Observatory, Lockheed-Martin, $1,208,321, 10 years

Hinode/XRT Mission Operations and Data Analysis, Harvard-Smithsonian Astrophysical Observatory, $1,527,684, 7 years

Resident Archive Services and Maintenance of the Yohkoh Legacy data Archive, NASA, $105,367, 2 years (with Takeda and Acton)

Neumeier, J.J.

Growth and Physical Properties Measurements of Novel Condensed Matter Materials, NSF, $345,000, 3 years (2009 – 2012)

Growth and Physical Properties Measurements of Novel Condensed Matter Materials, NSF, $354,202, 4 years (2005 – 2009)

Linear thermal expansion measurements with sub-atomic resolution for the study of phase transitions in novel condensed matter systems, DOE, $374,671, 4 years
REU Site: Condensed Matter and LASER Physics REU Program at Montana State University, NSF, $352,000, 4 years

Qiu, J.

Observational study of dynamics of active region corona, NASA, $364,281, 3 years (with Wang)

CAREER: an Observational Study of Magnetic Reconnection, NSF, $479,519, 5 years

Rebane, A.

Advanced two photon chromohores for optical power limiting, AFOSR, $750,000, 5 years (with Drobizhev)

Maximum coherence in optical transitions in rare earth ion-activated solids, NSF, $110,000, 1 year (with Cone and Babbitt)

Building better probes for 2 photon microscopy, NIH, $960,000, 4 years (with Drobizhev and Hughes)

Smith, R.J.

Using Metallic Interlayers to Stabilize Metal-Metal Interfaces, NSF, $360,000, 4 years

SECA Coal Based Systems Core Research, DOE, $1,498,292, 7 years (HiTEC)

Regenerative SOFC Development for Aerospace Technology Platforms (see Idzerda)

Study of Silicon Transport in Low Purity/Low cost Insulation Materials for Solid Oxide Fuel Cells, Siemens Power Generation, $300,000, 3 years (with Sofie, Gannon)

Tsuruta, S.

Warm Absorbers in the Optically Highly Polarized AGN IRAS 12397-3333, NASA/XMM-Newton Guest Observer Program, $47,127, 3.5 years

Willoughby, S.D.

Studying best practices for grading incentive of in-class clicker questions, MSU Teaching and Learning Innovation Grant, $2000, 1 year

2. Publications appearing in print or accepted for publication in 2009

Babbitt, W. R.

M.Tian, I. Zafarullah, T. Chang, K. R. Mohan, and W. R. Babbitt. *Demonstration of geometric operations on the Bloch vectors in an ensemble of rare-earth metal atoms*. Physical Review A, no. 79, p.022312

R. Reibel, C. Harrington, J. Dahl, C. Ostrander, P. Roos, T. Berg, R. Mohan, M. Neifeld, and W. R. Babbitt. *Demonstrations of analog-to-digital conversion using a frequency domain stretched processor*. Optics Express , July 9, no. 17, p.11281-11286

P. A. Roos, R. R. Reibel, T. Berg, B. Kaylor, Z. Barber, W. R. Babbitt. *Ultra-broadband optical chirp linearization for precision metrology applications*. Optics letters, no. 34, p.3692

Zeb W. Barber, Wm. Randall Babbitt, Brant Kaylor, Randy R. Reibel, and Peter A. Roos, *Accuracy of active chirp linearization for broadband frequency modulated continuous wave ladar*. Applied Optics, January 9, no. 49, p.213-219

Z. W. Barber, C. Harrington, C. W. Thiel, W. R. Babbitt, and R. Krishna Mohan. *Angle of Arrival Estimation Using Spectral Interferometry*. Journal of Luminescence, accepted

C. W. Thiel, R. M. Macfarlane, T. Bottger, Y. Sun, R. L. Cone, W. R. Babbitt. *Optical decoherence and persistent spectral holeburning in Er3+:LiNbO3*. Journal of Luminescence, accepted

C. W. Thiel, Y. Sun, T. Bottger, W. R. Babbitt, R. L. Cone. *Optical decoherence and persistent spectral holeburning in Tm3+:LiNbO3*. Journal of Luminescence, accepted

Canfield, R. C.

Des Jardins, A., Canfield, R., Longcope, D., and McLinden, E.. *Signatures of Magnetic Stress Prior to Three Solar Flares Observed by RHESSI*. Astrophysical Journal, March 2009, no. 693, p.866-893

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Charlie J. Keith, Kevin S. Repasky, Rick L. Lawrence, Steven C. Jay and John L. Carlsten. *Monitoring effects of a controlled subsurface carbon dioxide release on vegetation using a hyperspectral imager*. IJGGC, December 2009, no. 3, p.626

Jamie L. Barr , Seth D. Humphries, Amin R. Nehrir, Kevin S. Repasky, Laura M. Dobeck, John L. Carlsten, and Lee H. Spangler. *Laser Based Carbon Dioxide Monitoring Instrument Testing During a Thirty Day Controlled Underground Carbon Release Field Experiment*. International Journal of Greenhouse Gas Control, accepted

Cone, R.L.

W. Tittel, M. Afzelius, T. Chanelière, R. L. Cone, S. Kröll, S. A. Moiseev, and M. Sellars. *Photon-Echo Quantum Memory in Solid State Systems*. Laser & Photonics Reviews, March 2009, no. DOI: 10.1002/lpor.200810056, p.24 pages

Thomas Böttger, C. W. Thiel, R. L. Cone, and Y. Sun. *Effects of magnetic field orientation on optical decoherence in Er3+:Y2SiO5*. Phys. Rev. B., no. 79, p.115104-1 to 115104-8

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K G Arun, Stas Babak, Emanuele Berti, Neil Cornish, Curt Cutler, Jonathan Gair, Scott A Hughes, Bala R Iyer, Ryan N Lang , Ilya Mandel , Edward K Porter , Bangalore S Sathyaprakash , Siddhartha Sinha , Alicia M Sintes , Miquel Trias , Chris Van Den Broeck. *Massive Black Hole Binary Inspirals: Results from the LISA Parameter Estimation Taskforce.*. Classical and Quantum Gravity, May 2009, no. 26, p.094027

Vincent Corbin, Neil J. Cornish. *Semi-classical limit and minimum decoherence in the Conditional Probability Interpretation of Quantum Mechanics.*. Foundations of Physics, March 2009, no. 39, p.474-485

Tyson B. Littenberg and Neil J. Cornish . *A Bayesian Approach to the Detection Problem in Gravitational Wave Astronomy.*. Phys. Rev. D, September 2009, no. 80, p.063007

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Z. Suo, A. Yang, R. Avci, M. Deliorman, P. Rugheimer, D. W. Pascual and Y. U. Idzerda. *Antibody Selection for Immobilizing Live Bacteria*. Anal. Chem., October 2009, no. 81, p.7571

H. Li, Y. U. Idzerda, M. T. Klem, K. B. Sebby, T. Douglas, D. J. Singel and M. Young. *Determination of Anisotropy Energy Constants of Protein Encapsulated Iron Oxide Nanoparticles be Electron Magnetic Resonance*. J. Magn. Magn. Mater., August 2009, no. 321, p.175

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Longcope, D. W.; Guidoni, S. E.; Linton, M. G.. *Gas-Dynamic Shock Heating of Post-Flare Loops due to Retraction Following Localized, Impulsive Reconnection*. The Astrophysical Journal Letter, January 2009, no. 690, p.L18-L22

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Plowman, Joseph E.; Kankelborg, Charles C.; Longcope, Dana W.. *Coronal Loop Expansion Properties Explained Using Separators*. Astrophysical Journal, November , no. 706, p.108-112

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M. S. da Luz, J. J. Neumeier, R. K. Bollinger, A. S. Sefat, M. A. McGuire, R. Jin, B. C. Sales, D. Mandrus. *High resolution measurements of the thermal expansion of Co-doped BaFe2As2*. Physical Review B/American Physical Society, June 2009, no. 79, p.214505

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A.B.Vorontsov, A.G.Vavilov, A.V.Chubukov. *Interplay between magnetism and superconductivity in Fe-pnictides*. Phys. Rev. B, no. 79, p.060508(R)

A.B.Vorontsov, A.G.Vavilov, A.V.Chubukov. *Superfluid density and penetration depth in Fe-pnictides.*. PRB, no. 79, p.140507(R)

A.B. Vorontsov. *Broken translational and time-reversal symmetry in unconventional superconducting films*. Phys Rev Lett, , no. 102, p.177001

G.R.Boyd, P.J.Hirschfeld, I.Vekhter, A.B.Vorontsov. *Inversion of specific heat oscillations with in-plane magnetic field angle in 2D d-wave superconductors*. Phys Rev B, no. 79, p.064525

V. Mishra, A.B. Vorontsov, P.J. Hirschfeld, I. Vekhter. *Theory of thermal conductivity in extended-s state superconductors: application to ferropnictides*. PRB, no. 80, p.224525

C. Martin, R.T. Gordon, M. A. Tanatar, H. Kim, N. Ni, S. L. Bud'ko, P. C. Canfield, H. Luo, H. H. Wen, Z. Wang, A. B. Vorontsov, V. G. Kogan, R. Prozorov. *Nonexponential London penetration depth of external magnetic field in superconducting \\ Ba$_{1-x}$K$_{x}$Fe$_{2}$As$_{2}$ single crystals.*. PRB , no. 80, p.020501(R)

A.V.Chubukov, M.G.Vavilov, A.B.Vorontsov. *Momentum dependence and nodes of the superconducting gap in iron-pnictides*. PRB, no. 80, p.140515(R)

A.B.Vorontsov, A.V.Chubukov, M.G.Vavilov, A.Abanov. *Reduced effect of impurities on the universal pairing scale in the cuprates*. arXiv:0909.4580, accepted

Willoughby, S. D.

S. D. Willoughby and A. Metz. *Exploring gender differences with different gain calculations in astronomy and biology* . American Journal of Physics, no. 77, p.651-657

Appendix 6: Curriculum Vitae for all faculty

LOREN W. ACTON
Montana State University
Research Professor of Physics

EDUCATION

Ph.D., Astro-Geophysics, l965, University of Colorado. Thesis: "X-Radiation of the Sun".
B.S. (with honors), Engineering Physics, l959, Montana State University.
Attended Multnomah School of the Bible, Portland, OR, 1954-55.

EXPERIENCE

1993-present Research Professor of Physics, Department of Physics
Montana State University, Bozeman, Montana, USA 59717
1964-1993 Lockheed Palo Alto Research Laboratory, Palo Alto, CA.
Senior Consulting Scientist, Physical & Electronic Sciences Laboratory.
Carried out research in solar and cosmic astronomy utilizing space instrumentation.

PROFESSIONAL SOCIETIES

American Association for the Advancement of Science (AAAS)
American Astronomical Society (AAS)
International Academy of Astronautics (IAA)
Association of Space Explorers (ASE)

AWARDS & HONORS

1986 Spaceflight Achievement award of American Astronautical Society.
1988 Robert E. Gross award for technical excellence, Lockheed Corp.
1988 Honorary Doctor of Science from Montana State University.
1989 Fellow of Am. Assoc. for the Advancement of Science.
1993 NASA Exceptional Scientific Achievement Medal.
1996 Wiley Award for meritorious research, Montana State Univ.
2000 Honorary Doctor of Science from the University of Colorado.
2000 Hale Prize for long-term contribution to solar physics from AAS.

SPECIAL ACTIVITIES

l964-Present. Principal Investigator on NASA solar research programs including 8 rocket experiments, the Mapping X-Ray Heliometer on Orbiting Solar Observatory-8, X-Ray Polychromator for the Solar Maximum Mission, and the Soft X-Ray Telescope for the Japan/US/UK YOHKOH Mission.
1985 Payload Specialist on scientific space shuttle (Challenger 8) mission called SPACELAB 2. Launch 29 July, 8 day mission.
1988-1991 - NASA Space Science and Applications Advisory Committee

PUBLICATIONS and LECTURES

Over 200 publications in the popular and scientific literature.
More than 350 lectures to a variety of student, general public, and scientific audiences.

March 2010

Brief Biographical Sketch

Jeffrey P. Adams, Ph.D.

Office of the Provost
Montana State University, Bozeman, MT 59717
406-994-7835; adams@physics.montana.edu

Education:

Queen's University Kingston, Ontario, Canada	Engineering Physics	B.Sc. (ENG) 1988
Queen's University	Mathematics and Physics Secondary Education	B.Ed. 1992
Queen's University	Nuclear Physics	Ph.D. 1991
Queen's University	Postdoc	1992 – 1996

Appointments:

Montana State University—Bozeman, MT
Assistant Vice Provost for Undergraduate Education (August 2001—December 2003, half-time; January 2004—present, full time)
Associate Professor of Physics (August 1996—December 2003; promotion to associate in fall 2002)
Queen's University—Kingston, Ontario, Canada
Adjunct Assistant Professor (September 1992—August 1996)

Five Relevant Publications:

Edward E. Prather, Timothy F. Slater, Jeffrey P. Adams, Janelle M. Bailey, Lauren V. Jones, Jack A. Dostal, "Research on a Lecture-Tutorial Approach to Teaching Introductory Astronomy for Non–Science Majors," The Astronomy Education Review, vol. 3(2), on-line at http://aer.noao.edu/ (2004).

Learner-Centered Astronomy Teaching: Strategies for Astro 101 by Timothy F. Slater and Jeffrey P. Adams, Prentice Hall, ISBN 0130466301, 167 pages (2003).

Jeff Adams and Tim Slater, "Learning Through Sharing," *Journal of College Science Teaching*, vol. 31(6), pp. 384-387 (2002).

Jeffrey P. Adams and Timothy F. Slater, "Implementing a Web-Based Adaptive Senior Exit Survey for Undergraduates," *Academic Exchange Quarterly*, vol. 5(1), pp. 51-57 (2001).

Jeff Adams and Tim Slater, "Astronomy in the National Standards," *Journal of Geoscience Education*, vol. 48(1), pp. 39-45 (2000).

Other Publications:

Lecture-Tutorials for Introductory Astronomy (first edition) by Jeffrey P. Adams, Edward E. Prather, Timothy F. Slater and the Conceptual Astronomy and Physics Education Research (CAPER) Team, Prentice Hall, ISBN 0131479970, 92 pages (2005). Now in 6th printing.

Learner-Centered Astronomy Teaching: Strategies for Astro 101 by Timothy F. Slater and Jeffrey P. Adams, Prentice Hall, ISBN 0130466301, 167 pages (2003).

Tim Slater and Jeff Adams, "Mathematical Reasoning Over Arithmetic in Introductory Astronomy," The Physics Teacher, vol. 40(5). pp. 268-272 (2002).

Tim Slater, Jeffrey P. Adams, Gina Brissenden, and Doug Duncan, "What Topics Are Taught in Introductory Astronomy Courses?" *The Physics Teacher*, vol. 39(1), pp. 52-55 (2001).

Jeff Adams and Tim Slater, "Stellar Bar Codes," *The Physics Teacher*, 38(1), pp. 35-36 (2000).

Synergistic Activities:

- Member of Conceptual Astronomy and Physics Education Research (CAPER) team, which conducts research and curriculum development focused on college students
- Chair of University Assessment and Outcomes Committee
- Assessment Director for MSU's biology curriculum reform project ($1.9 M) funded by the Howard Hughes Medical Institute (HHMI)
- Assessment Coordinator for two successive core curriculum reform grants ($150,000 each) funded by the William and Flora Hewlett Foundation for General Education In Research Universities
- Assessment Specialist for "SUCCESS: Senior Undergraduate Capstone Course in Environmental Sciences," Funded by Cooperative State Research, Education, and Extension Service/USDA, $90,000, August 2000-August 2003, PI: Catherine A. Zabinski, Co-PIs: Jon W. Wraith.

Collaborators & Other Affiliations:

Brissenden, Gina	National Institute for Science Education
Brown, Tom	University of Minnesota—Mankato
Deming, Grace	University of Maryland
Duncan, Doug	University of Colorado
Hufnagel, Beth	Anne Arundel Community College
Jacobs, Gwen	Montana State University
Lindell (Adrian), Rebecca	Southern Illinois University Edwardsville
Miller, John	Montana State University
Pittendrigh, Adele	Montana State University
Prather, Ed	University of Arizona
Slater, Tim	University of Arizona
Wraith, Jon	Montana State University
Zabinski, Catherine	Montana State University
Zeilik, Michael	University of New Mexico

Graduate and Postdoctoral Advisor:

Boris Castel	Queen's University (retired)

Biographical Sketch of Prof. Recep Avci

Montana State University
Department of Physics
EPS 264, Bozeman, MT 59717, USA
Phone: 406-994-6164,
Fax: 406-994-6040
Email: avci@physics.montana.edu

Professional Preparation

Istanbul University, Istanbul Turkey.	Physics	B.S.	1973
Georgetown University, Washington DC	English Language		1974
Univ. of Illinois, Urbana, Illinois, USA	Solid State Physics	M.S.	1976
Univ. of Illinois, Urbana, Illinois, USA	Solid State Physics	Ph.D.	1978

Appointments

Montana State University	Research Professor of Physics	1990 - present
Montana State University	Director of ICAL*	1992- Present
K. Fahd Univ., Dhahran, S. Arabia	Assistant/Associate Prof. of Physics	1980 - 1990
Montana State University	Postdoctoral Associate	1978-1980

Research and professional experience

Area of specialization: Study of fundamental and applied aspects of bulk and bio-materials and of surfaces and interfaces with a wide variety of spectroscopic and microscopic techniques. Current interests include immobilization and manipulation of individual live micro-organisms in their physiological environment in order to observe their response to external stimuli and to observe byproducts of their activities in and around the local environment including their contribution to biocorrosion. Other related interests include receptor-ligand interactions associated with outer membrane proteins, adhesins and exopolymeric substances associated with a bacterium and understanding at the molecular level the interactions (such as charge transfer) of these adhesins with the environment. Founder and director of ICAL (www.physics.montana.edu/ical/ical.html), 1992-present.

Grant Activities*:* Exceeding 3 million dollars in the last 7 years excluding instrumentation grants.

Selected publications on immunoimmobilization, biophysics and biochemistry:

1. Z.Y. Suo, X.H. Yang, R. Avci, M. Deliorman, P. Rugheimer, D.W. Pascual and Y. Idzerda, *Antibody Selection for Immobilizing Living Bacteria*, **Analytical Chemistry,** 2009, **81**(18), 7571-7578.
2. Suo, Z.Y., R. Avci, M. Deliorman, X.H. Yang and D.W. Pascual, *Bacteria Survive Multiple Puncturings of Their Cell Walls*, **Langmuir**, 2009, **25**(8), 4588-4594.
3. Suo, Z.Y., R. Avci, X.H. Yang and D.W. Pascual, *Efficient immobilization and patterning of live bacterial cells*, **Langmuir**, 2008, **24**(8), 4161-4167.
4. Arce, F.T., R. Carlson, J. Monds, R. Veeh, F.Z. Hu, P.S. Stewart, R. Lal, G.D. Ehrlich and R. Avci, *Nanoscale Structural and Mechanical Properties of Nontypeable* Haemophilus influenzae *Biofilms*, **Journal of Bacteriology**, 2009, **191**(8), 2512-2520.
5. Yang, X.H., B.J. Hinnebusch, T. Trunkle, C.M. Bosio, Z.Y. Suo, M. Tighe, A. Harmsen, T. Becker, K. Crist, N. Walters, R. Avci, D.W. Pascual, *Oral vaccination with Salmonella simultaneously expressing Yersinia pestis F1 and V antigens protects against bubonic and pneumonic plague*, **J. Immunol.** 2007, **178**(2):1059-67.
6. Schweitzer, M.H., W.X. Zheng, C.L. Organ, R. Avci, Z.Y. Suo, L.M. Freimark, V.S. Lebleu, M.B. Duncan, M.G.V. Heiden, J.M. Neveu, W.S. Lane, J.S. Cottrell, J.R. Horner, L.C. Cantley, R. Kalluri, and J.M. Asara, *Biomolecular Characterization and Protein Sequences of the Campanian Hadrosaur* B. canadensi,. **Science**, 2009, **324**(5927), 626-631.
7. de Brouwer, J.F.C., K.E. Cooksey, B. Wigglesworth-Cooksey, M.J. Staal, L.J. Stal, and R. Avci, *Time of Flight-Secondary Ion Mass Spectrometry on isolated extracellular fractions and intact biofilms of three species of benthic diatoms.* **Journal of Microbiological Methods**, 2006. **65**(3): p. 562-572.

* Imaging and Chemical Analysis Laboratory at MSU (www.physics.montana.edu/ical/ical.html)

8. Suo, Z.Y., X.H. Yang, R. Avci, L. Kellerman, D.W. Pascual, M. Fries, and A. Steele, *HEPES-stabilized encapsulation of Salmonella typhimurium.* **Langmuir**, 2007. **23**(3): p. 1365-1374.
9. Avci, R., M.H. Schweitzer, R.D. Boyd, J.L. Wittmeyer, F.T. Arce, and J.O. Calvo, *Preservation of bone collagen from the late cretaceous period studied by immunological techniques and atomic force microscopy.* **Langmuir**, 2005. **21**(8): p. 3584-3590.
10. Schweitzer, M.H., Z. Suo, R. Avci, J.M. Asara, M.A. Allen, F.T. Arce, and J.R. Horner, *Analyses of soft tissue from Tyrannosaurus rex suggest the presence of protein.* **Science**, 2007. **316**(5822): p. 277-280.
11. Suo, Z.Y., F.T. Arce, R. Avci, K. Thieltges, and B. Spangler, *Dendritic structures of poly(ethylene glycol) on silicon nitride and gold surfaces.* **Langmuir**, 2006. **22**(8): p. 3844-3850.
12. Suo, Z., R. Avci, M.H. Schweitzer, and M. Deliorman, *Porphyrin as an ideal biomarker in the search for extraterrestrial life.* **Astrobiology**, 2007. **7**(4): p. 605-615.

Selected publications on corrosion, biocorrosion, biofouling and surface characterization:

13. Shi, X.M., Z.X. Yang, T.A. Nguyen, Z.Y. Suo, R. Avci, and S.Z. Song, *An electrochemical and microstructural characterization of steel-mortar admixed with corrosion inhibitors.* **Science in China Series E-Technological Sciences**, 2009, **52**(1): 52-66.
14. Shi, X.M., T.A. Nguyen, **Z.Y. Suo**, Y.J. Liu, R. Avci, *Effect of nanoparticles on the anticorrosion and mechanical properties of epoxy coating*, **Surface Coat. Tech.**, 2009, **204**(3), 237-245
15. Arce, F.T., R. Avci, I.B. Beech, K.E. Cooksey, and B. Wigglesworth-Cooksey, *A live bioprobe for studying diatom-surface interactions.* **Biophysical Journal**, 2004. **87**(6): p. 4284-4297.
16. Arce, F.T., R. Avci, I.B. Beech, K.E. Cooksey, and B. Wigglesworth-Cooksey, *Modification of surface properties of a poly(dimethylsiloxane)-based elastomer, RTV11, upon exposure to seawater.* **Langmuir**, 2006. **22**(17): 7217-7225.
17. Arce, F.T., R. Avci, I.B. Beech, K.E. Cooksey, and B. Wigglesworth-Cooksey, *Microelastic properties of minimally adhesive surfaces: A comparative study of RTV11 (TM) and Intersleek elastomers (TM).* **Journal of Chemical Physics**, 2003. **119**(3): 1671-1682.
18. Beech, I.B., V. Zinkevich, L. Hanjangsit, R. Gubner, and R. Avci, *The effect of Pseudomonas NCIMB 2021 biofilm on AISI 316 stainless steel.* **Biofouling**, 2000. **15**(1-3): 3-12.
19. Beech, I.B., R. Gubner, V. Zinkevich, L. Hanjangsit, and R. Avci, *Characterisation of conditioning layers formed by exopolymeric substances of Pseudomonas NCIMB 2021 on surfaces of AISI 316 stainless steel.* **Biofouling**, 2000. **16**(2-4): 93-104.
20. Shi, X.M., R. Avci, and Z. Lewandowski, *Electrochemistry of passive metals modified by manganese oxides deposited by Leptothrix discophora: two-step model verified by ToF-SIMS.* **Corrosion Science**, 2002. **44**(5): 1027-1045.
21. Shi, X., R. Avci, and Z. Lewandowski, *Microbially deposited manganese and iron oxides on passive metals - Their chemistry and consequences for material performance.* **Corrosion**, 2002. **58**(9): p. 728-738.
22. Geiser, M., R. Avci, and Z. Lewandowski, *Microbially initiated pitting on 316L stainless steel.* **International Biodeterioration & Biodegradation**, 2002, **49**(4): 235-243.
23. Groenewold, G.S., G.L. Gresham, R. Avci, and M. Deliorman, *Characterization of bidentate phosphoryl compounds on soil particulates using SIMS.* **Surface and Interface Analysis**, 2009. **41**(3): p. 244-250.
24. Groenewold, G.S., M.M. Cortez, A.K. Gianotto, G.L. Gresham, J.E. Olson, R.V. Fox, B.M. White, W.F. Bauer, R. Avci, M. Deliorman, and E. Williams, *Surface analysis of particulates from laboratory hood exhaust manifold.* **Surface and Interface Analysis**, 2007, **39**(6): 547-553.
25. Yalcin, S. and R. Avci, *Characterization of PdAu thin films on oxidized silicon wafers: interdiffusion and reaction.* **Applied Surface Science**, 2003, **214**(1-4): 319-337.
26. Shi, X., R. Avci, M. Geiser, and Z. Lewandowski, *Comparative study in chemistry of microbially and electrochemically induced pitting of 316L stainless steel.* **Corrosion Science**, 2003. **45**(11): 2577-2595.
27. Olesen, B.H., R. Avci, and Z. Lewandowski, *Manganese dioxide as a potential cathodic reactant in corrosion of stainless steels.* **Corrosion Science,** 2000, **42**(2): 211-227.
28. Geesey, G. G., R J Gillis, R. Avci, D. Daly, M. Hamilton, P. Shope, G. Harkin, *The influence of surface features on bacterial colonization and subsequent substratum chemical changes on 316L stainless steel*, **Corrosion Science,** 1996, **38**, 73-95.
29. Pendyala J., R. Avci, G.G. Geesey, P. Stoodley, M. Hamilton and G. Harkin, *Chemical effects of biofilm colonization on 304 stainless steel*, **J. Vac. Sci. &Tech. A**, 1996, **14**(3): 1755-1760
30. Lee, W., Z. Lewandowski, S. Okabe, W.G. Characklis, and R. Avci, *Corrosion of mild steel underneath aerobic biofilms containing sulfate reducing bacteria*, Part I&II, **Biofouling** 1993, **7**, 197-216 & 217-239.

Wm RANDALL BABBITT
Professor of Physics
Director of the Spectrum Lab
Montana State University, Box 173840
Bozeman, MT 59717-3840

Phone: (406) 994-6156
Fax: (406) 994-4452
Email: babbitt@physics.montana.edu

EDUCATION

Harvard University, Ph. D. Physics, 1987
Stanford University, B. S. Physics, 1982

EXPERIENCE

2002-present Director
The Spectrum Lab, Montana State University
Major Research Projects: Laser development and stabilization, laser remote sensing, and spectral-spatial holographic microwave signal processing systems.

1997-present Professor
Department of Physics, Montana State University
Major Research Projects: Optical coherent transients, spectral-spatial holographic phenomena and devices, quantum computing, smart-pixels with smart illumination.

1993-1997 Research Associate Professor, 1997
Research Assistant Professor, 1993-1997
Department of Electrical Engineering, The University of Washington
Major Research Projects: Optical coherent transient systems, free-space optical interconnects, monolithically integrated emitter and detector sensor arrays.

1987-1993 Research Scientist
High Technology Center, The Boeing Company
Major Research Projects: Optical coherent transient systems, coordinate measurement systems based on intensity modulated optical radar, multiple optically stabilized semiconductor lasers, linear position sensors based on chirped intensity modulated laser radar, diffractive optical array generators for free space optical systems.

1982-1987 Research Assistant with Prof. Thomas W. Mossberg,
Department of Physics, Harvard University
Major Research Projects: Optical coherent transient pulse shape storage, processing, and computing in gases and cryogenic solids, relaxation processes in cryogenic solids, phase conjugation and one-way phase distortion compensation of images. Thesis topic: The response of inhomogeneously broadened absorbers to complex excitation pulses: Applications to optical data storage and optical signal processing.

1979-1982 Research Assistant with Prof. John M. J. Madey,
Department of Physics, Stanford University
Major Research Projects: Free electron lasers. Honors Thesis Title: The effect of parasitic cavities on the electron bunches circulating in a storage ring.

CONSULTING

- W. R. Babbitt Consulting, LLC, 2006-present, Optical signal processing systems
- LightSmyth Technologies, Inc., 2000, Founder, Slab waveguide optical processors
- Templex Technology, Inc., 1996-1998, Spectral-spatial holographic routers and memories
- The Boeing Company, 1993-1997, Coordinate measurement system based on intensity modulated optical radar

AWARDS AND HONORS (SINCE ARRIVING AT MSU IN 1997)

- 2008 recipient of the MSU Meritorious Technology/Science Award
- MSU Recognition of Research, Creativity, and Contributions to Economic Development – Partnership with S2 Corporation, Oct 18, 2006.
- George Abraham Outstanding Paper Award, GOMACTech 2004, for "Demonstration of the Spatial-Spectral Coherent Holographic Integrating Processor (S2-CHIP) for RF Signal Processing Applications", by K. D. Merkel, Z. Cole, R. K. Mohan and W. R. Babbitt, presented at the GomacTech2003 conference in Tampa, Florida, on April 3, 2003
- Charles and Nora L. Wiley Faculty Award for Meritorious Research and Creativity, 2002

TEACHING EXPERIENCE

Courses taught at the Montana State University

Physics 213, General and Modern Physics III: S05, S06

Physics 222, Honors General and Modern Physics: S00, S01, S02, and S03

Physics 353, Holography-Laser Photography: S98, S99, S00, S01, S03, S04, S05, S06, S08, S09, S10, Mentored instructors R. R. Reibel (S02) and P. A. Roos (S07)

Physics 361, Laboratory Electronics: S08, S09, S10

Physics 500, Optical Coherent Transient Seminar:
S98, F98, S99, F99, S00, S01, F01, S02, F02, F03, S04, F04, S05

Physics 400, Optical Coherent Transient Seminar: F01, F02, F03, S04, F04, S05

Physics 500, Optical Signal Processing Seminar: S00, S01, and S02

STUDENT RESEARCH SUPERVISION

Current Graduate Students

Eric Curtis (PhD).

PhD Students Supervised

Randy Reibel (PhD granted in August 2002), Carrie S. Cornish (Research done at MSU, UW PhD granted in August 2000), Kristian D. Merkel (UW PhD granted in June 1998), Ijaz Zafarullah (PhD, 2008)

MS Students Supervised

Scott Wagemann (MS 2009), Robert Peters, (M.S. degree in August 2001), Xiaofang Chen, (M.S. degree in May 2000), Jinjun Xia, (M.S. degree in May 2001), Zachary Cole, (M.S. degree in January 2000), Molly J. Byrne, (UW EE Masters degree in April 1995), Kristian D. Merkel, (UW EE Masters degree in June 1994)

Postdoctoral Associates Supervised

Mingzhen Tian, Kris Merkel, and Kevin Repasky.

Current and Past Undergraduate Students in physics

Aaron Dalbey, Nathan Haydon, Garret Dan Vo, Erin Egbert, Christoffer Renner(Goldwater Scholar), Jason Dahl, Jim Murray(Goldwater Nominee), Daryn Denson, Zeb Barber (Goldwater Scholar), Robert Regester, Daryn Benson, Jesse Law, Joe Fischer, and Katrina Kujawa.

PROFESSIONAL ACTIVITIES

University Service (last 3 years listed)

Research Compliance Committee, member, March 2007 to present.
Subcommittee on Research Integrity, Chair, October 2007 to present

International Conference Committees and Sessions Chaired (Last 3 years listed)

Co-Chair, Storage and Manipulation of Quantum Information in Optical-Addressed Solids held in Bozeman in January 2008.

Program subcommittee member, Optical Processing and Analog Subsystems, OFC/NFOEC 2009, San Diego, CA, March 24-26, 2009.

International Advisory Committee, Holeburning and Single Molecule Conference, Palm Cove, Great Barrier Reef, Queensland, Australia June 21-25, 2009

Program subcommittee member, Optical Processing and Analog Subsystems, OFC/NFOEC 2010, San Diego, CA, March22-25, 2010

OUTREACH IN THE COMMUNITY

Science Presentations and Outreach at Elementary and High Schools (Last 5 year listed)

MSU for a day, March 8, 1009, Capital High, Helena, 4 presentations on pressure (Singing Rod, Liquid Nitrogen, Beds of Nails.)

Science Olympiad, 11/24/2009 event caption, Physics Science Lab

1/27/10 Tour of Hologram Show and Q&A to local pre-school class (Jean Hannula)

MSU for a day 10/28/08 (7 high school classes taught in Whitefish, MT)

MSU for a day 11/19/08 (8 high school classes taught in Billings, MT)

August 5, 2008, summer creative workshop for 22 8-13 year olds, Science Experimentation with liquid nitrogen, Bozeman Public Library.

April 26, 2007 March to College Days (4 presentations to Bozeman High School sophomores of "3D Holography and other Fun Optics" with holography show.)

Fall 2006-Spring 2007 Advisor to Christian Heritage School Team for 2006 Destination ImagiNation, Challenge B: CSI:DI. They got first place at the state competition in January 2007 and then on to win first place in their division at the global competition.

November 2006 Two holography presentations for National Society of Collegiate Scholars' March to College Days.

November 2005 Set up the holography show as an exhibit at the Exit Gallery in the MSU SUB from November 21 to December 2, 2005. Over 1800 visitors viewed the exhibit.

PUBLICATIONS

Refereed Archival Journal Publications (72 total, most recent 10 listed)

64) W. R. Babbitt, M. A. Neifeld, and K. D. Merkel, " Broadband Analog to Digital Conversion with Spatial-Spectral Holography," J. Lumin. 127, 152-157 (2007).

65) C. J. Renner, R. R. Reibel, M. Tian, T. Chang, and W. R. Babbitt, "Broadband photonic arbitrary waveform generation based on spatial-spectral holographic materials," JOSA B, Vol. 24, 2979-2987 (2007).

66) M.Tian, I. Zafarullah, T. Chang, K. R. Mohan, and W. R. Babbitt, "Demonstration of geometric operations on the Bloch vectors in an ensemble of rare-earth metal atoms," Physical Review A 79, 022312 (2009)

67) R. Reibel, C. Harrington, J. Dahl, C. Ostrander, P. Roos, T. Berg, R. Mohan, M. Neifeld, and W. R. Babbitt, "Demonstrations of analog-to-digital conversion using a frequency domain stretched processor," Optics Express 17, 11281-11286 (2009).

68) P. A. Roos, R. R. Reibel, T. Berg, B. Kaylor, Z. Barber, W. R. Babbitt, "Ultrabroadband optical chirp linearization for precision metrology applications," Opt. Let. 34, 3692 (2009).

69) Zeb W. Barber, Wm. Randall Babbitt, Brant Kaylor, Randy R. Reibel, and Peter A. Roos, "Accuracy of active chirp linearization for broadband frequency modulated continuous wave ladar," Appl. Opt. 49, 213-219 (2010).

70) Z. W. Barber, C. Harrington, C. W. Thiel, W. R. Babbitt, and R. Krishna Mohan, "Angle of Arrival Estimation Using Spectral Interferometry", accepted to J. Lum.

71) C. W. Thiel, R. M. Macfarlane, T. Bottger, Y. Sun, R. L. Cone, W. R. Babbitt, "Optical decoherence and persistent spectral holeburning in Er3+:LiNbO3," accepted to J. Lum.

72) C. W. Thiel, Y. Sun, T. Bottger, W. R. Babbitt, R. L. Cone, "Optical decoherence and persistent spectral holeburning in Tm3+:LiNbO3," accepted to J. Lum.

Books published

W. R. Babbitt, R. L. Cone, A, Rebane, and R. W. Equall, Editors, J. Lum. **107**, (2004).

Invited Conference Presentations (16 total, most recent 5 listed)

12) W. R. Babbitt, "Microwave Signal Processing with Spatial-Spectral Holography," Annual Meeting of LEOS (IEEE Lasers and Electro-Optics Society), Sydney, Australia, October 27, 2005, Invited Talk

13) W. R. Babbitt, "Digitization of Microwave Signals with Spatial Spectral Holography," Optical Fiber Communication Conference (OFC), March 25-29, 2007, Anaheim, CA, OSA Technical Digest Series (CD), paper Oth16, Invited Talk.

14) W. R. Babbitt, P.A. Roos, Z. Cole, R.R. Reibel, T. Berg, B. Kaylor, K.D. Merkel, K.H. Wagner, F. Schlottau, Y. Li, and A. Hoskins, "High Resolution Range/Doppler Ladar Using Broadband Coherent Optical Processing," 14th Coherent Laser Radar Conference (CLRC) July 8-13, 2007, Snowmass, Colorado, Invited talk.

15) W. R. Babbitt, "Microwave Signal Processing with Spatial-Spectral Holography," 10th Intl Meeting on Hole Burning, Single Molecule, and Related Spectroscopies: Science and Applications (HBSM 2009), Palm Cove, June 22, 2009, Invited Talk.

16) Wm. Randall Babbitt, Zeb Barber, and Charles Thiel, Broadband Optical Delay and Filtering in Spectrally Structured Materials, OSA Slow and Fast Light (SL) Topical Meeting, Waikiki, Hawaii, July 12-17, 2009, Invited Talk.

Reviewed Conference Publications (94 total, most recent 4 listed

91) C. W. Thiel, R. M. Macfarlane, R. L. Cone, Y. Sun, T. Böttger, K. D. Merkel, and W. R. Babbitt, Spectroscopy and Dynamics of Er3+:LiNbO3 at 1.5 Microns for Quantum Information and Signal Processing Applications, 10th Intl Meeting on Hole Burning, Single Molecule, and Related Spectroscopies: Science and Applications (HBSM 2009), Palm Cove, Australia, June 22-27, 2009, Invited talk.

92) R. Krishna Mohan, Cal Harrington, Zeb W. Barber, Charles W. Thiel, W. Randy Babbitt, Direct spectral phase mapping using correlative spectrum analyzer for direction finding, HBSM 2009, June 22-27, 2009 Palm Cove,, Australia, poster

93) C. W. Thiel, Y. Sun, T. Böttger, W. R. Babbitt, and R. L. Cone, Optical Decoherence, Spectral Diffusion, and 169Tm Hyperfine Structure of Tm3+:LiNbO3 at 794 nm for Quantum Computing and Signal Processing Applications," 10th Intl Meeting on Hole Burning, Single Molecule, and Related Spectroscopies: Science and Applications (HBSM 2009), Palm Cove, Australia, June 22-27, 2009.

94) W. R. Babbitt et al, Demonstrations of Spectral Holographic Analog-to-Digital Converter, 10th International Meeting on Hole Burning, Single Molecule, and Related Spectroscopies: Science and Applications (HBSM 2009), Palm Cove, Australia, June 22-27, 2009.

Non-Reviewed Conferences Proceedings (24 total, most recent 1 listed)

24) Elizabeth T. Kunkee, Ken Tsai, Andrew D. Smith, T. Jung, L. Lembo, and Richard Davis, W. Randall Babbitt, R. Krishna-Mohan, Z. Cole, K. Merkel, and K. Wagner, "Photonically-Enabled RF Spectrum Analyzer Demonstration", Proceedings SPIE 6975-5, March 17, 2008, Orlando.

Workshop Presentations and Lectures since 1995 (15 total, most recent 1 listed)

15) W. R. Babbitt and K. D. Merkel, "Fundamentals and Applications of Spatial-Spectral Holography," Technology Seminar, National Reconnaissance Office, March 2008.

Patents Issued (14 total, most recent 5 listed)

10) K. D. Merkel and W. R. Babbitt, "Techniques for multiple frequency chirp readout of material with inhomogeneously broadened absorption spectrum," U. S. Patent No. 7,193,879 (March 20, 2007)

11) K. D. Merkel, Z. Cole, K. M. Rupavatharam, W. R. Babbitt, K. H. Wagner, T. Chang, "Method and apparatus for processing high time-bandwidth signals using a material with inhomogeneously broadened absorption spectrum," U. S. Patent No. 7,265,712 (September 4, 2007).

12) T. Chang, M. Tian, W. R. Babbitt, K. D. Merkel, "Techniques for using chirped fields to reconfigure a medium that stores spectral features," U. S. Patent No. 7,307,781 (December 11, 2007).

13) Z. Cole, R. R. Reibel, K. M. Rupavatharam, W. R. Babbitt, K. D. Merkel, T. Chang, , "Method and Apparatus for Detecting Optical Spectral Properties Using Optical Probe Beams with Multiple Sidebands." U. S. Patent No. 7,379,652 (May 27, 2008).

14) W. R. Babbitt, M. A. Neifeld, K. D. Merkel, "Broadband Analog to Digital Conversion using Analog Spectral Recording." U. S. Patent No. 7,471,224 (December, 30 2008).

CURRICULUM VITAE

Richard C. Canfield

Education

Ph.D. (Astrogeophysics), January 1968, University of Colorado

M. S. (Astronomy), June 1961, University of Michigan, Ann Arbor

B. S. (Astronomy), June 1959, University of Michigan, Ann Arbor

Appointments

2009-present, Research Professor (retired), Department of Physics, Montana State University–Bozeman

1996-2009, Research Professor, Department of Physics, Montana State University–Bozeman

1985-1996, Astronomer, Institute for Astronomy, University of Hawaii

1980-1985, Research Physicist, University of California, San Diego

1983-1990, Adjunct Lecturer, Department of Physics, University of California, San Diego

1976-1980, Associate Research Physicist, University of California, San Diego

1970-1976, Astrophysicist, Sacramento Peak Observatory

1969-1970, Fellow, Sonnenborgh Observatory, Utrecht

1968-1969, Visiting Scientist, High Altitude Observatory

Research Interests

Solar magnetism, magnetic helicity, solar flares, Coronal Mass Ejections, solar-interplanetary physics

Recent Awards

MSU Alumni and Chamber of Commerce Award for Excellence, mentor - 1999

Wiley Award for Outstanding Research at Montana State University 2000

Recent Professional Activities

Chair, Max Millennium Steering Committee, 1999–presnt

Editorial Board, "Solar Physics", Kluwer Academic Publishers, 1989–2008

Mentoring Activities

Total PhD students: 10. PostDoctoral students: 12

Recent Publications

Author or co-author of 137 refereed publications, cited 4945 times as of 3/31/10.

Maria D. Kazachenko, Richard C. Canfield, Dana W. Longcope, Jiong Qiu, Angela DesJardins and Richard W. Nightingale, "SUNSPOT ROTATION, FLARE ENERGETICS, AND FLUX ROPE HELICITY: THE ERUPTIVE FLARE ON 2005 MAY 13", Astrophysical Journal, 704, 1146-1158, 2009

Des Jardins, A., Canfield, R., Longcope, D., and McLinden, E., "Signatures of Magnetic Stress Prior to Three Solar Flares Observed by RHESSI", Astrophysical Journal, 693, 886-893, 2009

Des Jardins, A., Canfield, R.C., Longcope, D., Fordyce, C., and Waitukaitis, S., "Reconnection in Three Dimensions: The Role of Spines in Three Eruptive Flares", Astrophysical Journal, 693, 1628, 2009

Pevtsov, A. A., Canfield, Richard C., Sakurai, T., and Hagino, M., "On the Solar Cycle Variation of the Hemispheric Helicity Rule", Astrophysical Journal, 677, 719, 2008

David E. McKenzie and Richard C. Canfield, "Hinode X-Ray Telescope Observations of a Long-Lasting Coronal Sigmoid" Astronomy and Astrophysics, 481, 65, 2008

Richard C. Canfield, Maria D. Kazachenko, Loren W. Acton, D. H. Mackay, Ji Son, Tanya L. Freeman, "Yohkoh SXT Full-Resolution Observations of Sigmoids: Structure, Formation, and Eruption" Astrophysical Journal, 671, 81, 2007

Nandy, D., Mackay, D.H., Canfield, R.C., and Martens, P.C.H., "Twisted Magnetic Fields in the Solar Photosphere as Drivers of Space Weather: Observational and Theoretical Investigations", Journal of Atmospheric and Solar-Terrestrial Physics, 70, 605, 2008

Canfield, R.C., and Russell, A. J. B, " Solar Active Region Flux Fragmentation, Subphotospheric Flows, and Flaring", ApJ Letters, 662, L39, 2007

Curriculum Vita

JOHN L. CARLSTEN

Physics Department
Montana State University
Bozeman, Montana 59717
Telephone: (406) 994-6176

EDUCATION

B.S.	Physics	1969	University of Minnesota
M.S.	Physics	1971	Harvard University
Ph.D.	Physics	1974	Harvard University

Current Research Interests

Laser Sensing
- LIDAR for aerosols
- DIAL for CO_2 and H_2O

Memberships in Professional Societies

American Physical Society
Optical Society of America

PREVIOUS POSITIONS AND EXPERIENCE

1992 - Pres.	Regents Professor	Physics Department, Montana State University, Bozeman, Montana
2002 – 2006	Program Director (half time)	AMOP Program National Science Foundation
1992 - 1997	Director	Optical Technology Center Montana State University University, Bozeman, Montana
1990 - 1992	Professor	Physics Department, Montana State University, Bozeman, Montana
1984 - 1990	Associate Professor	Physics Department, Montana State University, Bozeman, Montana
1981 - 1984	Associate Group Leader	Los Alamos National Laboratory, Los Alamos, New Mexico
1979 - 1981	Staff Member	Los Alamos National Laboratory, Los Alamos, New Mexico
1976 - 1979	Assistant Professor	Physics Department, University of Colorado, Boulder, Colorado
1976 - 1979	Senior Research Assoc.	JILA, Univ. of Colorado Boulder, Colorado
1974 - 1976	Postdoc. Res. Assoc.	JILA, Univ. of Colorado Boulder, Colorado
1969 - 1974	Research Assistant	Physics Department, Harvard University, Cambridge, Massachusetts
1972	Teaching Assistant	Physics Department, Harvard University, Cambridge, Massachusetts
1966 - 1969	Research Assistant	Physics Department, University of Minnesota, Minneapolis, Minnesota

AWARDS

Outstanding Performance Award from Los Alamos National Laboratory (1980).
Phi Kappa Phi Fridley Distinguished Teaching Award at Montana State University (1986).
Wiley Award for Excellence in Research at Montana State University (1986).

Pi Sigma Alpha Mortar Board Award for Teaching at Montana State University (1987).
Pi Sigma Alpha Mortar Board Award for Teaching at Montana State University (1988).
Sigma Xi Outstanding Research Scientist Award at Montana State University (1989).
Outstanding Teaching Award in College of Letters and Science at Montana State University (1989).
Cox Excellence Award for Creative Scholarship and Teaching (1990).
Pi Sigma Alpha Mortar Board Award for Teaching at Montana State University (1992).
Regents Professorship at Montana State University (1992)
Pi Sigma Alpha Mortar Board Award for Teaching at Montana State University (1994).
James and Mary Ross Provost's Award for Excellence (2001).
Elected a Fellow of the Optical Society of America (2004).
Elected a Fellow of the American Physical Society (2005).
Montana State University President's Excellence in Teaching Award (2006).
Montana State University Award for Research, Creativity and Contribution to Economic Development (2006).
Montana State University Physics Undergraduate Lecturing Instructor Award (2008).

RECENT REFEREED PUBLICATIONS (2006-current)

98. "Optical Detection of Honeybees Using Wing Beat Modulation of Scattered Light For Locating Explosives and Landmines", K.S. Repasky, J.A Shaw, R. Scheppele, C. Melton, J.L. Carlsten and L. Spangler, Applied Optics, 45, 1839 (2006)

99. "Frequency Stabilization of a Mode-locked External Cavity Diode Laser to a High Finesse Cavity", Yihan Xiong, Sytil Murphy, Kevin Repasky and J. L. Carlsten, *Opt. Eng*. **46**, 054203 (2007).

100. "Design and Characteristics of a Tapered Amplifier Diode System by Seeding with Continuous-Wave and Mode-Locked External Cavity Diode Laser", Y. Xiong, Sytil Murphy, J.L. Carlsten and Kevin Repasky, Optical Engineering, **45**, 124205 (2006).

101. "Extending the Continuous Tuning Range of an External Cavity Diode Laser", Kevin S. Repasky, Amin R. Nehrir, Justin T. Hawthorne, Gregg W. Switzer, and John L. Carlsten, Applied Optics **45**, 9013 (2006).

102. "Differential Absorption Measurements of Carbon Dioxide Using a Temperature Tuned Distributed Feedback Diode Laser", Kevin S. Repasky, Seth Humphries, and John L. Carlsten, Review of Scientific Instruments, **77**, 113107 (2006).

103. "Application of Extended Tuning Range for External Cavity Diode Lasers to Water Vapor Differential Absorption Measurements", M. D. Obland, A. R. Nehrir, K.S. Repasky, J.A Shaw and J.L. Carlsten, Journal of Optical Engineering , **46** 084301 (2007).

104. "Range Resolved Optical Detection of Honeybees by Use of Wing-Beat Modulation of Scattered Light for Locating Land Mines", D. S. Hoffman, A. R. Nehrir, K. S. Repasky, J. A. Shaw and J. L. Carlsten, Applied Optics, **46**, 3007 (2007).

105. "Theory of a Far-Off Resonance Mode-Locked Raman Laser in H2 with High Finesse Cavity Enhancement", Y. Xiong, Sytil Murphy, Kevin Repasky and J.L. Carlsten, JOSA B,**24** 2055 (2007).

106. "Mode-Locked Raman Laser in H2 Pumped by a Mode-Locked External-Cavity Diode Laser", Y. Xiong, Sytil Murphy, Paul Nachman, Kevin Repasky and J.L. Carlsten, JOSA B, **24**, 2893 (2007).

107. “Differential Absorption Instrument for Monitoring Sub-Surface Carbon Dioxide Concentrations”, Amin R. Nehrir, Kevin S. Repasky, Seth D. Humphries, and John L. Carlsten, submitted to the Journal of Applied Spectroscopy, Mar (2008).

108. “Testing carbon sequestration site monitor instruments using a controlled carbon dioxide release facility” Seth D. Humphries, Amin R. Nehrir, Charlie J. Keith, Kevin S. Repasky, Laura M. Dobeck, John L. Carlsten, and Lee H. Spangler, Applied Optics, 47, 548 (2008).

110. “Development of a widely tunable amplified diode laser differential absorption lidar for profiling atmospheric water vapor” M. D. Obland, K.S. Repasky, A. R. Nehrir, J.L. Carlsten and J.A. Shaw, resubmitted (2009).

111. “Water Vapor Profiling Using a Widely Tunable, Amplified Diode-Laser-Based Differential Absorption Lidar (DIAL)”, A. R. Nehrir, K.S. Repasky, J.L. Carlsten, M. D. Obland, and J.A. Shaw, J. Atmos. Oceanic Technol. (JTECH) 26, 733 (2009).

112. “Monitoring effects of a controlled subsurface carbon dioxide release on vegetation using a hyperspectral imager”, Charlie J. Keith, Kevin S. Repasky, Rick L. Lawrence, Steven C. Jay and John L. Carlsten, IJGGC 3, 626 (2009).

113. “Laser Based Carbon Dioxide Monitoring Instrument Testing During a Thirty Day Controlled Underground Carbon Release Field Experiment”, Jamie L. Barr , Seth D. Humphries, Amin R. Nehrir, Kevin S. Repasky, Laura M. Dobeck, John L. Carlsten, and Lee H. Spangler, Accepted for publication in the International Journal of Greenhouse Gas Control, 2009.

114. “Observational studies of atmospheric aerosols over Bozeman, Montana using a two color lidar, a water vapor DIAL, a solar radiometer, and a ground based nephelometer over a twenty four hour period”, Kevin S. Repasky, Amin R. Nehrir, Benjamin Todt, David S. Hoffman, Michael Thomas, John A. Reagan, John L. Carlsten, Joseph A. Shaw, Glenn E. Shaw, submitted 2010.

115. A diode laser based micro pulse differential absorption lidar (DIAL) for water vapor profiling in the lower troposphere”, Amin R. Nehrir, Kevin S. Repasky, John L. Carlsten, submitted 2010.

RECENT CONFERNCE PAPERS (2006-current)

126. “Preliminary testing of a water-vapor differential absorption lidar (DIAL) using a widely tunable amplified diode laser source”, Michael D. Obland, Kevin S. Repasky, Joseph A. Shaw, and John L. Carlsten, contributed paper at the 2006 IEEE International Geoscience and Remote Sensing Symposium, Denver Colorado, July/August 2006, presented by Obland.

127. “Differential absorption measurements of carbon dioxide and diatomic oxyger”, Proceedings of the Carbon Sequestration Conference, Alaxandria, VA., 2006 (with Seth Humphries, Amin Nehrir, Kevin Repasky, Joseph A. Shaw, and Lee H. Spangler).

128. “Initial Results from a Water-Vapor Differential Absorption Lidar (DIAL) using a Widely Tunable Amplified Diode Laser Source”, SPIE meeting, August 2007 (Presented by Michael D. Obland with Kevn S. Repasky, Amin R. Nehrir, Joseph A. Shaw, and John L. Carlsten as coauthors).

129. . “Atmospheric Carbon Dioxide Measurements Using a Tunable Laser Based System”, NETL Conference, Pittsburgh, PA, May 2007 , (Presented by Seth D. Humphries with Kevin S. Repasky, Amin Nehrir, Joseph A. Shaw, John L. Carlsten, and Lee H. Spangler as coauthors).

130. “Underground Fiber-Optic Differential Absorption Instrument for Monitoring Carbon Dioxide Soil Gas Concentration for Carbon Sequestration Site Monitoring”, Amin R. Nehrir, Seth D. Humphries, Kevin S. Repasky, John L. Carlsten, Lee H. Spangler, and Laura M. Dobeck, American Geophysical Union Annual Meeting, San Francisco, CA, 2007.

131. “Differential Absorption Measurements of Carbon Dioxide for Carbon Sequestration Site Monitoring Using a Temperature Tunable Diode Laser”, Seth D. Humphries, Amin R. Nehrir, Kevin S. Repasky, John L. Carlsten, Lee H. Spangler, and Joseph A. Shaw, American Geophysical Union Annual Meeting, San Francisco, CA, 2007.

132. “Differential Absorption Measurements of Carbon Dioxide for Carbon Sequestration Site Monitoring Using a Temperature Tunable Diode Laser”, Seth D. Humphries, Amin R. Nehrir, Kevin S. Repasky, John L. Carlsten, Lee H. Spangler, and Laura M. Dobeck, number 303, presented as a POSTER at the Seventh Annual Carbon Capture and Sequestration Conference, May 5 – 8, 2008, Pittsburgh, PA.

133. “Laser Based Instruments using Differential Absorption Detection for Above and Below Ground Monitoring of Carbon Dioxide”, Seth D. Humphries, Amin R. Nehrir, Kevin S. Repasky, John L. Carlsten, Lee H. Spangler, and L M Dobeck, American Geophysical Union Annual Meeting, San Francisco, CA, 2008.

134. “Laser Based Direct Detection of Carbon Dioxide for Surface and Subsurface for Monitoring Carbon Sequestration Sites”, Jamie Barr, Seth D. Humphries, Amin R. Nehrir, Kevin S. Repasky, John L. Carlsten, Lee H. Spangler, and Laura Dobeck, Annual Carbon Capture and Sequestration Conference, May , 2009, Pittsburgh, PA May, 2009.

135. “Design and Testing of a Compact Widely Tunable Diode Laser Based Differential Absorption Lidar (DIAL) for Water Vapor Profiling in the Lower Troposphere”, Amin R. Nehrir, Kevin S. Repasky, and John L. Carlsten, SPIE Conf, San Diego, California, August 2009.

136. “A Compact Widely Tunable Cascaded Master Oscillator Power Amplifier (MOPA) Diode Laser Based Micro-Pulse Differential Absorption Lidar (DIAL) for Water Vapor Profiling in the Lower Troposphere”, Amin R. Nehrir, Kevin S. Repasky, John L. Carlsten, The International Symposium on Tropospheric Profiling, Delft University, Holland, October 2009.

137. “Development and Initial Testing of a Multi-Sensor Platform for Aerosol Studies in the Lower Troposphere”, Kevin S. Repasky, Amin R. Nehrir, David S. Hoffman, Benjamin D. Todt, Tia L. Sharpe, Coulton Half Red, John L. Carlsten, Michael Thomas, and Joseph A. Shaw, American Geophysical Union Meeting, San Fransisco, CA, December, 2009.

138. “Observational Studies of Atmospheric Aerosols in the Lower Troposphere Using Multiple Sensors”, Kevin S. Repasky, Amin R. Nehrir, David S. Hoffman, Michael Thomas, John L. Carlsten, and Joseph A. Shaw, IGARSS 2010, Honolulu, Hawaii, 2010.

RECENT RESEARCH GRANTS AT MSU (2006-current)

33. “Laser Development for LIDAR”, NASA, co-PI with Kevin Repasky, Joe Shaw, David Dickensheets and Lee Spangler, $545,000 (2002-2004).

34. “IPA for Program Manager at NSF”, National Science Foundation, $350,000 (2002-2007).

35. “Basic Science of Retention Issues, Risk Assessment, and Measuring”, DOE, Co-PI with K. Repasky and J. Shaw, $126,662 (9/04-8/08).

36. “Development and Deployment of Compact Laser Sensors”, NASA Co-PI with K. Repasky and J. Shaw, $1,139,000 (10/04-9/08).

37. “Optical Detection of Honeybees for Landmine and Explosives Detection”, DOD Co-PI with K. Repasky and J. Shaw, $250,000 (11/06-9/08).

38. “Development of a Novel High Spectral Resolution Lidar for Studies of the Effects of Aerosols on the Earth's Climate”, NASA, $750,000, Co-PI with Kevin Repasky, 2008.

39. Development and Deployment of a compact eye-safe scanning differential absorption lidar (DIAL) for spatial mapping of carbon dioxide for Monitoring/Verification/ Accounting at Geologic Carbon Sequestration Sites”, Department of Energy, $405,119, Co-PI with Kevin Repasky, 2009.

BIOGRAPHICAL SKETCH of RUFUS L. CONE

Rufus L. Cone http://www.physics.montana.edu/faculty/cone/

Professor of Physics, Physics Department — Telephone: (406) 994 6175
Montana State University — FAX: (406) 994 4452
Bozeman, Montana 59717 — Email: cone@Montana.edu

Professional Preparation: Ph. D., Physics, 1967-1971, Yale University, Werner P. Wolf, Advisor
B. S., Physics, 1962-1966, Georgia Institute of Technology

Appointments:

2006 to present - Distinguished Professor of Letters and Science, Montana State University
1984 to present - Professor of Physics, Montana State University
1999 - Visiting Professor, Laboratoire de Physico-Chimie des Matériaux Luminescents, Université Claude Bernard Lyon I, Lyon, France.
1980, 1982, & 1991 - Visiting positions at Bell Laboratories, Murray Hill, NJ
1990 - 1991 - Visiting position at IBM Almaden Research Center, San Jose, CA
1986 - Visiting Professor, Laboratoire de Spectrometrie Physique, Université Grenoble
1983 - Science and Engineering Res. Council Fellow, the Clarendon Laboratory, University of Oxford, Oxford, UK
1977 to 1982 - Associate Professor of Physics, Montana State University
1974 to 1977 - Assistant Professor of Physics, Montana State University
1971 to 1974 - Assistant Professor of Physics, University of Georgia

List of pertinent publications:

1. *Photon-Echo Quantum Memory*, W. Tittel, M. Afzelius, R. L. Cone, T. Chanelière, S. Kröll, S. A. Moiseev, and M. Sellars, Laser & Photonics Reviews Laser & Photon. Rev. **4**, 244–267 (2010), DOI: 10.1002/lpor.200810056 http://www3.interscience.wiley.com/cgi-bin/fulltext/122269484/PDFSTART
2. *Effects of magnetic field orientation on optical decoherence in Er^{3+}:Y_2SiO_5*, Thomas Böttger, C. W. Thiel, R. L. Cone, and Y. Sun, Phys. Rev. B **79**, 115104 (2009). Highlighted in Virtual Journal of Quantum Information **9**, #3, March 2009.
3. *Controlled compositional disorder in Er^{3+}:Y_2SiO_5 for wide bandwidth hole burning material at 1.5 μm*, Thomas Böttger, C. W. Thiel, R. L. Cone, and Y. Sun, Physical Review B **77**, 155125 (2008). Highlighted in Virtual Journal of Nanoscale Science & Technology **17**, #18, May 5, 2008
4. *Optical decoherence and spectral diffusion at 1.5μm in Er^{3+}:Y_2SiO_5 versus magnetic field, temperature, and Er^{3+} concentration*, Thomas Böttger, C. W. Thiel, Y. Sun, and R. L. Cone, Phys. Rev. B. **73**, 075101 (2006).
5. *Optical Decoherence in Er^{3+}-doped Silicate Fiber: Evidence For Coupled Spin-Elastic Tunneling Systems*, R. M. Macfarlane, Y. Sun, P. B. Sellin, and R. L. Cone, Phys. Rev. Lett. **96**, 033602 (2006).

Other Publications:

1. *Exceptionally Narrow Homogeneous Linewidth in Erbium-Doped Glasses*, Y. Sun, R. L. Cone, L. Bigot, and B. Jacquier, Opt. Lett. **32**, No. 23 (2006).
2. *Coherent Integration of 0.5 GHz Spectral Holograms at 1536 nm using Dynamic Bi-Phase Codes*, Z. Cole, T. Böttger, Krishna Mohan, R. Reibel, W. R. Babbitt, R. L. Cone, and K. D. Merkel, Appl. Phys. Lett. **81**, 3525-3527 (2002).
3. *Semiconductor lasers stabilized to spectral holes in rare earth crystals to a part in 10^{13} and their application to devices and spectroscopy*, G. J. Pryde, T. Böttger, R. L. Cone, and R. C. C. Ward, J. Lumin. **98**, 309-315 (2002).
4. *Laser Stabilization at 1536 nm Using Regenerative Spectral Hole Burning*, P. B. Sellin, N. M. Strickland, T. Böttger, J. L. Carlsten, and R. L. Cone, Phys. Rev. B **63,** 155111-1 – 155111-7 (2001).

5. *Systematics of 4f Electron Energies Relative to Host Bands by Resonant Photoemission of Rare Earth Ions in Aluminum Garnets*, C. W. Thiel, H. Cruguel, H. Wu, Y. Sun, G. J. Lapeyre, R. L. Cone, R. W. Equall, and R. M. Macfarlane, Phys. Rev. B **64**, 085107 (2001).

Publications and Talks: 89 refereed publications, 74 invited and plenary talks, 3 licensed US patents.

Recent Awards:

Distinguished Professor of Letters and Science (one of only four). August 16, 2006.

3 successfully licensed patents and top awards from Montana State University for technology transfer

- *MSU Meritorious Technology/Science Award* (the 3rd awarded and the first in physical sciences). May 5, 2006.
- *MSU Recognition of Research, Creativity, and Contributions to Economic Development*, on October 18, 2006 – for partnership with S2 Corporation and three patents licensed to them earlier.

Recent research funding: AFOSR, ARO, DoD-DURIP, Scientific Materials Corp., Montana Board of Research and Commercialization Technology

Synergistic Activities:

1. Hosted *Workshop on the Storage and Manipulation of Quantum Information in Optically-Addressed Solids*, Bozeman, Montana, January 25-27, 2008, and *8th International Meeting on Hole Burning, Single Molecule, and Related Spectroscopies: Science and Applications*, July 27 – 31, 2003.
2. Development of three undergraduate courses in optics and lasers, including one called the physics of photography designed to appeal to non-science majors and teachers.
3. Characterization, design, and development of materials for quantum information in solids - including quantum memories, spectral hole burning devices, and "spatial-spectral holography."
4. Frequency stabilization of lasers (diode, fiber, Ti:Sapphire, mode-locked lasers, etc.) to persistent and 'regenerative' spectral holes and inhomogeneous optical lines. A number of international groups find these lasers critical to their quantum information research and demonstrations, and we are collaborating with Nobel Laureate John L. Hall.
5. Relationship of rare earth ion levels to host band states, impacting signal processing, laser materials, scintillators, and optical display phosphors.
6. Photoionization, photoconductivity, photorefractive effects, defects, and local structure in rare earth doped crystals.
7. Signal processing devices and spectral hole burning materials; coherent transients; and holography.
8. Energy levels and optical spectroscopy of rare earth compounds, including modeling of energy level structure and point defects in crystals.

Collaborators and Co-Editors within last 48 months:

W. R. Babbitt (Montana State University), Thomas Böttger (University of San Francisco), Randy Equall (Scientific Materials Corp.), Ralph L. Hutcheson (Scientific Materials Corp.), Bernard Jacquier (Université Lyon I, France), Gerald J. Lapeyre (Montana State University), Roger M. Macfarlane (Montana State University and IBM Almaden Research Center), Kris Merkel (Scientific Materials Corp.), Krishna Mohan (The Spectrum Lab, Montana State University), G. J. Pryde (University of Queensland), Aleksander Rebane (Montana State University), R. Reibel (Montana State University), Peter Sellin (Montana State University), Yongchen Sun (University of South Dakota).

Graduate Advisor: Werner P. Wolf, Professor of Physics and Applied Science, Yale University

Students and Postdocs: (subsequent appointment shown in parentheses)

12 Ph.D. degrees completed; **Recent Ph.D.'s:** C.W. Thiel, 2003 (MSU Spectrum Lab); G. Reinemer, 2003 (Idaho State University.); T. Böttger, 2002 (University of San Francisco); T.L. Harris, 2001 (SRI International); **11 postdoc/scientists supported – 7 in recent years:** C. W. Thiel (MSU Spectrum Lab), Annabelle Collombet (University of Hamburg), P. B. Sellin (S2 Corp.), Y. Sun (University of South Dakota), G.J. Pryde (U. of Queensland), H. Cruguel (CEA/Saclay) and A. Braud (U. Caen)

Neil Cornish

Montana State University
Department of Physics
Bozeman, MT 59717

Cell: (406) 579-3394
Office: (406) 994-7986
Email: cornish@physics.montana.edu

Education

B.Sc. Physics, First Class Honours, University of Melbourne, 1990.

M.Sc. Physics, University of Melbourne, 1992.

Ph.D. Physics, University of Toronto, 1996.

Profession Positions

Associate Professor, Dept. of Physics, Montana State University, 2005 to Present

Assistant Professor, Dept. of Physics, Montana State University, 1999–2005

Postdoctoral Research Associate, WMAP Satellite Mission, Princeton University, 1998–1999

Postdoctoral Fellow in Hawking's Relativity & Cosmology Group, Cambridge University, 1996–1998

Research Interest

Gravitational Wave Astronomy

General Relativity and early Universe Cosmology

Awards

2006 – College of Letters & Science Meritorious Research Award

2005 – Wiley Award for Meritorious Research.

2005 – APS 2005 World Year of Physics Speaker.

2004 – Discover Magazine Top 100 Science Stories for 2004

2003 – Presenter, National Academy of Sciences Frontiers of Science

2001 – *Class. Quant. Grav.* Editors' Choice, Noteworthy Papers of 2001.

1992→1996 – Commonwealth Scholar, University of Toronto.

1990→1992 – Australian Postgraduate Research Award, University of Melbourne.

1989 – Kernot Research Scholarship in Physics, University of Melbourne.

1989 – Dixson Scholarship in Physics, University of Melbourne.

1988 – E. M. & J. F. Ward Prize in Experimental Physics, University of Melbourne.

Membership

American Physical Society

American Aastronomical Society

Australasian Society for General Relativity and Gravitation

Professional Service

ASTRO 2010 Decadal Survey, Cosmology and Fundamental Physics Panel: 2009

NASA Senior Review: 2008

NASA Advisory Council, Astrophysics Sub-Committee: 2006-2008

LISA International Science Team: 2005-present

Co-Chair, LISA Data Analysis Development Working Group

Council Member, LIGO Scientific Collaboration

Regular Referee for *Phys. Rev. Lett*, *Phys. Rev. D*, *Class. Quant. Grav.*, *Ap.J.*

Current Grants

NSF: "Searches for Transient Gravitational Wave Signals", PI: Neil Cornish, 8/1/09 - 7/31/12, $302,246

NASA: "Enhancing LISA's Science Reach", PI: Neil Cornish, 5/1/10 - 4/30/13, $499312

NASA: "LISA Data Analysis Development", PI: Neil Cornish, 5/1/07 - 4/30/10, $338646

Publications

Publications: 80 with h-index = 26.

Publications Last Year (Excluding LIGO/Virgo Collaboration)

Alternative Derivation of the Response of Interferometric Gravitational Wave Detectors, N. J. Cornish, Phys. Rev. D **80**, 087101 (2009)

Bayesian Approach to the Detection Problem in Gravitational Wave Astronomy, T. B. Littenberg & N. J. Cornish, Phys. Rev. D**80**, 063007 (2009)

Semi-classical limit and minimum decoherence in the Conditional Probability Interpretation of Quantum Mechanics., V. Corbin & N. J. Cornish, Found. Phys. **39**, 474 (2009)

Characterizing the Gravitational Wave Signature from Cosmic String Cusps, J. Key & N. J. Cornish Phys. Rev. D**79**, 043014 (2009)

Massive Black Hole Binary Inspirals: Results from the LISA Parameter Estimation Taskforce., K. G. Arun *et al.*, Class. Quant. Grav. **26** 094027 (2009)

Alan E. Craig
Physics Department, Montana State University
(406)-994-6869
craig@physics.montana.edu

Education

Ph.D., Optical Sciences, University of Arizona, 1984
B.S., Electrical Engineering and Physics, Princeton University, 1975

Expertise

Optics: Quantum optoelectronics, surface plasmon and semiconductor optoelectronics. Multi-spectral information processing: techniques and devices.

Experience

Research professor: 2002 - present
University laboratory Director: 1999 - 2002
DoD basic research program manager: AFOSR 1989 - 1999
Research scientist, NRL: 1984 - 1989

Research Interests

Fundamental and applied aspects of optical interactions at the nanoscale:

Photon coupling to spin-selective nanostructures, especially to semiconductor (silicon) and metal nanoparticles. Surface plasmon interface dynamics modified by magnetic field behavior in 2DEG nano-plasmas. Spin and magnetism mediated selection rules for optical transitions; photon initiation from anyon trajectories, inductive response in quantum processes. NSOM and optical trap techniques for characterizing and controlling optical attributes of nanoparticles.

Quantum device structures for computation based on spectral diversity of optical fields and coherent optical processes in inhomogeneously broadened absorbers. Modelocked laser supercontinuum for spectral metrology. Applications in coherent broadband data encoding and coherent control.

Member

Optical Society of America
IEEE Lasers and Electro-Optics Society
SPIE

Current Grant

Computing Device Applications of Group IV Nanoparticle Spectroscopy; AFOSR/DEPSCoR. $750,000, including university match. Sept 2008 – Sept 2011.

Publications and Conference Presentations

24 papers, 24 presentations (8 invited).

Postdoctoral Associates and Graduate Students advised

Mentored 2 postdoctoral associates, 4 Ph.D. students. Currently 1 graduate student and 1 BS physics graduate in group.

Recent Presentations/Publications

1. Craig, Alan E., Picoplasma Optoelectronics, Workshop on Future Trends in Microelectronics, 14 – 19 June, 2009, Sardinia.

2. Silicon Nanosphere Memory, Workshop on the Storage and Manipulation of Quantum Information in Optically-Addressed Solids (SMQIOAS), January 25 – 27, 2008, Bozeman, MT.

3. Craig, Alan E., The homogeneous dispersive lineshape as a wavelet basis, SPIE International Symposium on Optoelectronics (Photonics West) 2007, Conference 6482: "Advanced Optical and Quantum Memories and Computing IV", 24 – 25 January, 2007, San Jose, CA.

4. Craig, Alan E., Rare earths vs. rare earths: spectral storage in f-d and f-f materials, SPIE International Symposium on Optoelectronics (Photonics West) 2006, Conference 6130: "Advanced Optical and Quantum Memories and Computing III", 24 – 25 January, 2006, San Jose, CA.

5. Craig, Alan E., A waveguide microring optical modulator, SPIE International Symposium on Optoelectronics (Photonics West) 2005, Conference 5735: "Advanced Optical and Quantum Memories and Computing II", 25 – 26 January, 2005, San Jose, CA.

Mikhail Drobijev

Department of Physics

Montana State University, Bozeman, MT 59717

Tel. (406) 994-7810 Fax: (406)-994-4452

e-mail: drobijev@physics.montana.edu

Education: Ph.D., 1998 – P. N. Lebedev Physics Institute, Russian Academy of Sciences, Moscow, Russia. Laser Physics

B.S., M.S.,1986 – Moscow Institute of Physics and Technology, Moscow Russia

Employment:

2002 to present: Research Assistant Professor, Physics Dept., Montana State University

1999 to 2002: Postdoctoral Research Assistant, Physics Dept., Montana State University

1986 to 1999: Research Associate, P. N. Lebedev Physics Institute, Russian Academy of Sciences, Moscow, Russia.

Other Experience:

1995 – 1998: Russian to English scientific translator for English version of "Optics and Spectroscopy", published by American Physical Society .

Research Interests: Nonilinear optics and laser spectroscopy of organic and biological molecules; Two-photon absorption, mechanisms of enhancement and applications in photodynamic therapy of cancer, and 3D microscopy; biophotonics and photophysics of fluorescent proteins.

Member: Biophysical Society

Current grants:

"Building Better Probes for 2-Photon Microscopy" NIH with 2 co-PIs (Aleksander Rebane and Thomas Hughes) $973,648 for 4 years Start date: 09/30/2008

"Advanced Multi-Photon Chromophores for Broad-Band Ultra-Fast Optical Limiting" (Aleksander Rebane PI) with 1 co-PI. $750,000 for 5 years Strat date: 03/01/2009

Papers presented at conferences: 90

Publications: 74 including the following from the last 2 years (2008 – 2009)

1. H. A. Collins, M. Khurana, E. H. Moriyama, A. Mariapillai, E. Dahlstedt, M. Balaz, M. K. Kuimova, M. Drobizhev, V. X. D. Yang, D. Phillips, A. Rebane, B. C. Wilson, H. L. Anderson, "Blood-vessel closure using photosensitizers engineered for two-photon excitation", Nat. Photonics, 2008, 2; p. 420-424.
2. J. R. Starkey, A. K. Rebane, M. A. Drobizhev, F. Meng, A. Gong, A. Elliott, K. McInnerney, C. W. Spangler, "New two-photon activated photodynamic therapy sensitizers induce xenograft tumor regressions after near-IR laser treatment through the body of the host mouse," Clin. Cancer Res., 2008, 14(20), p. 6564-6573.
3. N. S. Makarov, M. Drobizhev, A. Rebane, "Two-photon absorption standards in the 550 – 1600 nm excitation wavelength range," Opt. Express, 2008, 16(6), p. 4029-4047.
4. M. Drobizhev, N. S. Makarov, A. Rebane, G. de la Torre, T. Torres, "Strong two-photon absorption in push-pull phthalocyanines: Role of resonance enhancement and permanent dipole moment change upon excitation," J. Phys. Chem. C. 2008, 112(3), p. 848-859.
5. M. Drobizhev, N. S. Makarov, A. Rebane, H. Wolleb, H. Spahni, "Very efficient two-photon induced photo-tautomerization in non-symmetrical phthalocyanines" J. Lumin., 2008, 128, p. 217-222.
6. A. Rebane, N.S. Makarov, M. Drobizhev, B. Spangler, E. S. Tarter, B. D. Reeves, C. W. Spangler, F. Q. Meng, Z. Y. Suo, "Quantitative prediction of two-photon absorption cross section based on linear spectroscopic properties", J. Phys. Chem. C,, 2008, 112, p. 7997-8004.

7. A. Rebane, M. Drobizhev, N. S. Makarov, B. Koszarna, M. Tasior, D. T. Gryko, “Two-photon absorption properties of meso-substituted A(3)-corroles”, Chem. Phys. Lett., 2008, 462, p. 246-250.
8. M. K. Kuimova, H. A. Collins, M. Balaz, E. Dahlstedt, J. A. Levitt, N. Sergent, K. Suhling, M. Drobizhev, N. S. Makarov, A. Rebane, H. L. Anderson, D. Phillips, “Photophysical properties and intracellular imaging of water-soluble porphyrin dimers for two-photon excited photodynamic therapy,” Org. Biomol. Chem., 2009, 7(5), p. 889-896.
9. M. Drobizhev, S. Tillo, N.S. Makarov, T.E. Hughes, A. Rebane, “Absolute two-photon absorption spectra and two-photon brightness of orange and red fluorescent proteins,” J. Phys. Chem. B, 2009, 113(4), p. 855-859.
10. M. Drobizhev, S. Tillo, N.S. Makarov, T.E. Hughes, A. Rebane, “Color hues in red fluorescent proteins are due to internal quadratic Stark effect”, J. Phys. Chem. B, 2009, 113, p. 12860-12864.
11. S. E. Tillo, T. E. Hughes, N. S. Makarov, A. Rebane, M. Drobizhev, “A new approach to dual-color two-photon microscopy with fluorescent proteins”, BMC Biotech., 2010, 10, Art. # 6.

GREGORY E. FRANCIS, Professor of Physics

Department of Physics, College of Letters and Science
Montana State University - Bozeman
ph: (406) 994-6625, fax: (406) 994-4452, e-mail: francis@physics.montana.edu

EDUCATION

Ph.D., Physics, Massachusetts Institute of Technology, 1987
B.S., Physics, Brigham, Young University, 1980

ACADEMIC APPOINTMENTS

Professor, Department of Physics, Montana State University, 2006 - present
Associate Professor, Department of Physics, Montana State University, 1998 - 2006
Assistant Professor, Department of Physics, Montana State University, 1992 - 1998

TEACHING EXPERIENCE

Department of Physics, Montana State University, Physics, 1992 - present
Department of Physics, University of Washington - Seattle, 1990 -1992

HONORS AND DISTINCTIONS

James and Mary Ross Provost's Award for Excellence, 2005
President's Excellence in Teaching Award, 2001
MSU Alumni Excellence Award, 2008, 2002, 2001, and 1995
MSU Influential Educator Award, 2001
Anna Fridley Award for Distinguished Teaching, 1998
College of Letters and Science Outstanding Teaching Award, 1997
Mortar Board Professor of the Month, 2002 and 1996
$\pi\beta\phi$ Professor of the Year, 1994

SELECTED PUBLICATIONS

College Physics I, 1st Edition, Thomson, 2005
College Physics II, 1st Edition, Thomson, 2005
Physics: A Conceptual World View, 7th Edition, Cengage, 2010
Problem Solving to Accompany Physics: A Conceptual World View, 7th Edition, Cengage, 2010
Instructor's Resource Manual to Accompany Physics: A Conceptual World View, 7th Edition, Cengage, 2010
Test Bank to Accompany Physics: A Conceptual World View, 1800 questions, Cengage, 2010
Tutorials in Introductory Physics, First Edition, Prentice Hall, 2002
"Do They Stay Fixed?," The Physics Teacher, 1998
"Effectiveness of Tutorials in Introductory Physics," Proceeding of the International Conference on Undergraduate Physics Education, 1996
Physics by Inquiry, Volumes I and II, Wiley, 1995
"New Regimes of Magnetic Reconnection in Collisionless Plasmas," Physical Review Letters, 1988
"A Theory of Fast Wave Absorption, Transmission, and Reflection in the Ion Cyclotron Range of Frequencies," Physics of Fluids, 1988
"Finite Temperature Effects on the Space-Time Evolution of Two-Stream Instabilities," Physics of Fluids, 1986
"Relativistic Analysis of Absolute and Convective Instability Evolutions in Three Dimensions," Physical Review Letters, 1984

SELECTED SERVICE

Member of University Pre-Health Professions Advisory Committee, 1998 - 2006
Voting member, University Long Range Planning Committee, 1998 - 2001
Voting member, American Association of Physics Teachers Committee on Physics Education Research, 1993 - 1997
Event captain, Montana State Science Olympiad, 1992 - 2007
Guest Lecturer, AED pre-med honor society MCAT preparation, 1995 - present
Voting member, Undergraduate Committee, 1993 - present
Participant, MSU-for-a-day high school outreach program, 1994 - present
Member of Examination Review Board, American Dental Association, 1992 - 1997
19 Ph.D. thesis and candidacy committees, 1992 - present

Prof. Dr. Valentin GRACHEV (Valentyn Grachov)

Physics Department
Montana State University
243 EPS, Bozeman Montana 59717
e-mail: grachev@physics.montana.edu
Phone: (406) 994-3386
Fax: (406) 994-4452

Main areas of research activity

- Theory of Electron Paramagnetic Resonance (EPR), Nuclear Magnetic Resonance (NMR) and Electron Nuclear Double Resonance (ENDOR)
- Low-symmetry effects, hidden and/or gauge symmetries in the spin- and other Hamiltonians of high-spin paramagnetic defects and molecular magnets and low-dimensional magnetic clusters with anisotropic interactions
- Magnetic resonance of extrinsic, intrinsic and radiation defects in inorganic and organic materials (together with experimentalists)
- Phenomenological and microscopic theories of defect properties
- Multifrequency magnetic resonance spectroscopy of regularly ordered (crystals), partly ordered (fibers, nanostructures, layered materials) and disordered systems (organic materials, powders),
- Computer simulation and development of methods for experimental data treatment.

Education and academic degrees

Professor (Honour degree), Institute for Problems of Materials Sciences, Ukraine
Doctor of Sciences (Habilitation, Phys. and Math.); Inst. of Semiconductors, Kiev, Ukraine
Candidate of Sciences (Ph.D., Phys. and Math.); Inst. of Semiconductors, Kiev, Ukraine
M.Sc. in Physics (Theoretical physics), State University, Kiev, Ukraine

Career / Employment

2002 – to present	Senior Research Scientist, Physics Department, Montana State University, Bozeman, USA
1997 - 2002	Research Scientist, Osnabrück University, Germany
1994-1996	1. Physikalische Institut der J.-L. Universität Giessen, Germany
1989-1994	Leading Researcher, Institute for Materials Sciences, Kiev, Ukraine
1965-1989	Leading Researcher, Senior Researcher, Researcher, Engineer, Institute of Semiconductors, Ukrainian Academy of Sciences, Ukraine

Visiting researcher / visting professor

University Aix-Marseille 3, Marseille, France. 1994-1995, 2000
Department of Physics, Osnabrück University, Germany. 1992, 1997.
Huygens Laboratory, Leiden University, Leiden, The Netherlands. 1995
Physikalische Institut der J.-L. Universität Giessen, Giessen, Germany 1992-1993
Institute of Physics CS AS, Prague, Czech Republic. 1992-1993

Publication summary

- Scientific articles in refereed journals: 92 (including 1 book and 2 chapters in two books)
- Proceedings of academic conferences: 15
- Presentations and contributions to scientific meetings: more than 90
- Eight hundreds of citations, impact h-index - 13.

Ph.D. supervising: Five Ph.D. theses were defended under my supervision

Research projects (leadership and/or participation)

2010-2002, **USA**:

- NSF, “Multifrequency spectroscopy of rare-earth and transition ions in optical materials”
- NASA “Point defects created by radiation in non-linear optical crystals used for space-based laser systems”
- DURIP DoD, “Multifrequency system for the study of defects in solids”
- National Foundation of Science and Advanced Technologies / CRDF, USA “Periodically poled lithium niobate crystals - application to wavelength-conversion devices”.
- NASA EPSCoR “Thermal stability of radiation defects in non-linear optical crystals”
- Montana Board of Research and Commercialization Technology, “Development of advanced materials for optoelectronics and optical communication technologies”
- NASA “Identification of atomic defects due to radiation in non-linear optical crystals used for space-based laser systems”
- NSF, “Impurity locations and mechanisms of charge compensation in stoichiometric lithium niobate and lithium tantalate crystals”

2004 – 1996, **Germany**:

- Defects and their interrelations in congruent, stoichiometric and regularly ordered lithium niobate
- Bilateral German-Ukrainian project “Stoichoimetric lithium niobate - new material with improved parameters for extended electrooptical applications; characterization of its defect structure”.
- International project INTAS-96-0699 “Preparation and investigation of regularly ordered $LiNbO_3$ – the basis for tailoring fundamental material properties and advanced applications”.

1997 – 1993, **Ukraine**:

- International project INTAS-94-1080 “New oxide materials for advanced electrooptical applications: defect structure as related to performance”.
- European Oxide Crystals Network.

Research acievements

- Theory of EPR, NMR and ENDOR, low-symmetry effects in resonance spectra, hidden symmetry in the spin- and other Hamiltonians.
- Revision of the radiospectroscopy background: the case of non-cubic general spin-Hamiltonians, which contain implicitly an inseparable combination of parameters and are practically unsuited for the description of EPR, NMR or ENDOR, because of the impossibility of unique determination of coupled parameters. An additional hidden gauge symmetry was found and a method of the elimination of all superfluous operators was proposed to obtain the correct spin-Hamiltonian.
- Interpretation of numereous new EPR, NMR, ENDOR and optical spectra in crystals and disordered materials: radiation defects in piezoelectric TeO_2, superionic $Li_2B_4O_7$ and $KTiOPO_4$, intrinsic and extrinsic defects in ferroelectric $LiNbO_3$, incipient ferroelectric $KTaO_3$, and ferroelastic $BiVO_4$, the donors in the semiconductors like Si, SiC, alloy $Si_{1-x}Ge_x$, free hole, gadolinium and gadolinium-hole complexes in the layered semiconductors GaSe and so on. Characteristics of several dozens of paramagnetic centers were obtained.
- Systematization and generalization of investigations of crystal defects in the review "ENDOR in non-metallic crystals" for *"Successes of Physical Sciences*" and monography "Electric effects in radiospectroscopy".

Teaching

USA, Montana State University, Bozeman

- Quantum Mechanics
- Solid State Physics
- Condensed Matter Physics
- Novel Materials for Physics and Engineering

Germany, 1. Physikalische Institut, Universität Giessen:

- Radiospectroscopy of Solid State (graduate students)

Ukraine, Kiev:

- Quantum Mechanics (Politechnical Institute).
- Mathematics and physics for high school students.

Additional Information

- ***Scientific level.*** Manuscript reviewer for: Phys. Rev. and Phys. Rev. Letters, J. Phys. Chem. Sol., J. Phys.: Cond. Matters, Phys. Stat. Sol., J. Magn. Res., Appl. Magn.Res., Sov. Solid State Physics.
- ***Ability to work in a cooperative way***. An experience of close cooperation with different experimentalists from many institutions of Europe and USA. About 80% of published articles are results of investigations carried out in collaboration with experimentalists.
- ***Creativity***. Wrote dozens of educational and specialized programs. At present, the approaches for the treatment and interpretation of experimental data and software developed by me are successfully used by many research groups: Prag (Czech Republic), Paris, Lille and Marseille (France), Berlin, Freiburg, Giessen, Leipzig, Marburg, Paderborn, and Osnabrück (Germany), Budapest (Hungary), Tokio (Japan), Riga (Latvia), Wrozlav and Zielona Gora (Poland), St-Petersburg, Kazan and Murmansk (Russia), Linkoeping (Sweden), Amsterdam and Leiden (The Netherlands), Bozeman (USA) etc.

Biographical Sketch - Yves U. Idzerda
Montana State University, Department of Physics
EPS 242, Bozeman, MT 59715, Idzerda@physics.montana.edu

APPOINTMENTS

Montana State University	Professor of Physics	2006 - present
Montana State University	Assoc. Director, CBIN	2004 - present
Montana State University	Associate Professor of Physics	2000 - 2006
Naval Research Laboratory	Head, Artificially Structured Materials and Non-linear Physics Section	1998 - 2000
Naval Research Laboratory	Research Physicist	1988 - 1998

PROFESSIONAL PREPARATION

Washington University, St. Louis, MO.	Physics	B.S.	1981
Washington University, St. Louis, MO.	Elec. Eng.	B.S.	1981
Univ. of Washington, Seattle, WA.	Physics	M.S.	1983
Univ. of Maryland, College Park, MD.	Physics	Ph.D.	1986

AWARDS AND HONORS

Fellow, American Physical Society (2008).

SELECTED PUBLICATIONS (6 out of 160):

1. "Determining Exchange Splitting in a Magnetic Semiconductor by Spin-Filter Tunneling"; T. S. Santos, J. S. Moodera, K. Venkataraman, E. Negusse, J. Holroyd, J. Dvorak, M. Liberati, Y. U. Idzerda and E. Arenholz; Phys. Rev. Lett. **101**, 147201 (2008).
2. "EuO - A Ferromagnetic Semicoonductor with over 90% Spin Polarization Epitaxially Integrated with Silicon", A. Schmehl, R. P. Panguluri, A. Herrnberger, S. Thiel, V. Vaithyanathan, M. Liberati, M. Wagner, T. Heeg, J. Schubert, Y. Idzerda, B. E. Nadgorny, J. Mannhart and D. G. Schlom, Nature 6, 882 (2007).
3. "Magnetic Characterization of CoFeB/MgO and CoFe/MgO Interfaces", E. Negusse, A. Lussier, J. Dvorak, Y. U. Idzerda, S. R. Shinde, Y. Nagamine, S. Furukawa, K. Tsunekawa and D. D. Djayaprawira, Appl. Phys. Lett. 90, 092502 (2007).
4. "Chemical Inhomogeneity and Mixed State Ferromagnetism in Diluted Magnetic Semiconductor Co:TiO_2", S. Ogale, D. Kundaliya, S. Mehraeen, Lianfeng Fu, S. Zhang, A. Lussier, J. Dvorak, N. Browning, Y. Idzerda and T. Venkatesan, Chem. Mater. 20, 1344 (2008).
5. "Synthetic Control over Magnetic Moment and Exchange Bias in All-Oxide Materials Encapsulated within a Spherical Protein Cage", M. T. Klem, D. A. Resnick, K. Gilmore, M. Young, Y. U. Idzerda and T. Douglas, J. Am. Chem. Soc. 129, 197 (2007).
6. "First-principles calculation of precession damping in the itinerant ferromagnets Fe, Co, and Ni", K. Gilmore, Y. U. Idzerda and M. D. Stiles, Phys. Rev. Lett. 99, 027204 (2007).

SYNERGISTIC ACTIVITIES

1. Co-organizer; Workshop in Magnetic Nanostructures, Berkeley, CA (2010).
2. Spokesperson/ Coordinator of the MSU Nanomaterials X-ray Characterization Facility, located at beamline U4B of the National Synchrotron Light Source (2000-2008).
3. Assoc. Director for the Center for BioInspired NanoMaterials at Montana State University (2003-2010), a multi-disciplinary Center that has participants from physics, chemistry, biology, engineering, and plant sciences.
4. Past-Chair and Member of the Physical Sciences Proposal Review Panel for the Advanced Light Source (1999-current). The PSP is an advisory committee that evaluates outside user proposal for beamtime at the Advanced Light Source
5. General Chair for the Conference on Magnetism and Magnetic Materials (MMM) in Jacksonville, FL, 2004.
6. General Chair for the General Chair for the Physics and Chemistry of Semiconducting Interfaces Conference (PCSI) in Bozeman, MT, 2005.
7. Co-organizer; Workshop in Magnetic Nanostructures, Interfaces, and New Materials: (2004).

Charles C. Kankelborg
Department of Physics
Montana State University
Bozeman, MT 59717-3840
Phone: 406-994-7853
FAX: 406-994-4452
kankel@physics.montana.edu

Education

Ph.D., September 1996 Department of physics, Stanford University, Stanford, CA. Dissertation: "Multispectral observations of coronal X-ray bright points"

B.S. (summa cum laude, Phi Beta Kappa, Sigma Pi Sigma, Phi Kappa Phi), June 1989 Department of Physics, University of Puget Sound, Tacoma, WA. Honors thesis: "Instabilities of turbulent vortex wakes"

Research Interests

Solar magnetic activity; Coronal loops; X-ray bright points; Image analysis; EUV optics and space instrumentation; Numerical modeling.

Research Experience

2007 - present: Associate Professor, Department of Physics, Montana State University, Bozeman, MT.

2001 - 2007: Assistant Professor, Department of Physics, Montana State University, Bozeman, MT.

April 2001 - August 2001: Research Scientist, Department of Physics, Montana State University, Bozeman, MT. Principal Investigator: "MOSES: A Slitless Multi-Order Solar Extreme Ultraviolet Spectrograph for Fast Imaging Spectroscopy of the Solar Chromosphere and Corona." sounding rocket payload funded for three years by NASA.

August 1996 - April 2001: Postdoctoral Scholar, Department of Physics, Montana State University, Bozeman, MT. Transition Region And Coronal Explorer satellite environmental testing, science operations, observing sequences, automatic exposure control, and data analysis.

Dec 1998 - Dec 1999: Principal Investigator, "Application of three-dimensional, time dependent modeling to a survey of X-ray bright points", NASA SEC Guest Investigator Program.

Jan 1990 - July 1996: Stanford University. Graduate research assistant for Prof. A. B. C. Walker; Multi-Spectral Solar Telescope Array rocket payload. Participated in two successful rocket flights, including calibration of EUV and FUV telescopes, flight software, integration and testing of flight hardware, recovery, and data analysis.

Sep - Dec 1990: Stanford University. Research assistant for Prof. Blas Cabrera. Designed hardware for low temperature physics experiments.

Jun 1988 - Dec 1989: Flow Research, Inc., Kent, WA. DOT Tip Vortex project; performed laboratory simulations of aircraft vortex wakes. Assisted in laser doppler velocimetry experiments.

Summer 1988: University of Puget Sound. Designed and built computer controlled single-vortex dynamics experiment. Isolated self-induction effects and bursting instability previously observed only in twin-vortex systems.

Summer 1987: University of Puget Sound. Indepentent study and research in fluid mechanics with Prof. A. S. Thorndike. Designed and built gas viscometer; made measurements of atmospheric viscosity.

Awards

Presidential Early Career Award for Scientists & Engineers (PECASE), awarded December 19, 2008 at the White House, "for the development of novel instrumentation for imaging spectroscopy in Solar Physics; and for mentoring undergraduate and graduate students involved in experiments on sounding rockets."

Spring 2006: first recipient of the new **Outstanding Graduate Level Instructor** award, presented by the physics graduate students.

Professional Societies

Member, American Geophysical Union
Associate Member, Solar Physics Division of the American Astronomical Society
Member, American Scientific Affiliation

Service

I have served on several NASA review panels, including SR& T, Suborbital, MIDEX science review, and TMC reviews for major space missions (2). Referee for The Astrophysical Journal, Solar Physics, and others. Chaired sessions at AAS/SPD meetings.

Public Outreach

I enjoy sharing the exciting results of space science research with the general public. I have given public presentations on science for local church youth gatherings, for the Southwest Montana Astronomical Society, and at public and private schools in Montana.

2008-2009, under the auspices of a NASA supplementary E/PO grant, I produced *Rocket Scientists*, DVD about *MOSES*, student research and what it is like to be a physics major in college. The video, with discussion questions, evaluation cards and materials about NASA-related scholarships and internships, was distributed to all 212 public and private high schools in the state of Montana, and to the Space Grant directors in all 50 states. Directed by Scott Wiessinger, MFA student in the MSU SNHF program.

2004-2005, NASA supplementary E/PO grant "SMARTS: Seeing, Measuring and Researching the Turbulent Sun." Undertaken in partnership with MSGC, Bozeman High teacher

Marty Stuart, and the Southwest Astronomical Society, this project purchased an H-alpha imaging system for showing the Sun's turbulent and rapidly changing chromosphere to students and members of the public. The telescope resides at Bozeman High School for use in the astronomy curriculum, and is still used for public outreach every summer.

I was privileged to contribute editorial suggestions and a short interview for "Here Comes the Sun", a planetarium show produced in 2000 by James Manning at the Museum of the Rockies.

Peer Reviewed Publications

1. "Structure of a Transition Region Explosive Event Observed in He II: Transition Region Imaging-Spectroscopy with MOSES", J. L. Fox, C. C. Kankelborg, and R. J. Thomas, *ApJ*, (2009 in preparation).

2. "Fluxon modeling of low-beta plasmas", C. E. Deforest and C. C. Kankelborg, *Journal of Atmospheric and Terrestrial Physics*, **69**, 116-128, (2007).

3. "An imager with added value for the Solar Orbiter mission", L. K. Harra, C. C. Kankelborg, R. J. Thomas, J. L. Fox, and B. Winter, *Advances in Space Research*, **36**, 1422-1425, (2005).

4. "SADE: The starspot and dynamo explorer", P. C. H. Martens, L. W. A. Acton, D. Klumpar, C. Kankelborg, R. A. Stern, G. Peres, and J. L. Culhane, *Advances in Space Research*, **32**, 1123-1124, (2003).

5. "The Relationship Between X-Ray Radiance and Magnetic Flux", A. A. Pevtsov, G. H. Fisher, L. W. Acton, D. W. Longcope, C. M. Johns-Krull, C. C. Kankelborg, and T. R. Metcalf, *ApJ*, **598**, 1387-1391, (2003).

6. "Topology is destiny: Reconnection energetics in the corona", D. W. Longcope and C. C. Kankelborg, *Earth, Planets, and Space*, **53**, 571-576, (2001).

7. "Evidence of Separator Reconnection in a Survey of X-Ray Bright Points", D. W. Longcope, C. C. Kankelborg, J. L. Nelson, and A. A. Pevtsov, *ApJ*, **553**, 429–439, (2001).

8. "High resolution imaging with multilayer telescopes: resolution performance of the MSSTA II Telescopes", D. S. Martinez-Galarce, A. B. Walker, D. B. Gore, C. C. Kankelborg, R. B. Hoover, T. W. Barbee, and P. F. Boerner, *Optical Engineering*, **39**, 1063–1079, (2000).

9. "On the Nature of the "Moss" Observed by TRACE", P. C. H. Martens, C. C. Kankelborg, and T. E. Berger, *ApJ*, **537**, 471–480, (2000).

10. "Time Variability of the "Quiet" Sun Observed with TRACE. II. Physical Parameters, Temperature Evolution, and Energetics of Extreme-Ultraviolet Nanoflares", M. J. Aschwanden, T. D. Tarbell, R. W. Nightingale, C. J. Schrijver, A. Title, C. C. Kankelborg, P. Martens, and H. P. Warren, *ApJ*, **535**, 1047–1065, (2000).

11. "Forward modeling of the coronal response to reconnection in an X-ray bright point", C. Kankelborg and D. Longcope, *Sol. Phys.*, **190**, 59–77, (1999).

12. "A new view of the solar outer atmosphere by the Transition Region and Coronal Explorer", C. J. Schrijver, A. M. Title, T. E. Berger, L. Fletcher, N. E. Hurlburt, R. W. Nightingale, R. A. Shine, T. D. Tarbell, J. Wolfson, L. Golub, J. A. Bookbinder, E. E. Deluca, R. A. McMullen, H. P. Warren, C. C. Kankelborg, B. N. Handy, and B. de Pontieu, *Sol. Phys.*, **187**, 261–302, (1999).

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14. "A new view of the solar corona from the transition region and coronal explorer (TRACE)", L. Golub, J. Bookbinder, E. Deluca, M. Karovska, H. Warren, C. J. Schrijver, R. Shine, T. Tarbell, A. Title, J. Wolfson, B. Handy, and C. Kankelborg, *Physics of Plasmas*, **6**, 2205–2216, (1999).

15. "Coronal Heating by Collision and Cancellation of Magnetic Elements", D. W. Longcope and C. C. Kankelborg, *ApJ*, **524**, 483–495, (1999).

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17. "Observation and Modeling of Soft X-Ray Bright Points. I. Initial Results", C. C. Kankelborg, A. B. C. Walker, R. B. Hoover, and T. W. Barbee, *ApJ*, **466**, 529+, (1996).

18. "Multi-Spectral Solar Telescope Array. V - Temperature diagnostic response to the optically thin solar plasma", C. E. Deforest, C. C. Kankelborg, M. J. Allen, E. S. Paris, T. D. Willis, J. F. Lindblom, R. H. O'Neal, A. B. C. Walker, T. W. Barbee, and R. B. Hoover, *Optical Engineering*, **30**, 1125–1133, (1991).

19. "Multi-Spectral Solar Telescope Array. II - Soft X-ray/EUV reflectivity of the multilayer mirrors", T. W. Barbee, J. W. Weed, R. B. Hoover, M. J. Allen, J. F. Lindblom, R. H. O'Neal, C. C. Kankelborg, C. E. Deforest, E. S. Paris, and A. B. C. Walker, *Optical Engineering*, **30**, 1067–1075, (1991).

Invited Conference Presentations

1. "The Sun, Multilayers and MOSES (invited talk)", C. Kankelborg, *Physics of X-Ray Multilayer Structures meeting*, (2008).

2. "MOSES Instrument Status", C. C. Kankelborg, *First Solar Orbiter Imager Meeting, Mullard Space Science Laboratory, UK*, (2004).

3. "Inversion of MOSES Data", C. C. Kankelborg, *First Solar Orbiter Imager Meeting, Mullard Space Science Laboratory, UK*, (2004).

4. "MOSES", C. C. Kankelborg, *Second Solar Orbiter Imager Meeting, Mullard Space Science Laboratory, UK*, (2003).

5. "MOSES Science", C. C. Kankelborg, *First Solar Orbiter Imager Meeting, Mullard Space Science Laboratory, UK, November 20-21*, (2002).

6. "MOSES Instrument", C. C. Kankelborg, *First Solar Orbiter Imager Meeting, Mullard Space Science Laboratory, UK, November 20-21*, (2002).

7. "MOSES Deconvolution", C. C. Kankelborg, *First Solar Orbiter Imager Meeting, Mullard Space Science Laboratory, UK, November 20-21*, (2002).

8. "Simultaneous Imaging and Spectroscopy of the Solar Atmosphere: Advantages and Challenges of a 3-Order Slitless Spectrograph", C. C. Kankelborg and R. J. Thomas, In *Proc. SPIE, UV/EUV and Visible Space Instrumentation for Astronomy and Solar Physics*, volume 4498, pages 16–26, (2001).

Other Publications and Contributed Conference Presentations

1. "Reconnectionless CME eruption: putting the Aly-Sturrock conjecture to rest", L. A. Rachmeler, C. E. DeForest, and C. C. Kankelborg, *ArXiv e-prints*, (2008).

2. "Coronal Tomography", C. C. Kankelborg, *ArXiv e-prints*, (2008).

3. "Measuring the MOSES Point Spread Function", T. L. Rust, S. Chart, and C. C. Kankelborg, *AGU Spring Meeting Abstracts*, , B6+, (2008).

4. "Preventing Systematic Error due to Instrument PSF in MOSES Inversions", J. L. Fox and C. C. Kankelborg, *AGU Spring Meeting Abstracts*, , B5+, (2008).

5. "Coronal Tomography", C. C. Kankelborg, *AGU Spring Meeting Abstracts*, , D2+, (2008).

6. "Ni/Mg multilayer mirror for 30.4 nm light", T. Naibert and C. Kankelborg, *Physics of X-Ray Multilayer Structures meeting*, (2008).

7. "The effect of reconnection on a confined flux rope", L. A. Rachmeler, C. E. Deforest, and C. C. Kankelborg, *AGU Fall Meeting Abstracts*, , A233+, (2007).

8. "Three Dimensional Structure and Time Evolution of a Transition Region Explosive Event Observed in He II", J. L. Fox, C. C. Kankelborg, R. J. Thomas, and D. Longcope, *AGU Fall Meeting Abstracts*, , A840+, (2007).

9. "Three Dimensional Structure Of A Complex Bipolar Jet: Transition Region Imaging-spectroscopy With MOSES", L. Fox, C. C. Kankelborg, and D. Longcope, In *American Astronomical Society Meeting Abstracts*, volume 210 of *American Astronomical Society Meeting Abstracts*, pages 95.01–+, (2007).

10. "Fluxon Modeling of Eruptive Events With and Without Reconnection", C. DeForest, L. Rachmeler, A. Davey, and C. Kankelborg, In *American Astronomical Society Meeting Abstracts*, volume 210 of *American Astronomical Society Meeting Abstracts*, pages 53.05–+, (2007).

11. "Low Cost X-ray Optics for Studying StellarDynamo Cycles", T. Rust, L. Acton, C. Kankelborg, and P. Martens, In *American Astronomical Society Meeting Abstracts*, volume 210 of *American Astronomical Society Meeting Abstracts*, pages 23.02–+, (2007).

12. "The Sensitivity of Hybrid Differential Stereoscopy for Spectral Imaging", C. E. DeForest and C. C. Kankelborg, *ArXiv e-prints*, **704**, (2007).

13. "Fluxon Modeling of Active Region Evolution", C. E. Deforest, C. C. Kankelborg, A. R. Davey, and L. Rachmeler, *AGU Fall Meeting Abstracts*, , B7+, (2006).

14. "Fluxon Modeling of Low-Beta Plasmas", C. E. DeForest and C. C. Kankelborg, *ArXiv Astrophysics e-prints*, (2006).

15. "First Results From the MOSES Rocket Flight", C. Kankelborg, J. L. Fox, and R. J. Thomas, In *AAS/Solar Physics Division Meeting*, pages 37.04–+, (2006).

16. "Quantifying The Relationship Between Reconnection Rate And Energy Release In A Survey Of Coronal Bright Points", A. V. Malanushenko, D. Longcope, E. Aver, and C. Kankelborg, In *AAS/Solar Physics Division Meeting*, pages 10.01–+, (2006).

17.

18. "The Hi-C Sounding Rocket Experiment", L. Golub, J. Cirtain, E. DeLuca, G. Nystrom, C. Kankelborg, D. Klumpar, D. Longcope, and P. Martens, In *AAS/Solar Physics Division Meeting*, pages 06.05–+, (2006).

19. "Narrow-band EUV multilayer coating for the MOSES sounding rocket", S. M. Owens, J. S. Gum, C. Tarrio, S. Grantham, J. Dvorak, B. Kjornrattanawanich, R. Keski-Kuha, R. J. Thomas, and C. C. Kankelborg, In *Optics for EUV, X-Ray, and Gamma-Ray Astronomy II. Edited by Citterio, Oberto; O'Dell, Stephen L. Proceedings of the SPIE, Volume 5900, pp. 5-13 (2005).*, pages 5–13, (2005).

20. "Fast Inversion of MOSES Data", C. C. Kankelborg and J. L. Fox, *American Astronomical Society Meeting Abstracts*, **204**, 69.01, (2004).

21. "An imager with added value for the Solar Orbiter mission", L. Harra, C. Kankelborg, R. Thomas, J. Fox, and B. Winter, In *35th COSPAR Scientific Assembly*, page 1120, (2004).

22. "Data inversion for the Multi-Order Solar Extreme-Ultraviolet Spectrograph", J. L. Fox, C. C. Kankelborg, and T. R. Metcalf, In *Optical Spectroscopic Techniques and Instrumentation for Atmospheric and Space Research V., Larar, Allen M.; Shaw, Joseph A.; Sun, Zhaobo., eds. Proc. SPIE*, volume 5157, pages 124–132, (2003).

23. "A Fluxon Model for the Behavior of Solar Force-Free Magnetic Fields", S. Blane McCracken and C. Kankelborg, *APS Meeting Abstracts*, , J6+, (2003).

24. "Measuring EUV Doppler Shifts and Line Widths With the *MOSES* Slitless Spectrograph", C. C. Kankelborg and J. L. Fox, *American Astronomical Society Meeting*, (2003).

25. "Numerical Modeling of "Velocity Redistribution" in the Solar Transition Region", J. L. Fox and C. C. Kankelborg, *American Astronomical Society Meeting*, (2003).

26. "Fast EUV Imaging and Spectroscopy", C. C. Kankelborg, *OpTeC Meeting, Museum of the Rockies, Bozeman, MT*, (2002).

27. "A Parametric Inversion Technique for MOSES Data", J. L. Fox and C. C. Kankelborg, *American Astronomical Society Meeting*, **200**, (2002).

28. "Forward Modeling of MOSES Response to the Solar Atmosphere", M. J. S. Cirtain, C. C. Kankelborg, and M. Reiser, *American Astronomical Society Meeting*, **200**, (2002).

29. "The Importance of Plasma Viscosity in Narrow Band Bright Point Observations", R. A. McMullen, D. W. Longcope, and C. C. Kankelborg, *American Astronomical Society Meeting*, **200**, (2002).

30. "Sensitivity of MOSES to Chromospheric Spectral Line Profiles", C. C. Kankelborg, *American Astronomical Society Meeting*, **200**, (2002).

31. "Nanoflare Modeling of an X-Ray Bright Point Coronal Loop", R. A. McMullen, D. W. Longcope, and C. C. Kankelborg, In *Multi-Wavelength Observations of Coronal Structure and Dynamics*, page 95, (2002).

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34. "Fluxon Modeling of Force Free Magnetic Fields: Voronoi Method", C. E. DeForest, C. C. Kankelborg, and D. W. Longcope, *AGU Spring Meeting Abstracts*, , 41, (2001).

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37. "A Reflight of the Explorer-1 Science Mission: The Montana EaRth Orbiting Pico Explorer (MEROPE)", D. M. Klumpar, M. Obland, G. Hunyadi, S. Jepsen, B. Larsen, C. Kankelborg, and W. Hiscock, *AGU Spring Meeting Abstracts*, , 52, (2001).

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41. "Scientific Objectives of the EUV Spectral Imager for Solar Orbiter", Petrus C. Martens and Charles C. Kankelborg, In *Solar Encounter: Proc. 1st Solar Orbiter Workshop*, pages 293–296, (2001).

42. "Solar Plumbing? Constraints on the 3D geometry of constant-width coronal loops.", P. C. H. Martens and C. C. Kankelborg, *AAS/Solar Physics Division Meeting*, **32**, (2000).

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44. "Having Our Cake and Eating it, Too: Fast Imaging Spectroscopy With a Multi-Order Slitless Spectrograph", C. C. Kankelborg, D. W. Longcope, and P. C. H. Martens, *AAS/Solar Physics Division Meeting*, **32**, (2000).

45. "X-ray bright points: A case study in solar reconnection", D. Longcope and C. Kankelborg, *Bulletin of the American Astronomical Society*, **32**, 845, (2000).

46. "VLA Decimetric Observations of EUV Transient Events Detected by SOHO and TRACE", R. F. Willson and C. Kankelborg, In *ESA SP-446: 8th SOHO Workshop: Plasma Dynamics and Diagnostics in the Solar Transition Region and Corona*, J.-C. Vial and B. Kaldeich-Schü, editors, page 715, (1999).

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51. "The TRACE Mission: Initial Scientific Results", A. M. Title, T. D. Tarbell, J. Wolfson, K. Schrijver, R. R. Fisher, T. Gang, L. Golub, R. A. McMullen, C. Kankelborg, and TRACE Collaboration, *Bulletin of the American Astronomical Society*, **30**, 1398, (1998).

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53. "Observation and Modeling of Soft X-ray Bright Points. II. Determination of Temperature and Energy Balance", C. C. Kankelborg, A. B. C. Walker, II, and R. B. Hoover, *Bulletin of the American Astronomical Society*, **29**, 885, (1997).

54. "Multispectral Observations of Coronal X-Ray Bright Points", C. C. Kankelborg, *Ph.D. Thesis*, (1996).

55. "Design and performance of thin foil XUV filters for the Multi-Spectral Solar Telescope Array II", J. E. Plummer, C. E. DeForest, D. S. Martinez-Galarce, C. C. Kankelborg, D. B. Gore, R. H. O'Neal, A. B. Walker, F. R. Powell, R. B. Hoover, T. W. Barbee, and J. W. Weed, In *Proc. SPIE Vol. 2515, p. 565-575, X-Ray and Extreme Ultraviolet Optics, Richard B. Hoover; Arthur B. Walker; Eds.*, volume 2515, pages 565–575, (1995).

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57. "Calibration of multilayer mirrors for the Multi-Spectral Solar Telescope Array II", C. C. Kankelborg, J. E. Plummer, D. S. Martinez-Galarce, R. H. O'Neal, C. E. DeForest, A. B. Walker, T. W. Barbee, J. W. Weed, R. B. Hoover, and F. R. Powell, In *Proc. SPIE Vol. 2515, p. 436-444, X-Ray and Extreme Ultraviolet Optics, Richard B. Hoover; Arthur B. Walker; Eds.*, volume 2515, pages 436–444, (1995).

58. "Multi-Spectral Solar Telescope Array VIII: the second flight", A. B. Walker, M. J. Allen, C. E. DeForest, C. C. Kankelborg, D. S. Martinez-Galarce, J. E. Plummer, R. B. Hoover, T. W. Barbee, and D. B. Gore, In *Proc. SPIE Vol. 2515, p. 182-193, X-Ray and Extreme Ultraviolet Optics, Richard B. Hoover; Arthur B. Walker; Eds.*, volume 2515, pages 182–193, (1995).

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60. "Performance of the multilayer-coated mirrors for the MultiSpectral Solar Telescope Array", M. J. Allen, T. D. Willis, C. C. Kankelborg, R. H. O'Neal, D. S. Martinez-Galarce, C. E. Deforest, L. R. Jackson, J. D. Plummer, A. B. Walker, T. W. Barbee, J. W. Weed, and R. B. Hoover, In *Proc. SPIE Vol. 2011, p. 381-390, Multilayer and Grazing Incidence X-Ray/EUV Optics II, Richard B. Hoover; Arthur B. Walker; Eds.*, volume 2011, pages 381–390, (1994).

61. "Calibration of the Multi-Spectral Solar Telescope Array multilayer mirrors and XUV filters", M. J. Allen, T. D. Willis, C. C. Kankelborg, R. H. O'Neal, D. S. Martinez-Galarce, C. E. Deforest, L. Jackson, J. Lindblom, A. B. C. Walker, and T. W. Barbee, In *Multilayer and grazing incidence X-ray/EUV optics for astronomy and projection lithography; Proceedings of the Meeting, San Diego, CA, July 19-22, 1992 (A93-39601 15-74)*, volume 1742, pages 562–574, (1993).

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66. "The Ultra High Resolution XUV Spectroheliograph. II - Predicted performance", A. B. C. Walker, J. F. Lindblom, J. G. Timothy, M. J. Allen, C. E. Deforest, C. Kankelborg, R. H. O'Neal, E. S. Paris, T. Willis, and T. W. Barbee, In *X-ray/EUV optics for astronomy, microscopy, polarimetry, and projection lithography; Proceedings of the Meeting, San Diego, CA, July 9-13, 1990 (A92-25201 09-74). Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1991*, volume 1343, pages 319–333, (1991).

67. "Multi-Spectral Solar Telescope Array", A. B. C. Walker, M. J. Allen, C. Deforest, C. Kankelborg, J. F. Lindblom, R. H. O'Neal, E. Paris, R. B. Hoover, and T. W. Barbee, *BAAS*, **22**, 808, (1990).

68. "Performance of compact multilayer coated telescopes at soft x-ray/EUV and far-ultraviolet wavelengths I", R. B. Hoover, T. W. Barbee, P. C. Baker, J. F. Lindblom, M. J. Allen, C. E. Deforest, C. C. Kankelborg, R. H. O'Neal, E. S. Paris, and A. B. Walker, In *Proc. SPIE Vol. 1235, p. 821-832, Instrumentation in Astronomy VII, David L. Crawford; Ed.*, volume 1235, pages 821–832, (1990).

ADNET Systems, Inc.
NASA GSFC
Greenbelt, MD 20771

(301) 286-8958 (work)
(240) 413-2435 (mobile)
robert.j.leamon@nasa.gov
bobandoe@mac.com

Robert J. Leamon

Education

1994–1999 **University of Delaware** Newark, DE

Ph. D., Physics

- Dissertation: "Dissipation of Magnetic Fluctuations in the Solar Wind"
- Dissertation advisor: Prof. N. F. Ness

1990–1994 **Imperial College** London, UK

B. Sc., Physics with a Year in Europe

- First Class Honours
  Senior thesis advisor: Prof. D. J. Southwood (now scientific director, ESA)
- Third Year spent at l'Université de Paris-XI, Orsay, France

Research Interests

Space Plasma Physics:

Interplanetary Magnetic Field; MHD Waves & Turbulence; Heating of the Solar Wind and Corona; Magnetic Helicity; CMEs & Magnetic Clouds; Space Weather; Interpretation of Spacecraft Data.
I consider most of my work data-oriented, with occasional forays into theory and have assisted in construction of space hardware.

Employment

July 2006–present **ADNET Systems, Inc.** Greenbelt, MD
Sept. 2003–June 2006 **L-3 Communications/GSI**

Principal Support Scientist (SOHO Experimental Operations Facility)

- Basic Science: Investigating the properties of magnetoacoustic waves in the solar atmosphere;
  ◦ interplay between coronal holes and the chromosphere beneath them;
  ◦ heating of the solar corona and solar wind by dissipation of Alfvén waves and turbulent magnetic fluctuations
  ◦ development of solar wind forecast model.
- Mission Operations: SOHO/EIT Science Planner: daily monitoring of the instruments health; reporting of solar activity; development of code to simplify and automate posting movies on the web.
- Future Mission Operations: Involved with planning for Living with a Star/ Solar Dynamics Observatory (SDO);
  ◦ technical evaluation of HMI vector magnetograph data processing capabilities;
  ◦ developed software to run an interactive/ public outreach video wall to display SDO and other solar data, allowing transparent overlay, and using object graphics and OpenGL routines;
  ◦ independent verification of AIA EUV telescope calibration (He II 304Å) against atomic physics models and EVE spectral irradiance data.

Employment (cont)

Oct. 2000–Aug. 2003 **Montana State University** Bozeman, MT

Post-Doctoral Scholar

- Supervision of students:
  ◦ primary responsibility for three 10-week full-time undergraduate research experience projects (Brian Lundberg, U. Arizona, summer 2002; Sarah Jones, Dartmouth College, fall 2002; Karen Wilson, U. Missouri, summer 2003), one publication, one in preparation;
  ◦ assisted MSU undergraduate (Zachary Blehm) with his senior thesis.
- Writing graphical display & analysis routines for Yohkoh soft X-ray images
- Investigating the nature of coronal "sigmoids" & Coronal Mass Ejections; Coordination and correlation of solar and interplanetary data; Prediction of "Space Weather."

January–Sept. 2000 **Bartol Research Institute** Newark, DE

Post-Doctoral Fellow

- Writing extraction of spacecraft data, analysis & graphical display routines for ACE magnetic field experiment.
- Investigating the nature of the turbulent dissipation range, in the solar wind and solar corona.

1994–1999 **University of Delaware** Newark, DE

Graduate Research Assistant/ Graduate Teaching Assistant

- Thesis research involved analysis and computational modelling of high-frequency fluctuations of the interplanetary magnetic field, using WIND/ MFI data.
- Helped investigate and diagnose the cause of high-frequency noise problems on the WIND/MFI instrument.
- Helped build magnetic shielding for fuel valves on the Advanced Composition Explorer (ACE).
- Wrote graphical display & analysis routines for ACE magnetic field data.
- Taught laboratory and discussion sections for Introductory Physics classes (Calculus-based, Algebra-based and Non-science major courses).
- Graded Exams.

Membership of Professional Societies

1994– Institute of Physics (UK)

1995– American Geophysical Union

1995– American Institute of Physics (associate member through AGU)

2001– American Physical Society (associate member through IoP)

Professional Service Activities

- Referee for *JGR, GRL, ApJ, A&A, Solar Physics* and various proceedings.
- Sat on three NASA Peer Review Panels; reviewed various proposals for NSF and DoD.
- Chair of one AGU Meeting Session.

Refereed Journal Publications

- McIntosh, S.W., Leamon, R.J. and De Pontieu, B., 2009, The Spectroscopic Footprint of the Fast Solar Wind, *Astrophys. J.*, submitted.
- Leamon, R.J. and McIntosh, S.W., 2009, How the Solar Wind Ties to its Photospheric Origins *Astrophys. J.* 697, L28.
- Leamon, R.J. and McIntosh, S.W., 2008, Could We Have Forecast "The Day the Solar Wind Died"? *Astrophys. J.* 679, L147.
- Hamilton, K., Smith, C.W., Vasquez, B.J., and Leamon, R.J., 2008, Anisotropies and helicities in the solar wind inertial and dissipation ranges at 1 AU, *J. Geophys. Res.* 113, 1106.
- Vasquez, B.J., Smith, C.W., Hamilton, K., MacBride, B.T., and Leamon, R.J., 2007, Evaluation of the turbulent energy cascade rates from the upper inertial range in the solar wind at 1 AU, *J. Geophys. Res.* 112, 7101.
- McIntosh, S.W., Leamon, R.J., Davey, A.R., and Wills-Davey, M.J., 2007, The Posteruptive Evolution of a Coronal Dimming, *Astrophys. J.* 660, 1653.
- Leamon, R.J. and McIntosh, S.W., 2007, Empirical Solar Wind Forecasting from the Chromosphere, *Astrophys. J.* 659, 738.
- Smith, C.W., Hamilton, K., Vasquez, B.J., and Leamon, R.J., 2006, Dependence of the Dissipation Range Spectrum of Interplanetary Magnetic Fluctuations on the Rate of Energy Cascade, *Astrophys. J.* 645, L85.
- McIntosh, S.W. and Leamon, R.J., 2005, Is There a Chromospheric Footprint of the Solar Wind? *Astrophys. J.* 624, L117.
- Leamon, R.J., Canfield, R.C., Jones, S.L., Lambkin, K., Lundberg, B.J., and Pevtsov, A.A., 2004, Helicity of magnetic clouds and their associated active regions, *J. Geophys. Res.* 109, 5106.
- Leamon, R.J., Canfield, R.C., Blehm, Z., and Pevtsov, A.A., 2003, What Is the Role of the Kink Instability in Solar Coronal Eruptions? *Astrophys. J.* 596, L255.
- Leamon, R.J., Canfield, R.C., and Pevtsov, A.A., 2002, Properties of magnetic clouds and geomagnetic storms associated with eruption of coronal sigmoids, *J. Geophys. Res.* 107, 1234.
- Leamon, R.J., Matthaeus, W.H., Smith, C.W., Zank, G.P., Mullan, D.J., and Oughton, S., 2000, MHD-driven Kinetic Dissipation in the Solar Wind and Corona, *Astrophys. J.* 537, 1054.
- Leamon, R.J., Smith, C.W., Ness, N.F., and Wong, H.K., 1999, Dissipation range dynamics: Kinetic Alfvén waves and the importance of electron beta, *J. Geophys. Res.* 104, 22331.
- Matthaeus, W.H., Zank, G.P., Leamon, R.J., Smith, C.W., Mullan, D.J., and Oughton, S., 1999, Fluctuations, Dissipation and Heating in the Corona, *Space Science Rev.* 87, 269.
- Leamon, R.J., Matthaeus, W.H., Smith, C.W., and Wong, H.K., 1998, Contribution of cyclotron-resonant damping to kinetic dissipation of interplanetary turbulence, *Astrophys. J.* 507, L181.

Refereed Journal Publications (cont)

- Leamon, R.J., Smith, C.W., Ness, N.F., Matthaeus, W.H., and Wong, H.K., 1998, Observational constraints on the dynamics of the interplanetary magnetic field dissipation range, *J. Geophys. Res.* 103, 4775.
- Leamon, R.J., Smith, C.W., and Ness, N.F., 1998, Characteristics of magnetic fluctuations within coronal mass ejections: The January 1997 event, *Geophys. Res. Lett.* 25, 2505.
- Southwood, D.J., Dougherty, M.K., Leamon, R.J., and Haynes, P.L., 1995, Origin and dynamics of field nulls detected in the Jovian magnetospheres, *Adv. Space Res.* 16, 177.
- Leamon, R.J., Dougherty, M.K., Southwood, D.J., and Haynes, P.L., 1995, Magnetic nulls in the outer magnetosphere of Jupiter: Detections by Pioneer and Voyager spacecraft, *J. Geophys. Res.* 100, 1829.

Refereed Conference Proceedings

- McIntosh, S. W., J. Burkepile, and R. J. Leamon, 2009, More of the Inconvenient Truth About Coronal Dimmings, in Proceedings of the Second Hinode Science Meeting, edited by M. Cheung, B. Lites, T. Magara, J. Mariska, and K. Reeves, ASP, San Francisco.
- Leamon, R. J., W. H. Matthaeus, C. W. Smith, and H. K. Wong, 1999, Considerations limiting cyclotron-resonant damping of cascading interplanetary turbulence and why the 'slab' approximation fails, in Solar Wind Nine (SW9), edited by S. R. Habbal, R. Esser, J. V. Hollweg, and P. A. Isenberg, p. 465. AIP, New York.
- Leamon, R. J., N. F. Ness, C. W. Smith, and H. K. Wong, 1999, Dynamics of the dissipation range for solar wind magnetic fluctuations, SW9, p. 469.

Invited Presentations

- "Solar Wind sources and Coronal Holes," XXVII IAU General Assembly (Rio de Janeiro, Brazil), August 2009.
- "The Turbulent Solar Wind with Application to Charged Particle Transport," 37th COSPAR Scientific Assembly (Montreal, Canada), July 2008.
- "The Turbulent Solar Wind: Energy-Containing, Inertial, and Dissipation Range Characteristics," International Space Science Institute (ISSI) workshop on Transport of Energetic Particles in the Inner Heliosphere (Bern, Switzerland) November 2007.
- "The Importance of Topology and Reconnection in Active Region CMEs," IAU Symposium 226 (Beijing, China), September 2004.
(Proceedings edited by K. Dere, J. Wang, and Y. Yan, Cambridge University Press, 2005., pp.302-308)
- "Cascade and Dissipation in Solar Wind Turbulence," 43rd Annual Meeting of the APS Division of Plasma Physics (Long Beach, CA), October 2001.
(*Bull. Am. Phys. Soc.*, **46**, 182, 2001.)
- "Spatial Transport and Heating of the Solar Wind by Dissipation of Turbulent Magnetic Fluctuations," (Presented on behalf of Charles W.Smith and William H. Matthaeus) IAGA-IASPEI Joint Scientific Assembly (Hanoi, Vietnam), August 2001.

Invited Presentations (cont)

- "Kinetic Dissipation of the Interplanetary Turbulence Interaction with Cyclotron Waves, Kinetic Alfvén Waves and 2-D Structures," IAGA-IASPEI Joint Scientific Assembly (Hanoi, Vietnam), August 2001.
- "Dynamics of the Solar Wind Dissipation Range," International Union of Radio Science – National Radio Science Meeting (Boulder, CO), January 2000.

Current Support

Agency	Project Title	Job	Total Budget	Award Period	Effort (FTE)
NASA (LWS)	A Solar Wind Forecasting Model From The Chromosphere	PI	\$206k	11/2007–10/2010	0.25
NASA (LWS)	Coronal Morphology – The Interplay of Structure and Energetics (S.W. McIntosh, PI)	Co-I	\$301k	09/2008–08/2011	0.20

Pending Support

Agency	Project Title	Job	Total Budget	Award Period	Effort (FTE)
NASA (HGI)	Tying The Solar Wind To Its Photospheric Origins: Tracking The Footpoint Of Earth-Directed Solar Wind	PI	\$198k	1/2010–12/2012	0.25

Other Activities

- Rugby Referee:
  Awarded grade B-3 January 2007; promotion to B-2 pending.
  IRB Level 4 ('Elite') Training course taken June 2008.
  Candidate for USA Rugby's National Referee Development Panel.
- Guardian, Custodian and Tour Guide, Laurel Hill Historic Mansion, Fairmount Park, Philadelphia, March 1999– September 2000.

Bennett Link

Department of Physics
Montana State University
Bozeman, Montana 59717

Phone: (406) 994-6174
E-mail: link@physics.montana.edu
www.physics.montana.edu/people/

Position

Professor of Physics, Montana State University

Education

1984	B.S., Physics	University of Missouri-Rolla
1987	M.S., Astrophysics	University of Illinois at Urbana-Champaign
1991	Ph.D., Astrophysics	University of Illinois at Urbana-Champaign

Research Interests

Physical processes in and around neutron stars
High-energy astrophysics
Physics of high-density matter

Appointments

Professor of Physics, Montana State University	2007–present
Associate Professor of Physics, Montana State University	2000–2007
Assistant Professor of Physics, Montana State University	1993–2000
Director's Fellow, Los Alamos National Laboratory	1991-93

Awards and Honors

Director's Fellowship, Los Alamos National Laboratory	1991-93
Time Magazine's Person of the Year	2006
Outstanding Graduate-Level Instructor	2009

Graduate Students Supervised in Research: 5

Conference Presentations: 14 invited, 20 contributed

Colloquia and Seminars: 32

Recent Publications in Peer-reviewed Journals (32 total)

1. "Superfluid Friction and Late-time Thermal Evolution of Neutron Stars"
   M. B. Larson & B. Link 1999, *Astrophysical Journal*, 521, 271.
2. "Gamma Ray Bursts with Peculiar Temporal Asymmetry"
   G. E. Romero, D. F. Torres, I. Andruchow, L. A. Anchordoqui & B. Link
   1999, *Mon. Not. Roy. Astron. Soc.*, 308, 799.
3. "Pulsar Constraints on Neutron Star Structure and Equation of State"
   B. Link, R. I. Epstein, J. M. Lattimer 1999, *Physical Review Letters*, 83, 3362.
4. "Quaking Neutron Stars"
   L. M. Franco, B. Link & R. I. Epstein 2000, *Astrophysical Journal*, 543, 987.
5. "Precession Interpretation of the Isolated Pulsar B1828-11"
   B. Link & R. I. Epstein 2001, *Astrophysical Journal*, 556, 392.
6. "Simulations of Glitches in Isolated Pulsars"
   M. B. Larson & B. Link 2002, *Mon. Not. Roy. Astron. Soc.*, 333, 613.
7. "Vortex Unpinning in Precessing Neutron Stars"
   B. Link & C. Cutler 2002, *Mon. Not. Roy. Astron. Soc.*, 336, 211.
8. "The Crustal Rigidity of a Neutron Star, and Implications for PSR 1828-11 and other Precession Candidates"
   C. Cutler, G. Ushormirsky & B. Link 2003, *Astrophysical Journal*, 588, 975.
9. "Constraining Hadronic Superfluidity with Neutron Star Precession"
   B. Link 2003, *Physical Review Letters*, 91, 101101.
10. "Link Replies:"
    B. Link 2004, *Physical Review Letters*, 92, 149002.
11. "TeV Neutrinos from Young Neutron Stars"
    B. Link & F. Burgio 2005, *Physical Review Letters*, 94, 181101.
12. "Precession of the Isolated Neutron Star PSR B1828-11"
    T. Akgun, B. Link & I. Wasserman 2006, *Mon. Not. Roy. Astron. Soc.*, 365, 653.
13. "A Strong $\ddot{\nu} - \dot{\nu}$ Correlation in Radio Pulsars and Implications for Torque Variations"
    J. O. Urama, B. Link & J. M. Weisberg 2006, *Mon. Not. Roy. Astron. Soc.*, 370, L76.
14. "Flux Predictions of High-Energy Neutrinos from Pulsars"
    B. Link & F. Burgio 2006, *Mon. Not. Roy. Astron. Soc.*, 371, 375.
15. "Incompatibility of Long-period Neutron Star Precession with Creeping Neutron Vortices"
    B. Link 2006, *Astronomy & Astrophysics*, 458, 881.
16. "Precession as a Probe of the Neutron Star Interior"
    B. Link 2007, *Astrophys. Space Sci.*, 308, 435.
17. "Evidence for Heating of Neutron Stars by Magnetic Field Decay"
    J. Pons, B. Link, J. A. Miralles & U. Geppert 2007, *Physical Review Letters*, 98, 071101.
18. "Dynamics of Quantum Vorticity in a Random Potential"
    B. Link, *Physical Review Letters*, 102, 131101.

DANA WARFIELD LONGCOPE

Dept. Physics, College of Letters and Science
Montana State University-Bozeman
Ph: (406) 994-7851, e-mail: dana@physics.montana.edu

EDUCATION

Ph.D., Applied Physics, Cornell University, 1993
M.S., Applied Physics, Cornell University, 1988
B.S., Applied and Engineering Physics, Cornell University, 1986

ACADEMIC APPOINTMENTS

Professor, Physics Department, Montana State University-Bozeman, 2008–present
Associate Professor, Physics Department, Montana State University-Bozeman, 2002–2008
Assistant Professor, Physics Department, Montana State University-Bozeman, 1996–2002
Assistant Research Physicist, Space Sciences Laboratory, UC Berkeley, 1995–1996
Miller Research Fellow, University of California, Berkeley, 1993–1995
Associate Research Scientist, Courant Institute of Mathematical Sciences, NYU, 1992–1993

HONORS AND DISTINCTIONS

Dean's Award for Meritorious Research or Creative Activity, MSU College of L&S, 2008
Cox Family Award for Creative Scholarship and Teaching from Montana State University, 2006
Philip D. Thompson Lectureship at the National Center for Atmospheric Research, 2004
Nora L. Wiley Award for Meritorious Research from Montana State University, 2003
Karen Harvey Prize, Solar Physics Division of the American Astronomical Society, 2003
Presidential Early Career Award for Scientists and Engineers, 2000
National Science Foundation Faculty Early Career Development Award, 1997
Miller Fellowship for Basic Research in Science, 1993

UNIVERSITY SERVICE (select)

Faculty Senate Representative, 2007–2008
Member of University Technology Advisory Committee, 2006-present
Member of Information Technology Strategic Planning Committee, 2006
Member of College of Letters and Sciences Promotion, Retention & Tenure Committee 2006/07
Society of Physics Students, Faculty Advisor 2004–Present
Member of Physics Dept. Long Range Planning Committee 2008–Present
Chair of search committee for Observational Solar Astronomer, 2004/05
Search committee for Professor in ARC group, 2002–2004
Graduate Admissions & Recruiting committee 2004/05, 2006/07
Chair, Physics Department Exam committee 2004, 2009
Physics Department Exam committee 1997–2003, 2005–2006

PROFESSIONAL SERVICE (recent)

Dean of Heliophysics Summer School, Boulder, CO, 2010–2012
Member Representative in the Association of Universities for Research in Astronomy (AURA), 2008–present
Elected member of AURA's Solar Observatory Council (SOC), 2008–present
Editorial Board Member, *Solar Physics* 2008–present

Member of NASA Heliophysics Performance Assessment Committee of National Research Council, 2008–2009

Member of the Advanced Technology Solar Telescope Science Working Group, 2005–present

Member of National Research Council's Committee on Solar and Space Physics (CSSP), 2005–2010

Co-organizer of ten-week program, *Solar Magnetism and Related Astrophysics*, Institute for Theoretical Physics, Santa Barbara, Jan.–Mar. 2002

Chairman of NASA's Solar and Heliospheric Management Operations Working Group (SH-MOWG), 2001–2004

Member of NASA's Sun-Earth Connection Advisory Subcommittee (SECAS), 2001–2004

Solar Physics Division Committee of the American Astronomical Society (elected 2001), 2001–2004

Member, Panel on Solar Astronomy for the National Research Council's Survey of Astronomy and Astrophysics ("Decadal Survey"), 1999

REFEREED PUBLICATIONS (past 5 years, of 84 total)

1. "Reconstructing the Local Twist of Coronal Magnetic Fields and the Three-Dimensional Shape of the Field Lines from Coronal Loops in EUV and X-Ray Images", A. Malanushenko, D. W. Longcope, and D. E. McKenzie, *ApJ*, **707**, 1044–1063, (2009).

2. "Coronal Loop Expansion Properties Explained Using Separators", J. E. Plowman, C. C. Kankelborg, and D.W. Longcope, *ApJ*, **706**, 108–112, (2009).

3. "Sunspot Rotation, Flare Energetics and Flux Rope Helicity: The Eruptive Flare on 2005 May 13", M. D. Kazachenko, R. C. Canfield, D. W. Longcope, J. Qiu, A. Des Jardins, and R. W. Nightingale, *ApJ*, **704**, 1146–1158, (2009).

4. "Patchy reconnection in a Y-type current sheet", M. G. Linton, C. R. Devore, and D. W. Longcope, *Earth, Planets, and Space*, **61**, 573–576, (2009).

5. "Additive Self-helicity as a Kink Mode Threshold", A. Malanushenko, D. W. Longcope, Y. Fan, and S. E. Gibson, *ApJ*, **702**, 580–592, (2009).

6. "Signatures of Magnetic Stress Prior to Three Solar Flares Observed by RHESSI", A. Des Jardins, R. Canfield, D. Longcope, E. McLinden, and A. Dillman, *ApJ*, **693**, 886–893, (2009).

7. "Reconnection in three dimensions: The Role of spines in three eruptive flares", A. Des Jardins, R. Canfield, D. Longcope, C. Fordyce, and S. Waitukaitis, *ApJ*, **693**, 1628–1636, (2009).

8. "Effects of partitioning and extrapolation on the connectivity of potential magnetic fields", D. W. Longcope, G. Barnes, and C. Beveridge, *ApJ*, **693**, 97–111, (2009).

9. "The number of null points in the quiet Sun corona", D. W. Longcope and C. E. Parnell, *Sol. Phys.*, **254**, 51–75, (2009).

10. "Gas-dynamic shock heating of post-flare loops due to retraction following localized, impulsive reconnection", D. W. Longcope, S. E. Guidoni, and M. G. Linton, *ApJ. Lett.*, **690**, L18–L22, (2009).

11. "Defining and Calculating Self-Helicity in Coronal Magnetic Fields", D. W. Longcope and A. Malanushenko, *ApJ*, **674**, 1130–1143, (2008).

12. "Inferring Photospheric Velocity Fields Using Combination of Minimum Energy Fit, Local Correlation Tracking and Doppler Velocity", B. Ravindra, D. W. Longcope, and W. P. Abbett, *ApJ*, **677**, 751–768, (2008).

13. "Inductive magnetic footpoint tracking by combining the minimum energy fit with the local correlation tracking and doppler velocity", B. Ravindra and D. Longcope, *J. Astrophys. Astr.*, **29**, 63–67, (2008).

14. "Fast magnetosonic waves launched by transient, current sheet reconnection", D. W. Longcope and E. R. Priest, *Phys. Plasmas*, **14**, 122905-1 – 11, (2007).

15. "A Quantitative, Topological Model of Reconnection and Flux Rope Formation in a Two-Ribbon Flare", D. Longcope and C. Beveridge, *ApJ*, **669**, 621–635, (2007).

16. "Determining the Source of Coronal Helicity Though Measurements of Braiding and Spin Helicity Fluxes in Active Regions", D. W. Longcope, B. Ravindra, and G. Barnes, *ApJ*, **668**, 571–585, (2007).

17. "Modeling and Measuring the Flux Reconnected and Ejected by the Two-ribbon Flare/CME event on 7 November 2004", D. Longcope, C. Beveridge, J. Qiu, B. Ravindra, G. Barnes, and S. Dasso, *Sol. Phys.*, **244**, 45–73, (2007).

18. "Tests and Comparisons of Velocity Inversion Techniques", B. T. Welsch, W. P. Abbett, M. L. DeRosa, G. H. Fisher, M. K. Georgoulis, K. Kusano, D. W. Longcope, B. Ravindra, and P. W. Schuck, *ApJ*, **670**, 1434-1452, (2007).

19. "A model for patchy reconnection in three dimensions", M. G. Linton and D. W. Longcope, *ApJ*, **642**, 1177–1192, (2006).

20. "A hierarchical application of the Minimum Current Corona", C. Beveridge and D. W. Longcope, *ApJ*, **636**, 453–461, (2006).

21. "A hierarchical application of the Minimum Current Corona", C. Beveridge and D. W. Longcope, *ApJ*, **636**, 453–461, (2006).

22. "Coronal Flux Recycling Times", R. M. Close, C. E. Parnell, D. W. Longcope, and E. R. Priest, *Sol. Phys.*, **231**, 45–70, (2005).

23. "Implementing a Magnetic Charge Topology Model for Solar Active Regions", G. Barnes, D. W. Longcope, and K. D. Leka, *ApJ*, **629**, 561–571, (2005).

24. "Topological Methods for the Analysis of Solar Magnetic Fields", D. W. Longcope, *Liv. Rev. Solar Phys.*, **2**, (2005), Online Article.

25. "Observations of separator reconnection to an emerging active region", D. W. Longcope, D. McKenzie, J. Cirtain, and J. Scott, *ApJ*, **630**, 596–614, (2005).

26. "On Three-Dimensional Magnetic Skeleton Elements due to Discrete Flux Sources", C. Beveridge and D. W. Longcope, *Sol. Phys.*, **227**, 193–206, (2005).

27. "Coronal Heating at Separators and Separatrices", E. R. Priest, D. W. Longcope, and J. Heyvaerts, *ApJ*, **624**, 1057–1071, (2005).

Associate Professor Dr. Galina MALOVICHKO

Physics Department, Montana State University
243 EPS, Bozeman, Montana 59717. The USA

Phone: (406) 994-3474 (Office)
e-mail: malovichko@physics.montana.edu
http://www.physics.montana.edu/eprlab/
http://www.physics.montana.edu/faculty/malovichko/

Current research interests

Magnetic resonance of intrinsic, extrinsic and radiation defects in photonic materials, nanostructures and materials for telecommunications and computing.

Education

Ph.D. (Phys. and Math.), Institute for Problems of Material Sciences, Kiev, Ukraine.
M.Sc. in Physics with excellence, Rostov-on-Don State University, USSR

Positions

2002 – to present Associate Professor (tenure), Physics Department, Montana State University, the USA
2002-1997 senior research scientist; Osnabrück University, Germany
1996-1994 research scientist; 1. Physikalische Institut der J.-L. Universität Giessen, Germany
1994-1978 head of the group, senior research scientist; research scientist, junior research scientist, postgraduate student, and engineer; Institute for Problems of Material Sciences, Academy of Sciences of Ukraine, Kiev, Ukraine

Awards

Nominated for "***President's Excellence in Teaching Award***", MSU, Montana (2007).
APS award for Professional Skills Development Workshop, Baltimore, Maryland (2006).
Outstanding Faculty Award, Physics Department, MSU, Montana (2004).

Awarded Grants in the USA (Principal Investigator – G.Malovichko)

1. "Multifrequency spectroscopy of rare-earth and transition ions in optical materials", **NSF**, $342,000, 8/1/2008-7/30/2011.

2-12. **NASA**, $110,010, 2007-2008; **NASA**, $160,010, 2006-/2007; **DURIP DoD**, $264,886, 2006-2007; **NFSAT / CRDF**, $30,000, 2006-2007; **NASA EPSCoR**, $39,951. 2005-2006; **MBRCT**, $240,000, 2005-2007; **NASA**, $95,254, 2005-2006; **NSF**, $7,000, 2005-2006; **NSF**, $7,000, 2004-2005; **NSF**, $339,870, 2003-2006; **NSF EPSCoR**, $57,000, 2002-2003.

Grants and awards in Europe (2004-1990, PI or Co-PI)

15 awards and grants from European Scientific Foundation, German DFG and DAAD, French CNRS, INTAS-96, INTAS-94, Science and Technology Center of Ukraine, Ukrainian Ministry of Science, and industry (total about €900,000).

Teaching

Courses for graduate and undergraduate students of Physics, Chemistry and Biochemistry, Chemical and Biological Engineering, and Electrical and Computer Engineering Departments: ***Novel Materials for Physics and Engineering*** **(2010, 2008, 2006),** ***Quantum Mechanics*** **1 (2007, 2004),** ***Solid State Physics*** **(2007, 2005, and 2003),** ***Condensed Matter Physics*** **1 (2008, 2006, 2004),** ***Condensed Matter Physic*****s 2 (2009, 2005, 2003),** ***Magnetic resonance*** **(seminar, 2010, 2009, 2008),** ***Undergraduate research / Creative activity*** **(2008, 2007, 2006, 2005, and 2004),** ***Independent study*** **(2009, 2007).**

Selected service

Member of the Award Nomination Committee of the International EPR/ESR Society
Chair of sessions at seven international conferences
Panel member: NSF; Directorates of Engineering (DEPDT), and Math. and Phys. Sci. (DMR).
Book reviewer: John Wiley & Sons, Inc.
Manuscript reviewer: PRL, PRB, APL, JAP, JMR, JPCM, JPCS, PSS, JCG, AMR, etc.
Internal service. Committees: Search for Condensed Matter Physics theorist; Shop, Space and Services; Graduate; Graduate Recruiting; Graduate Admission, etc.

Publication summary

- Scientific articles in refereed journals – 53
- Invited presentations at national and international academic conferences - 20
- Proceedings of the academic conferences - 9
- Contributed talks and published contributions to academic conferences - 78
- Invited colloquiums, lectures and seminars – 33.

Recent publications in refereed journals and books

G.Malovichko, V.Bratus, V.Grachev, E.Kokanyan. Electron paramagnetic resonance and electron-nuclear double resonance study of nonequivalent Yb^{3+} centers in congruent and nearly stoichiometric lithium niobate. *Physica Status Solidi (b*): **246**, No. 1, 215–225 (2009).

G.Malovichko, V.Grachev, J.Jorgensen, M.Meyer, M.Munro, B.Todt, I.Vrable, E.Kokanyan, V.Bratus, S.Okulov. Magnetic resonance study of non-equivalent centers created by 4f-Ions in congruent and stoichiometric lithium niobate. MRS Proceedings. v. **1111**. D01-03 (2009).

G.Malovichko, V.Bratus, M.Munro, E.Kokanyan, S.Okulov, V.Grachev. Multifrequency spectroscopy of laser active centers Nd^{3+} and Yb^{3+} in nearly stoichiometric $LiNbO_3$. *Physica Status Solidi* (c), **4**, 1346–1351 (2007).

G.Malovichko, V.Grachev, T.Rust, V.Pankratov. Flight to Mars and radiation defects in $Li_2B_4O_7$ and $KTiOPO_4$. *Physica Status Solidi* (c), **4**, 1288–1292 (2007).

G.Malovichko, R.Petersen, Ch.Bäuman, V.Grachev. Second axial Fe^{3+} center in stoichiometric lithium tantalate. *Journal of Applied Physics,* **100***, 023911* (2006).

I.Schepetkin, A.Potapov, A.Khlebnikov, E.Korotkova, A.Lukina, G.Malovichko, L.Kirpotina, and M.Quinn. Decomposition of reactive oxygen species by copper(II) bis(1-pyrazolyl)methane complexes. *J Biol. Inorg. Chem*., **11**, 499-513 (2006)

B.Briat, V.G.Grachev, G.I.Malovichko, O.F.Schirmer, M.Wöhlecke. Defects in inorganic photorefractive materials and their investigations. Chapter in the book "*Springer Series in Optical Sciences,* v. 114: Photorefractive Materials and Applications 2", ed. by P.Günter and J.-P.Huignard. pp. 9-49 (2007).

G.Malovichko, V.Grachev, S.Okulov, E.Kokanyan, F.Henecker, A.Hofstaetter, O.Schirmer. EPR of Nd^{3+} in congruent and nearly stoichiometric lithium niobate. *Physica Status Solidi (b*), **243**, 409-415 (2006) (Editor Choice).

G.Malovichko, V.Grachev, O.Schirmer. Multifrequency spectroscopy of defects in complex oxides. *Physica Status Solidi (a)*, **202**, 207-221 (2005).

V.Grachev, G.Malovichko, O.Schirmer. Structures of point defects in lithium niobate. *Ukrainian Journal of Physics*, **49**, 438-448 (2004).

G.Malovichko, V.Grachev and O.Schirmer. Point Defects and Physical Properties of Ferroelectrics. Lithium Niobate. *Fundamental Physics of Ferroelectrics 2003.* Ed. by P.K.Davies and D.J.Singh, AIP Conference Proceedings, **677**, 196-203 (2003).

G.Malovichko, V.Grachev, A.Hofstaetter, E.Kokanyan, A.Scharmann, O.Schirmer. ENDOR study of Cr^{3+} centers substituting for lithium in lithium niobate. *Physical Review,* **B65**, 224116 (2002).

Recent invited presentations at academic conferences

G.Malovichko, V.Grachev, J.Jorgensen, M.Meyer, M.Munro, R.Petersen, I.Vrable, E.Kokanyan, V.Bratus, S.Okulov. Non-Equivalent Centers in Congruent and Stoichiometric $LiNbO_3$ and $LiTaO_3$. *International Scientific Workshop. "Oxide Materials for Electronic Engineering – fabrication, properties and application" (OMEE-2009).* Lviv, Ukraine (2009).

V.Grachev, J.Jorgensen, M.Meyer, V.Pankratov, Ya.Burak, A.Hunt, G.Malovichko. Trace Impurities, Intrinsic and Radiation Defects in Oxide Materials. *International Scientific Workshop. "Oxide Materials for Electronic Engineering – fabrication, properties and application".* Lviv, Ukraine (2009).

G.Malovichko, V.Grachev, J.Jorgensen, M.Meyer, M.Munro, B.Todt, I.Vrable, E.Kokanyan, V.Bratus and S.Okulov. Magnetic resonance study of non-equivalent centers created by 4f-ions in congruent and stoichiometric lithium niobate. *MRS Fall meeting*, Boston, USA (2008).

G.Malovichko, V.Grachev, M.Meyer, J.Jorgensen, T.Rust. Characterization of nonlinear optical crystals by the EPR. *Technical Meeting at Goddard Flight Space Center,* NASA (2007).

G.Malovichko, V.Bratus, M.Munro, E.Kokanyan, S.Okulov, V.Grachev. Multifrequency spectroscopy of laser active centers Nd^{3+} and Yb^{3+} in nearly stoichiometric $LiNbO_3$. *Euro-physical Conference on Defects in Insulating Materials (EURODIM 2006),* Milan, Italy, 2006.

G. Malovichko, V.Grachev. Luminescence, optical absorption and magnetic resonance of transition and rare earth impurities in lithium niobate. *6th European Conference on Luminescence Detectors and Transformers of Ionizing Radiation (LUMDETR 2006)*, Lviv, Ukraine (2006).

G.Malovichko, V.Grachev, O.F.Schirmer. Multiresonance, multifrequency spectroscopy of rare-earth and transition ions in lithium niobate. *International conference "$LiNbO_3$, from material to device, from device to system"*, Metz, France (2005).

G.Malovichko, V.Grachev, O.Schirmer. Multifrequency spectroscopy of defects in complex oxides. *International Conference on Defects in Insulating Materials*, Riga, Latvia (2004).

G.Malovichko, V.Grachev. Spectroscopic Study of Interrelations of Extrinsic and Intrinsic Defects in Lithium Niobate. *Photorefractive Workshop*, Florida, USA (2003).

V.Grachev, G.Malovichko, O.Schirmer. Comparison of the EPR and ENDOR data of $LiNbO_3$:Fe, $LiTaO_3$:Fe and $KTaO_3$:Fe. *Photorefractive Workshop*, Florida, USA (2003).

V.Grachev, G.Malovichko. EPR, ENDOR, NMR and optical study of materials for optical telecommunication. *International scientific - practical Conference "Spectroscopy in special application"*, Kyiv, Ukraine (2003).

G.Malovichko, V.Grachev, O.Schirmer. Point Defects and Physical Properties of Ferroelectrics. Lithium Niobate. *Fundamental Physics of Ferroelectrics 2003.* Williamsburg, USA (2003).

Recent invited colloquiums

G.Malovichko. EPR/ENDOR of transition ions in congruent and stoichiometric lithium niobate and tantalate. *Department of Nonlinear Optics*, *Osnabrueck University*, Germany (2007).

G.Malovichko. EPR, ENDOR and optical study of radiation defects in complex oxides. *Idaho State University*, Pocatello, Idaho, USA (2006).

Professional Affiliations:

American Physical Society
Optical Society of America
Material Research Society
International EPR/ESR Society.

Petrus C. Martens
Research Professor, Physics Department, Montana State University
Smithsonian Research Associate, Harvard-Smithsonian Center for Astrophysics
http://solar.physics.montana.edu/martens

Research: Solar physicist with experience in theoretical modeling, data analysis, automated feature recognition, and space instrumentation. Recent work includes automated feature recognition in solar imagery, long-term solar activity in the context of the Sun-Earth connection, coronal loops, solar flares, filament eruptions, and dynamos in the context of the solar-stellar connection. Space mission involvement with Yohkoh, SoHO, TRACE, Hinode, and SDO.

Education and Postdoctoral Positions:

B.A. Astronomy	1977	University of Utrecht, The Netherlands
M.A. Astronomy	1979	University of Utrecht
Ph.D. Astrophysics	1983	University of Utrecht (Cum Laude)

Postdoc, Laboratory for Space Research, Utrecht University, 1983-1984
National Academy of Sciences-NRC Research Associate, NASA-GSFC, 1984-1987
Special Studies in Management and Administration, Harvard University Extension School, 1988-1990

Professional History:

Current:	Research Professor, Physics Dept, Montana State University
2008 - 2009	Astrophysicist, Smithsonian Astrophysical Observatory
2004 - 2007	Research Professor, Physics Dept, Montana State University
1999 - 2004	Associate Research Professor, Montana State University
1993 - 1998	European Space Agency, SoHO Science Operations Coordinator
1990 - 1993	Lockheed Solar & Astrophysics Lab, Research Scientist
1987 - 1990	Harvard-Smithsonian Center for Astrophysics, Astrophysicist

Synergistic Activities:
- Lead on the NASA project "Design and Operation of a Solar Dynamics Observatory Science Center", a $ 3 million 4 year project to design and implement automated feature recognition for SDO and related solar physics observatories (2008-current)
- Co-founder and Co-I of the Virtual Solar Observatory (2000-current)
- Associate Editor, The Astrophysical Journal Letters (2005-current)
- Initial PI on NSF funded Research Experience for Undergraduates programs at Montana State University and at the Smithsonian Astrophysical Observatory
- Member, NASA Living With a Star Targeted Research & Technology Steering Committee (2009-2010)
- Member, NASA Solar & Heliospheric Management Operations Working Group (2007-2010)
- Chair of LWS TR&T Focus Team: "Solar Modulation of the galactic cosmic rays and the production of cosmogenic isotope archives of long-term solar activity, used to interpret past climate changes." (2008-current)

Graduate Students: Jonathan Cirtain, PhD in May 2005; Henry Winter, PhD May 2009. Barry Vanderhorst and Patricia Jibben, Master's degrees in 2005. Current graduate students are Andres Munoz (graduation September 2010), Jason Scott, and Ernest Amouzou.

Publications: Author and co-author of more than a hundred scientific publications. More than twenty of those are written with students and postdocs, usually with the student as first author. For a full list of publications, see: **http://solar.physics.montana.edu/martens/biblio.html**
Relevant recent publications:

- "Computer Vision for the Solar Dynamics Observatory", P.C.H. Martens et al., Solar Phys. 2010, submitted**:** http://solar.physics.montana.edu/martens/computer-vision09-v2.pdf
- "Scaling Laws and Temperature Profiles for Solar and Stellar Coronal Loops with Non-uniform Heating", P.C.H. Martens, Astrophys. J. 2010, in press: http://solar.physics.montana.edu/martens/papers/v3+proofs-apjformat.pdf
- "The Virtual Solar Observatory -- A Resource for International Heliophysics Research" (Invited Contribution), Frank Hill, Piet Martens et al. 2009, in: "Proceedings of the UN/ESA/NASA/Japan Workshop", eds. G. Eichhorn and H. Haubold, Earth, Moon, and Planets 104(10), 315-330.
- "Helioseismic Data Inclusion in Solar Dynamo Models", Andres Munoz-Jaramillo, Dibyendu Nandy, Petrus C.H. Martens, Astrophys. J. 2009, 698(1), 461-478.
- "Space Climate and the Solar-Stellar Connection: What Can We Learn From the Stars About Long-term Solar Variability" (Invited Review), Dibyendu Nandi and P.C.H. Martens, Advances in Space Research 2007, 40(7), 891-898. Reprint at: http://solar.physics.montana.edu/martens/papers/nandi_romania06.pdf

Presentations: Seminars and invited conference talks several times a year. Some relevant recent ones:

- Invited plenary talk: "Computer Vision for SDO: First Results from the SDO Feature Finding Algorithms", Petrus C. Martens et al., AAS Solar Physics Division Annual Meeting, Miami FL, May 2010.
- Invited presentation: "The Faint Young Sun Paradox", Committee on the Origin and Evolution of Life (COEL), Space Science Board of the NAS, annual meeting in Big Sky, MT, September 2009.
- Invited plenary talk: "The Unusual Minimum of Cycle 23: Observations and Interpretation", Petrus C. Martens, D. Nandy, A. Munoz-Jaramillo, AAS Solar Physics Division Annual Meeting, Boulder CO, June 2009.
- Invited plenary talk: "The Faint Young Sun Problem", International Workshop on "Solar Variability, Earth's Climate and the Space Environment", Bozeman, Montana, June 2008.

Current and pending grants and contracts:

Title: Design and Operation of an SDO Science Center
PI: Self
Agency/Program: NASA/SH
Performance Period: 01/01/2009-12/31/2012
Amount: $ 3,118,601.00

Title: Evolving Solar Magnetic Activity on Timescales Relevant for Space Climate
PI: Self
Agency/Program: NASA/LWS
Performance Period: 07/01/2008-06/30/2011
Amount: $ 496,567

Title: Virtual Solar Observatory: Implementation and Maintenance
PI: Dr. Frank Hill (NSO)
Agency/Program: NASA
Performance Period: 01/01/2010 - 12/31/2013
Amount: $ 40,000 (MSU subcontract)

Title: Atmospheric Imaging Assembly for the Solar Dynamics Observatory
PI: Dr. Alan Title (LMSAL)
Agency/Program: NASA/SDO
Performance Period: 09/01/2004 - 11/30/2013
Amount: Part of MSU subcontract

Title: Magnetic Origins of Solar Irradiance Variations
PI: Self
Agency/Program: NASA/LWS
Performance Period: 09/01/2007 - 08/31/2010
Amount: $ 339,000

Title: Diagnostic Modeling of Flaring and Quasi-static Coronal Loops
PI: Self
Agency/Program: NASA/SR&T
Performance Period: 10/21/2008 - 10/20/2011
Amount: $ 406,893

Pending:

Title: Large-scale Content-based Image Retrieval System (CBIR) for Interactive Search through the Virtual Solar Observatory
PI: Prof. Rafal Angryk (Computer Science, MSU)
Agency/Program: NASA/Epscor
Performance Period: 10/01/2010 – 09/30/2013
Amount: $ 1,100,000

DAVID E. McKENZIE

Department of Physics
P.O. Box 173840
Montana State University
Bozeman, MT 59717-3840
Ph: (406) 994-7843
e-mail: mckenzie@physics.montana.edu

Education:

Ph.D., May 1997
Department of Physics and Astronomy
University of Delaware, Newark, DE

M.S., August 1993
Department of Physics and Astronomy
University of Delaware, Newark, DE

B.S., May 1989
Department of Physics, Christian Brothers University, Memphis, TN

Appointments:

2009-date, Associate Research Professor, Physics Department, Montana State University–Bozeman

2004-2009, Assistant Research Professor, Physics Department, Montana State University–Bozeman

1998-2002, Research Scientist, Physics Department, Montana State University–Bozeman

1997-1998, Postdoctoral Research Associate, Montana State University–Bozeman

Research Interests

Solar flares and coronal activity; Magnetic reconnection; Education and Public Outreach

Relevant Publications

McKenzie, D.E., and Savage, S.L. "Quantitative Examination of Supra-Arcade Downflows in Eruptive Solar Flares", *Ap.J* **697**, 1569 (2009).

McKenzie, D.E., and Canfield, R.C. "Hinode X-ray Observations of a Long-Lasting Coronal Sigmoid", *Astronomy & Astrophysics Letters,* **4**81, 65 (2008).

Longcope, D.W., McKenzie, D.E., Cirtain J. and Scott, J. "Observations of separator reconnection to an emerging active region", *Ap.J* **630**, 596 (2005).

Innes, D.E., McKenzie, D.E. and Wang, T. "Observations of 1000 km s^{-1} Doppler Shifts in 10^7 K Solar Flare Supra-Arcade", *Sol. Phys.* **217**, 267 (2003).

Innes, D.E., McKenzie, D.E. and Wang, T. "SUMER Spectral Observations of Postflare Supra-Arcade Inflows", *Sol. Phys.* **217**, 247 (2003).

McKenzie, D.E. "Signatures of Reconnection in Eruptive Flares (Invited Review)", in *Multi-Wavelength Observations of Coronal Structure and Dynamics,*, P.C.H. Martens & D.P. Cauffman, eds., COSPAR Colloquia Series, Elsevier Science Ltd. pub. (2002), **13**, 155.

Berghmans, D., McKenzie, D., and Clette, F. "Active Region Transient Brightenings: A Simultaneous view by TRACE, EIT, and SXT", *Astronomy & Astrophysics,* **3**69, 291 (2001).

McKenzie, D.E. "Supra-arcade Downflows in Long-Duration Solar Flare Events", *Sol. Phys.* **195**, 381 (2000).

McKenzie, D.E. and Hudson, H.S. "X-Ray Observations of Motions and Structure Above a Solar Flare Arcade", *Ap.J* **519**, L93 (1999).

Canfield, R.C., Hudson, H.S., and McKenzie, D.E. "Sigmoidal Morphology and Eruptive Solar Activity", *Geophys. Res. Letters,* **2**6, 627 (1999).

Relevant Prior Scientific/Technical/Management Performance

PI for "Progenitors to Geoeffective Coronal Mass Ejections: Filaments and Sigmoids", Funding Agency: NASA, Period & Amount Funded: 05/2003-05/2007, $307k

PI for "Supra-Arcade Downflows and Three-Dimensional Models of Magnetic Reconnection", Funding Agency: NASA, Period & Amount Funded: 01/2004-12/2007, $192k

Co-I (Institution PI) for "Atmospheric Imaging Assembly for Solar Dynamics Observatory", Funding Agency: NASA/Subcontract from Lockheed Martin, Period & Amount Funded: 09/2004-02/2014, $971k

Co-I (Institution PI) for "X-Ray Telescope for Solar-B: Mission Operations and Data Analysis", Funding Agency: NASA/Subcontract from Harvard-Smithsonian Astrophysical Observatory, Period & Amount Funded: 01/2007-10/2009, $714k

Co-I for "Quantitative Measurements of Magnetic Reconnection to and from Emerging Active Regions", Funding Agency: NASA, Period & Amount Funded: 01/2007-12/2009, $323k

Co-I for "Resident Archive Services and Maintenance of the Yohkoh Legacy Archive", Funding Agency: NASA, Period & Amount Funded: 10/2008-09/2010, $105k

Dr. John Jacob Neumeier
Department of Physics
Montana State University
Bozeman, MT 59717, USA
phone: (406) 994-6171
email: neumeier@physics.montana.edu

Education

Ph.D.	Physics, University of California, San Diego, 1990 (with Prof. M. B. Maple).
M.S.	Physics, University of California, San Diego, 1986.
B.S.	Physics, Stockton State College, New Jersey, 1984.

Employment History

2007-	Professor of Physics at Montana State University.
2002-2007	Associate Professor of Physics at Montana State University.
1996-2002	Assistant Professor of Physics at Florida Atlantic University.
1993-1996	Postdoctoral Fellow at Los Alamos National Laboratory, supervisor: Dr. J. D. Thompson.
1990-1993	Postdoctoral Research, Physics Department, University of Munich, Munich, Germany, supervisor: Prof. J. S. Schilling.
1985-1990	Research Assistant, University of California, San Diego.
1984-1985	Teaching Assistant, University of California, San Diego.
1984	American Physical Society Intern at General Motors Research, Michigan.
1983	Summer Research Assistant, Brookhaven National Laboratory, New York.

Guest Appointments

2001	Guest Faculty Researcher, Argonne National Laboratory (May through September).
1997-1998	Visiting Scientist, Walther-Meissner-Institut, Garching, Germany (June and July).

Research Interests

Condensed matter and low temperature physics with emphasis on the thermodynamic properties of novel electronic and magnetic materials.

Awards

2009	Undergraduate Lecturing Instructor Award.
2002	Florida Atlantic University Distinguished Teacher of the Year Award.
2000	Teacher Incentive Program Award for excellence in teaching at Florida Atlantic University during the academic years 1997-1998 through 1999-2000.
2000	National Science Foundation CAREER Award.

Professional Affiliations

Member of the American Physical Society and the Neutron Scattering Society of America.

Editorial Activities

Journal Referee: Physical Review Letters, European Physics Letters, Physical Review B, Solid State Communications, Philosophical Magazine B, Physica C, Journal of Solid State Chemistry, and Journal of the Physics and Chemistry of Solids.
Proposal Review: National Science Foundation, Department of Energy, Petroleum Research Fund, and Research Corporation.

Research Supervision

Directed Professor Schilling's Munich research group (September 1990 - March 1993). Supervised Diplom (Masters) research of three University of Munich students : Andreas Schlögl (June 1992), Horst Zimmermann (June 1992), and Thomas Masselink (December 1992). Supervised the Masters thesis research of FAU students Daniel Goodwin (June 1999), Hirotoshi Terashita (September 1999), Juscelino Leao (July 2002), Emerson Timmins (July 2002). Supervised the Doctoral Thesis of FAU students Guoqing Wu (July 2002) and Hirotoshi Terashita (February 2005). Presently supervising the research of two Ph.D. students. Supervised four postdoctoral scholars at MSU: Carlos dos Santos (8/05-8/07), Jose Souza (4/07-10/08), Mario da Luz (10/07-4/09), and Ariana de Campos (10/07-2/08). Mentored 17 undergraduate researchers at MSU including 5 Capstone projects.

Director: MSU's Condensed Matter REU and RET Programs, this program provided summer research opportunities for 56 undergraduates and 10 teachers from 2003 through 2009.

Teaching Experience

College Physics I and II (3 semesters), General Physics I and II (nine years), Physical Science (two sections in 1998), Undergraduate Statistical and Thermal Physics (five semesters), Undergraduate Condensed Matter Physics (two semesters), Undergraduate Electromagnetism I (two semesters), Graduate Statistical Mechanics (one semester), Teaching assistant for the Advanced Physics Laboratory at the University of Munich (three years), Modern Physics Laboratory at the University of California (one year), and General Physics at the University of California (one semester).

Grant Activity (since arriving at MSU on 8/15/02)

Growth and Physical Properties Measurements of Novel Condensed Matter Materials, National Science Foundation, $345,000, 8/1/09 – 7/31/12, PI: John J. Neumeier.

REU Site: Condensed Matter and LASER Physics REU Program at Montana State University, National Science Foundation, $352,000, 5/1/06 – 4/30/10, PI: John J. Neumeier, Co-PI: Yves Idzerda.

Linear Thermal Expansion Measurements with Sub-Atomic Resolution for the Study of Phase Transitions in Novel Condensed Matter Systems, Department of Energy, $374,671, 1/31/06-1/31/10, PI: John J. Neumeier, no Co-PI.

Supplement to Growth and Physical Properties Measurements of Novel Condensed Matter Materials, National Science Foundation, $39,202, 12/30/05-6/30/08, PI: John J. Neumeier, no Co-PI.

Growth and Physical Properties Measurements of Novel Condensed Matter Materials, National Science Foundation, $315,000, 1/7/05 – 6/30/08, PI: John J. Neumeier, no Co-PI.

Montana State University REU Site Program : A Materials Research Education, National Science Foundation, $217,000, 5/1/03 – 8/31/05, PI: John J. Neumeier, Co-PI: Yves Idzerda.

Supplement to Montana State University REU Site Program : A Materials Research Education, National Science Foundation, $86,500. These funds support two K-12 or community college teachers each summer for three years. PI: John J. Neumeier, Co-PI: Yves Idzerda.

Acqusition of an Optical Image Furnace for Single Crystal Growth, Materials Research, and Education, National Science Foundation, $142,723. PI: John Neumeier.

CAREER: Synthesis and investigation of novel condensed matter compounds and development of a high-resolution capacitive dilatometer, National Science Foundation $359,967 with $114,220 transferred to MSU, 02/28/00-01/30/05, PI: John Neumeier, no Co-PI.

Metamagnetism and Unconventional Superconductivity in f and d-electron systems,

systems, Internal proposal for the National High Magnetic Field Laboratory, funded by the NSF, $210,382, 05/01/03 – 04/31/05, PI: Zachary Fisk, co PIs: Luis Balicas and John Neumeier. This was an internal NHMFL grant.

Personal

Citizenship: United States of America.
Marital Status: married with three children.
Foreign language: fluent in German.

Publications and Journal Citations

More than 100 refereed publications. They have been cited over 5250 times (h index = 37).

Most Significant Publications during MSU Employment

Electrical transport in $Li_{0.9}Mo_6O_{17}$: A two-band Luttinger liquid exhibiting Bose metal behavior, C. A. M. dos Santos, M. S. da Luz, Y.-K. Yu, J. J. Neumeier, J. Moreno, and B. D. White, Phys. Rev. B 77 (2008) 193106 (4 pages). - *Electrical transport study showing that superconductivity can be easily destroyed through the introduction of defects. Scaling of electrical resistivity in magnetic field shows that the behavior is identical to disordered thin films exhibiting Bose metal behavior – a state where superconductivity occurs in isolated regions that are not phase coherent with one another. This is the first bulk material to show such behavior. Cited 1 time.*

Magnetic signatures of ferromagnetic polarons in $La_{0.7}Ca_{0.3}MnO_3$,: Colossal magnetoresistance is not a Griffiths singularity, J. A. Souza, J. J. Neumeier, and Y.-K. Yu, Phys. Rev. B. 78 (2008) 014436 (5 pages). - *This investigation of the magnetic properties revealed the onset of an unusual local ferromagnetic state well above the transition temperature to ferromagnetism. Observation required the use of extremely small magnetic fields. We were able to argue that a previous claim of Griffiths phase behavior was incorrect. Cited 6 times.*

Capacitive-based dilatometer cell constructed of fused quartz for measuring the thermal expansion of solids, J. J. Neumeier, R. K. Bollinger, G. E. Timmins, C. R. Lane, R. D. Krogstad, and J. Macaluso, Rev. Sci. Instrum. 79 (2008) 33903 (8 pages). - D*escribes the first thermal expansion cell constructed entirely from fused quartz. Because the thermal expansion of fused quartz is extremely small, this cell performs exceedingly well when compared to conventional cells made from copper. Design, construction, thermometry, and performance are described. This project took over 8 years, and was conducted with graduate and undergraduate students. Cited 5 times.*

Dimensional crossover in the Purple Bronze $Li_{0.9}Mo_6O_{17}$, C. A. M. dos Santos, B. D. White, J. J. Neumeier, Y.-K. Yu, and J. A. Souza, Phys. Rev. Lett. 98 (2007) 266405 (4 pages). - *This thermal expansion study illustrates how a low dimensional compound can crossover to higher dimension when the conducting chains (the main structural element) move closer together as the temperature is lowered. The concept of dimensional crossover is very important in theories for Luttinger liquids, and can lead to superconductivity or unusual charge density wave states. Cited 9 times.*

Negative thermal expansion of MgB_2 in the superconducting state and anomalous behavior of the bulk Grüneisen parameter, J. J. Neumeier, T. Tomita, M. Debassai, J. S. Schilling, P. W. Barnes, D. G. Hinks, and J. D. Jorgensen, Phys. Rev. B **72** (Rapid Communication), 220505(R) (2005). - *A high resolution thermal expansion investigation of the normal to superconducting phase transition of an important superconductor. The results illustrate unusual behavior in the thermal expansion coefficient which leads to an anomalous Grüneisen parameter in the vicinity of the transition. This suggests anomalous phonon behavior that is connected to the superconductivity in this system. In this paper, the only published description of my quartz thermal expansion cell is provided. Cited 10 times.*

Method for analyzing second-order phase transitions: application to the ferromagnetic transition of a polaronic system, J. A. Souza, Yi-Kuo Yu, J. J. Neumeier, H. Terashita, and R. F. Jardim, Phys. Rev. Lett. **94**, 207209 (2005).
A new method for analyzing phase transitions in condensed matter systems. Utilizes thermal expansion and heat capacity data simultaneously to determine: (1) whether or not a phase transition is second-order and (2) the pressure dependence of the transition temperature. Application to a complex ferromagnetic system illustrate that the phase transition is indeed second order. Cited 21 times

Other Recent Publications (2007-2010)

High resolution measurements of the thermal expansion of Co-doped $BaFe_2As_2$, M. S. da Luz, J. J. Neumeier, R. K. Bollinger, A. S. Sefat, M. A. McGuire, R. Jin, B. C. Sales, and D. Mandrus, Phys. Rev. B **79**, 214505 (2009) (6 pages).

Magnetic, transport, and thermodynamic properties of $CaMn_2O_4$ single crystals, B. D. White, J. A. Souza, C. Chiorescu, J. J. Neumeier, and J. L. Cohn, Phys. Rev. B **79**, 104427 (2009) (9 pages).

Electrical resistivity, high resolution thermal expansion, and heat capacity measurements of gamma-Mo_4O_{11}, M. S. da Luz, A. de Campos, B. D. White, J. J. Neumeier, Phys, Rev. B **79**, 233106 (2009) (4 pages).

Magnetic signatures of ferromagnetic polarons in $La_{0.7}Ca_{0.3}MnO_3$,: Colossal magnetoresistance is not a Griffiths singularity, J. A. Souza, J. J. Neumeier, and Y.-K. Yu, Phys. Rev. B. **78**, 014436 (2008) (5 pages).

Crystal growth and characterization of Marokite $CaMn_2O_{4+\delta}$, B. D. White, C. A. M. dos Santos, J. A. Souza, K. J. McClellan, and J. J. Neumeier, J. of Crystal Growth **310**, 3325-3330 (2008).

Hydrostatic pressure effects on the electrical transport properties of $Pr_{0.5}Sr_{0.5}MnO_3$, F. J. Rueckert, M. Steiger, B. K. Davis, T. Huynh, J. J. Neumeier, and M. S. Torikachvili, Phys. Rev. B **77**, 64403 (20089) (6 pages).

Magnetic-polaron-driven magnetoresistance in the pyrochlore $Lu_2V_2O_7$, H. D. Zhou, E. S. Choi, J. A. Souza, J. Lu, Y. Xin, L. L. Lumata, B. S. Conner, L. Balicas, J. S. Brooks, J. J. Neumeier, and C. R. Wiebe, Phys. Rev. B Rapid Commun. **77**, 20411 (2008) (4 pages).

Anisotropic electrical resistivity of quasi-one-dimensional $Li_{0.9}Mo_6O_{17}$ determined by the Montgomery Method, M. S. da Luz, C. A. M. dos Santos, J. Moreno, B. D. White, and J. J. Neumeier, Phys. Rev. B **76**, 233105 (2007) (3 pages).

Relationship between macropscopic physical properties and local distortions of low-doping $La_{1-x}Ca_xMnO_3$: An EXAFS study, Y. Jiang, F. Bridges, L. Downward, and J. J. Neumeier, Phys. Rev. B **76**, 224428 (2007) (11 pages).

Impurity Conduction in and magnetic polarons in antiferromagnetic oxides, C. Chiorescu, J. L. Cohn, and J. J. Neumeier, Phys. Rev. B Rapid Commun. **76**, 20404 (2007) (4 pages).

Curriculum Vitae of Jiong Qiu

Education:

B. S. in Astronomy, July 1993, Department of Astronomy, Nanjing University, China
Ph. D. in Astrophysics, July 1998, Department of Astronomy, Nanjing University, China

Appointments:

2005 - present: Assistant Professor, Physics Department, Montana State University
2004 - 2005: Associate Research Professor, Physics Department, New Jersey Institute of Technology (NJIT)
2001 - 2004: Assistant Research Professor, Physics Department, NJIT
1998 - 2001: Postdoctoral Research Associate, Big Bear Solar Observatory, NJIT

Awards:

2007: Karen Harvey Prize by Solar Physics Division/American Astronomical Society
2008: NSF CAREER Award

Professional Societies:

1999 - present: American Astronomical Society (AAS), Solar Physics Division (SPD);
1999 - present: American Geophysical Union (AGU)

Current Grants:

“NSF CAREER: Magnetic Reconnection on the Sun: an Observational Investigation", NSF ATM; role: PI; total award amount: $479,518; total award period: 1/1/2008 - 12/31/2012
“An Observational Study of Loop Oscillations in the Active Corona", NASA SHP, role: PI; total amount: $364,281; total Award Period: 12/14/2007 - 12/13/2010

Total Postdoctoral Associates and Graduate Students Advised: Postdoc. Assoc. (2), M.S. (1), Current graduate students (2), current postdoc. (1)

Total Conference Presentations: 50+, invited: 5

Publications: 60; including the recent publications:
“Sunspot Rotation, Flare Energetics, and Flux Rope Helicity: The Eruptive Flare on 2005 May 13", Kazachenko, Maria D.; Canfield, Richard C.; Longcope, Dana W.; Qiu, Jiong; Des Jardins, Angela; Nightingale, Richard W., 2009, ApJ, 704, 1146
“Observational Analysis of Magnetic Reconnection Sequence", Qiu, J., 2009, ApJ, 692, 1110
“Evaluating Mean Magnetic Field in Flare Loops", Qiu J., Gary, D. E., Fleishman, G. D., 2009, Solar Physics, 255, 107
“Partially-erupting prominences: a comparison between observations and model-predicted observables", Tripathi, D.; Gibson, S. E.; Qiu, J.; Fletcher, L.; Liu, R.; Gilbert, H.; Mason, H. E., 2009, A&A, 498, 295
“"Modeling and measuring the flux reconnected and ejected by the two-ribbon flare/CME event on 7 November 2004", D. Longcope, C. Beveridge, J. Qiu, B. Ravindra, G. Barnes and S. Dasso, 2007, Sol Phys., 244, 45
“On the magnetic flux budget in low-corona magnetic reconnection and interplanetary coronal mass ejections", Qiu J., Hu Q., Howard, T. A., Yurchyshyn V. B. 2007, ApJ, 659, 758

“Direct Observation of High-Speed Plasma Outflows Produced by Magnetic Reconnection in Solar Impulsive Events", Wang, Tongjiang; Sui, Linhui; Qiu, Jiong, 2007, ApJL, 661, 207
“Determination of the Coronal Magnetic Field from Hot-Loop Oscillations Observed by SUMER and SXT", Wang, Tongjiang; Innes, Davina E.; Qiu, Jiong, 2007, ApJ, 656, 598

ALEKSANDER REBANE

Physics Department Phone: (406) 994 7831
Montana State University Fax: (406) 994 4452
Bozeman, Montana 59717 Email: rebane@physics.montana.edu
http://www.physics.montana.edu/faculty/rebane

EDUCATION

1981 Diploma *Cum Laude* in Physics, Tartu University, Estonia
1985 Ph.D. in Physics, Institute of Physics of the Estonian Academy of Sciences
1995 *Venia Legendi* at the Laboratory for Physical Chemistry at
Swiss Federal Institute of Technology in Zürich (ETHZ)

MEMBER

American Physical Society
Optical Society of America
Society of Photonics Instrumentation Engineers (SPIE)
World Federation of Scientists
Estonian and European Physical Society

ACADEMIC APPOINTMENTS

2003 to present Professor of Physics, Montana State University
1996 - 2003 Associate Professor of Physics, Montana State University
1990 - 1996 Oberassistent, Laboratory for Physical Chemistry, ETH Zürich
1986 - 1990 Senior Research Fellow, Institute of Physics, Tartu, Estonia
1981 - 1985 Research Fellow, Institute of Physics, Tartu, Estonia

OTHER ACADEMIC POSITIONS AND VISITING APPOINTMENTS

2008 to present Affiliated member, National Institute of Chemical Physics and Biophysics, Tallinn, Estonia.
1990, 1991 Visiting scientist, University of Southern California, Los Angeles
1987, 1988 Visiting scientist, University of Bayreuth, Germany

TEACHING EXPERIENCE

1997 to present Physics Department, Montana State Univ., graduate and upper division undergraduate, senior physics lab;
1991 1996 Department of Chemistry, Swiss Federal Institute of Technology, upper division physical chemistry;
1 or 2 courses per semester; Advisor to 15 Ph.D. and MS students

HONORS AND DISTINCTIONS

1993 - International Commission for Optics Prize
1996 - Leopold Ruzicka Prize, ETHZ
1999 - Charles and Nora Wiley Award, MSU
2003 - Cox Award, MSU

CONFERENCES AND EDITORIAL BOARDS

8th Int. Conf. Hole Burning and Single Molecules (HBSM), Bozeman 2003;

1st Int. Wrks. Opt. Manipulation of Quantum Information in Solids (SMQIOAS) Bozeman, 2008; SPIE Photonics West Conference Committee member.

RESEARCH SUMMARY

126	refereed journal publications
114	conference presentations (last 13 years)
25	invited talks (last 13 years)
5	book chapters
3	patents
$5.057M	external and internal grants

CURRENT FUNDING

2008-2011	Building better probes for two photon microscopy	NIH	$972k	Co-PI
2009-2014	Advanced multi-photon absorbers for ultra fast broad-band optical limiting	AFOSR	$750k	PI
2009-2010	Maximum coherence in optical transitions in rare earth ion-activated solids	NSF	$110k	PI

SELECTED PUBLICATIONS IN REFEREED JOURNALS

1. "Photochemical time-domain holography of weak picosecond pulses," A. Rebane, R. Kaarli, P. Saari, A. Anijalg, and K. Timpmann, Optics Commun. 47 (3), 173-176 (1983).
2. "Picosecond time- and space-domain holography by photochemical hole burning," P. Saari, R. Kaarli, and A. Rebane, J. Opt. Soc. Am. B 3 (4), 527 - 533 (1986).
3. "Holographic Interferometry of Ultrafast Optical Transients by Persistent Spectral Hole Burning," A. Rebane, J. Aaviksoo, Optics Lett. 13, 993 - 996 (1988).
4. "Associative Recall of Picosecond Time- and Space Domain Holograms," A. Rebane, Optics Commun. 67, 175 -180 (1988).
5. "Compression and Recovery of Temporal Profiles of Picosecond Light Signals by Persistent Spectral Hole-Burning Holograms," A. Rebane, Optics Commun. 67 (4), 301 - 304 (1988).
6. "Storage and Time Reversal of Femtosecond Light Signals via Persistent Spectral Hole Burning Holography," A. Rebane, J. Aaviksoo, and J. Kuhl, Appl. Phys. Lett. 54 (2), 93 - 95 (1989).
7. "Picosecond Time-Space Holographic Interferograms Stored by Persistent Spectral Hole Burning," A. Rebane, and O. Ollikainen, Optics Commun. 78 (5/6), 327-331 (1990).
8. "Error-Corrective Optical Recall of Digital Images by Photoburning of Persistent Spectral Holes,"A. Rebane, and O. Ollikainen, Optics Commun. 83 (3/4), p. 246 - 250 (1991).
9. "Time-resolved holography," A. Rebane, and Jack Feinberg, Nature 351, May 30, p. 378 - 380 (1991).
10. "Holography in Frequency Selective Media: Hologram Phase and Causality," A. Rebane, S. Bernet, A. Renn, and U. P. Wild, Optics Communications 86, 7 -13 (1991).
11. "Spectral Hole Burning and Holography V. Asymmetric Diffraction from Thin Holograms," S. Bernet, B. Kohler, A. Rebane, A. Renn, and U.P. Wild, JOSA B9 (6), 987- 991 (1992).
12. "Holography in Frequency Selective Media II: Controlling the Diffraction Efficiency," S. Bernet, B. Kohler, A. Rebane, A. Renn, and U.P. Wild, J. of Luminescence 53, 215 - 218 (1992).
13. "Optical Neural Networks Modeled by Persistent Spectral Hole-Burning," O. Ollikainen, Karl K. Rebane, and A. Rebane, Opt. Quant. Electron. 25, 569-585 (1993).
14. "Stark Effect in Dye-Doped Polymers Studied by Photochemically Accumulated Photon Echoes," H. Gygax, A. Rebane, and U.P. Wild, JOSA B 10, No.7, 1149 - 1158 (1993).
15. "Subpicosecond Pulse Shaping via Spectral Hole-Burning," H. Schwoerer, D. Erni, A. Rebane, and U.P. Wild, Optics Commun. 107, 123 - 128 (1994).

16. “Non-Collinear Parametric Generation in $LiIO_3$ and β-barium borate by Frequency-Doubled Femtosecond Ti:Sapphire Laser Pulses,” V. Krylov, A. Rebane, A. Kalintsev, D. Erni, and U.P. Wild, Opt. Lett. 20, 151-154 (1995).
17. “Second Harmonic Generation of Amplified femtosecond Ti:sapphire Laser Pulses,” Vitaly Krylov, Alexander Rebane, Alexander Kalintsev, Heinrich Schwoerer, and Urs P. Wild, Opt. Lett. 20, 1198-200 (1995).
18. “Spectrally controlled interference of picosecond time-and-space-domain holograms,” D. Erni, A. Rebane, and U.P. Wild, Opt. Lett. 20, 1065-1068 (1995).
19. “Holography in Frequency Selective Media III: Spectral Synthesis of Arbitrary Time Domain Pulse Shapes,” H. Schwoerer, D. Erni, and A. Rebane, J. Opt. Soc. Am. B 12, 1083-1093 (1995).
20. “Shaping of phase and amplitude of ultrashort laser pulses with organic spectral hole burning materials,” H. Schwoerer, D. Erni, A. Rebane, and U.P. Wild, Adv. Mater. 7, 457 - 460 (1995).
21. “Waveguide Narrow-Band Optical Filter by Spectral Hole-Burning,” M. Tschanz, A. Rebane, and U.P. Wild, Opt. Engineering 34, 1936-1940 (1995).
22. “Stimulated Raman scattering in Hydrogen by frequency-doubled amplified femtosecond Ti:Sapphire laser pulses,” V. Krylov, A. Rebane, U.P. Wild, D. Erni. O. Ollikainen, V. Bespalov, and D. Staselko, Opt. Lett. 21 (1996) 381-383.
23. “Third-harmonic generation in a plasma formed by optical breakdown of air in the field of femtosecond laser pulses with a high repetition rate,” A.K. Rebane, V.N. Krylov, N.I. Koroteev and A.M. Zheltikov, Quantum Electronics 26 (1996) 283-284.
24. "Nondestructive readout of time-and-space-domain holograms recorded by two-color photon-gated spectral hole burning," A. Rebane, D. Reiss, I. Renge, and U.P. Wild, Chem. Phys. Lett. 262, 155 (1996).
25. "Wave-matching of femtosecond and picosecond photon echoes in dye-doped polymer films," V. Zuikov, W. Ferri, O. Ollikainen, A. Rebane, and U.P. Wild, Laser Physics 6, 729 (1996).
26. “Total fluorescence spectra of free base chlorin and its photo-product in poly-vinylbutyral at liquid helium temperatures,” Wen-Ying Huang, Alexander Rebane, Urs P. Wild, Lawrence W. Johnson, J. of Luminescence, 71, n.3, 237-243 (1997)
27. "Femtosecond stimulated Raman scattering in gases in UV and visible spectral range," V. Krylov, O. Ollikainen, U.P. Wild, A. Rebane, V.G. Bespalov, D.I. Stasel'ko, JOSA B 15, n.12, p. (1998).
28. "Terahertz, bit-rate parallel multiplication by photon echo in low-temperature dye-doped polymer film," O. Ollikainen, C. Nilsson, A. Rebane, Optics Commun. 147 (4/6), 429 (1998).
29. "Efficient non-colinear parametric amplification of weak femtosecond pulses in the visible and near-infrared spectral range," V. Krylov, O. Ollikainen, J. Gallus, U.P. Wild, A. Rebane, A. Kalintsev, Optics Letters 23 (2), 100-102 (1998).
30. "Demonstration of ultrafast logic gate by interference of coherent transients," W. Ross, M. Drobizhev, C. Sigel, A. Rebane, Laser Physics, v.6, n.5, p.1102-1108 (1999).
31. "Transient stimulated Raman scattering in gas mixtures," V. Krylov, I. Fischer, V. Bespalov, D. Statselko, A. Rebane, Optic Letters, 24, n.22, 1623 - 1625 (1999).
32. "Femtosecond non-colinear and colinear parametric generation and amplification in BBO crystal," V. Krylov, J. Gallus, U.P. Wild, A. Kalintsev, A. Rebane, Appl. Phys. B, 70, 163-168 (2000).
33. “Single femtosecond exposure recording of image hologram by spectral hole burning in unstable tautomer of phthalocyanine derivative,” A. Rebane, M. Drobizhev, and C. Sigel, Opt. Lett. 25, 1633-1635 (2000).
34. “Persistent spectral hole burning by simultaneous two-photon absorption,” M. Drobizhev, A. Karotki and A. Rebane, Chem. Phys. Lett 334, 76-82 (2001).
35. “New dendrimer molecules with record large two-photon absorption cross-section,” M. Drobizhev, A. Karotki, A. Rebane, and C.W. Spangler, Optics Lett. 26, 1081-1083 (2001).
36. **“**Efficient singlet oxygen generation upon two-photon excitation of new porphyrin with enhanced nonlinear absorption**,”** A. Karotki, M. Kruk, M. Drobizhev, A. Rebane, E. Nickel, C. W. Spangler, IEEE J. Selected Topics in Quantum Electronics 7 (6), 971- 975 (2001).

37. “Two-photon excited coherence gratings in inhomogeneously broadened organic solid,” A. Karotki, M. Kruk, M. Drobizhev, and A. Rebane, J. Modern Optics 49 (3/4), 379-390 (2002).
38. “Resonance enhancement of two-photon absorption in porphyrins,” M. Drobizhev, A. Karotki, M. Kruk, A. Rebane, Chem. Phys. Lett. 355, 175-182 (2002).
39. “Multi-dimensional holography by persistent spectral hole burning,” A. Renn, U. P. Wild, and A . Rebane, J. Phys. Chem. 106, 3045-3060 (2002).
40. “FAST CARS: Engineering a laser spectroscopic technique for rapid identification of bacterial spores,” M.O. Scully, G.W. Kattawar, R.P. Lucht, T. Opatrny, H. Piloff, A. Rebane, A.V. Sokolov, and M.S. Zubairy, Proc. Nat. Acad. Sci. 99, 10994-11001 (2002).
41. “Enhancement of two-photon absorption in tetrapyrrolic compounds,” A. Karotki, M. Drobizhev, M. Kruk, Ch. Spangler, E. Nickel, N. Mamardashvili and A. Rebane, JOSA B 20, p.321- 332 (2003).
42. “Upconversion fluorescence in porphyrins: One-photon hot-band absorption versus two-photon absorption,” M. Drobizhev, A. Karotki, M. Kruk, A. Krivokapic, H. L. Anderson, and A. Rebane, Chem. Phys. Lett. 370, 690-699 (2003).
43. “ Strong cooperative enhancement of two-photon absorption in dendrimers,” M. Drobizhev, A. Karotki, Y. Dzenis, and A. Rebane, Zhiyong Suo and C.W. Spangler, J. Phys. Chem. B Letter 107 (31), 7540-7543 (2003).
44. “Two-photon absorption of tetraphenylporphin free base,” M. Kruk, A. Karotki, V. Kuzmitski, M. Drobizhev, V. Gael, and A. Rebane, J. of Luminescence 105, 45-55 (2003).
45. “Dramatic enhancement of intrinsic two-photon absorption in a conjugated porphyrin dimer,” A. Karotki, M. Drobizhev, Y. Dzenis, P. N. Taylor, H. L. Anderson, and A. Rebane, Phys. Chem. Chem. Phys, 6 (1), 7-10 (2004).
46. “Uncovering coherent domain structure in a series of π-conjugated dendrimers by simultaneous three-photon absorption.” M. Drobizhev, A. Karotki, M. Kruk, Yu. Dzenis, A. Rebane, Z. Suo, and C.W. Spangler, J. Phys. Chem. B (Letter) 108 (14): 4221-4226 (2004).
47. "Understanding strong two-photon absorption in π-conjugated porphyrin dimers via double-resonance enhancement in a three-level model," M. Drobizhev, Y. Stepanenko, Y. Dzenis, A. Karotki, A. Rebane, P. N. Taylor, and H.. Anderson, J. of American Chemical Society, 126 (47), 15352-15353 (2004).
48. "Extremely strong near-IR two-photon absorption in conjugated porphyrin dimers: Quantitative description with three essential states model," M. Drobizhev, Y. Stepanenko, Y. Dzenis, A. Karotki, A. Rebane, P. N. Taylor, and H. L. Anderson, *J. Phys. Chem. B*, 109 (15): 7223-7236 (2005).
49. "Slow light with persistent hole burning," R. N. Shakhmuratov, A. Rebane, P. Megret, and J. Odeurs, *Phys. Rev. A* **71**, 053811 (2005).
50. "Quantum interference in organic solid", A. Rebane, N. Christensson, M. Drobizhev, Y. Stepanenko, C.W. Spangler, *Optics Express* 13 (16), 6033-6038 (2005).
51. "New fluorophores based on triphenylamine for three-photon absorption," Z. Suo, M. Drobizhev, C.W. Spangler, N. Christensson, and A. Rebane, *Organic Letters*, 7 (22), 4807-4810 (2005).
52. "Synthesis, crystal structure and nonlinear optical behavior of *meso-meso E*-vinylene-linked porphyrin dimers without β-substituents," M. J. Frampton, H. Akdas, A. R. Cowley, J. E. Rogers, P. A. Fleitz, M. Drobizhev, A. Rebane and H. L. Anderson, *Organic letters,* 7 (24), 5365-5368 (2005).
53. "Strong two-photon absorption in new asymmetrically-substituted porphyrins: interference between charge-transfer and intermediate-resonance pathways." M. Drobizhev, F. Meng, A. Rebane, Y. Stepanenko, E. Nickel, and C. W. Spangler, *J. Physical Chemistry* B 110 (20), 9802-9814 (2006).
54. “Near-infrared two-photon absorption in phthalocyanines: Enhancement of lowest gerade-gerade transition by symmetrical electron-accepting substitution,“ M. Drobizhev, N. Makarov. Y. Stepanenko and A. Rebane, *J. Phys. Chem.* 124 (22), 224701 (2006).
55. "Strong cooperative enhancement of two-photon absorption in double-strand conjugated porphyrin ladder arrays," M. Drobizhev,. Y. Stepanenko, A. Rebane, C.J. Wilson, T. E.O. Screen, H.L. Anderson, *J. Am. Chem. Soc*. **128** (38), 12432-12433 (2006).
56. “Platinum acetylide two photon chromophores,” J. E. Rogers, J. E. Slagle, D. M. Krein, A. R. Burke, B. C. Hall, A. Fratini, D. G. McLean, P. A. Fleitz, T. M. Cooper, M. Drobizhev, N. S. Makarov, A. Rebane, K.-Y. Kim, R. Farley, and K. S. Schanze, *Inorg. Chem.* **46** (16), pp. 6483-6494 (2007).

57. "Optimizing two-photon absorption for volumetric optical data storage," N. S. Makarov, A. Rebane, M. Drobizhev, H. Wolleb, and H. Spahni, *JOSA B* **24** (8), pp.1874-1885 (2007).
58. "Resonance enhancement of two-photon absorption in fluorescent proteins," M. Drobizhev, N. S. Makarov, T. Hughes, and A. Rebane, *J. Phys. Chem. B* **111** (50), pp.14051-14054 (2007).
59. "Strong two-photon absorption in push-pull phthalocyanines: Role of low symmetry and permanent dipole moment change upon excitation," M. Drobizhev, N. S. Makarov, A. Rebane, G. de la Torre, T. Torres, *J. Phys. Chem. C*. 112 (3), pp. 848-859 (2008).
60. "New photodynamic therapy sensitizers induce xenograft tumor regressions after NIR laser treatment through the body of the host mouse," J. R. Starkey, A. Rebane, M. A. Drobizhev, F. Meng, A. Gong, A. Elliott, K. McInnerney and C. W. Spangler, *Clinical Cancer Research* **14** (20), pp.6564-6573 (2008).
61. "Blood-vessel closure using photosensitizers engineered for two-photon excitation," H. A. Collins, M. Khurana, E. H. Moriyama, A. Mariampillai, E. Dahlstedt, M. Balaz, M. K. Kuimova, D. Phillips, M. Drobizhev, A. Rebane, B. C. Wilson, and H. L. Anderson, *Nature Photonics* **2**, 420 - 424 (30 May 2008).
62. "Two-photon absorption standards in the 550-1600 nm excitation wavelength range," Nikolay S. Makarov, M. Drobizhev, A. Rebane, *Optics Express* **16** (6), pp. 4029-4047 (2008).
63. "Quantitative prediction of two-photon absorption cross section based on linear spectroscopic properties," A. Rebane, N.S. Makarov, M. Drobizhev, B. Spangler, E.S. Tarter, B.D. Reeves, Ch. W. Spangler, F. Meng, Z. Suo, *J. Phys. Chem. C* **112**, pp.7997–8004 (2008).
64. "Two-photon absorption properties of meso-substituted A3-corroles," D.T Gryko, A. Rebane, M. Drobizhev, N. S Makarov, B. Koszarna, M. Tasior, *Chem Phys Lett.* **462** (4-6), pp. 246-250 (2008).
65. "Photophysical properties and intracellular imaging of water-soluble porphyrin dimers for two-photon excited photodynamic therapy," M. K. Kuimova, H. A. Collins M. Balaz, E. Dahlstedt, J. A. Levitt, N. Sergent, K. Suhling, M. Drobizhev, A. Rebane, H. L. Anderson and D. Phillips, *Org. Biomol. Chem.*, **7**, 889 (2009).
66. "Absolute two-photon absorption spectra and two-photon brightness of orange and red fluorescent proteins," M. Drobizhev, S. Tillo, N.S. Makarov, T. E. Hughes, A. Rebane, *J. Phys. Chem. B* , 113 (4), pp 855–859 (2009) .
67. "Color hues in red fluorescent proteins are due to internal quadratic Stark effect," M. Drobizhev, S. Tillo, N. S. Makarov, Th. E. Hughes and A. Rebane, J. Phys. Chem. B, 113 (39), pp 12860–12864 (2009).
68. A.Rebane , M.A. Drobizhev , N. S. Makarov , E. Beuerman, C. Nacke , J. Pahapill, "Modeling non-Lorentzian two-photon absorption line shape in dipolar chromophores," J. Lumin. 130 (6), pp. 1055-1059 (2010).
69. S. E. Tillo, T. Hughes, N.S. Makarov, A. Rebane, M. Drobizhev, "A new approach to dual-color two-photon microscopy with fluorescent proteins," BMC Biotechnology, 10-6, (2010).

ISI Web of Knowledge Citations (including self-citations)

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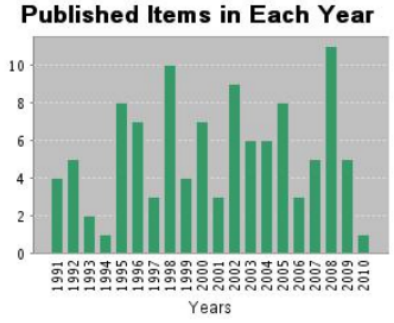

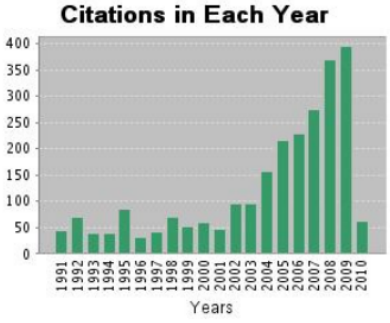

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Research Grants and Contracts (last 12 years)

1998-1999	Ultrafast photo-induced frequency conversion holograms	MSU MONTS	$25k	P.I.
1998-2000	Photon gated spectral hole burning holograms	NSF	$290k	P.I.
1998-2000	Ultrafast holographic image recording by single shot femtosecond spectral hole burning	AFOSR	$390k	P.I.
2001-2004	Two-photon coherence and ultrafast optical storage in organic molecules	AFOSR	$386k	P.I.
2001-2004	Electron transfer and electro-optic materials	Department of Energy	$120k	Co-P.I.
2001-2004	Ultrafast multi-photon processes in specialized organic dendrimers	AFOSR	$534k	P.I.
2002-2003	Excitons in organic nanostructures	NSF EPSCoR	$25k	P.I.
2004-2005	Two-photon volumetric re-writable optical memory material	Montana Board for Res. Com. Tech.	$120k	Co-P.I.
2004-2007	Electron transfer and electro-optic materials	DoE EPSCoR	$120k	Co-P.I.
2004-2005	Two-photon tetrapyrrole core dendrimers for efficient optical power limiting	AFOSR	$87k	PI
2005-2008	Porphyrins with enhanced two-photon absorption for ultra fast optical power limiting	AFOSR DEPSCoR	$525k	PI
2005-2006	Ultrafast studies of novel functionalized organic multi photon absorbers	AFOSR DURIP equipment grant	$475k	PI
2007-2009	Cancer treatment depth efficacy studies using the transplantable rabbit VX2 carcinoma	Montana Board for Res. Com. Technology	$120k	Co-PI
2008-2011	Building better probes for two photon microscopy	NIH	$972k	Co-PI
2009-2014	Advanced multi-photon absorbers for ultra fast broad-band optical limiting	AFOSR	$750k	PI
2009-2010	Maximum coherence in optical transitions in rare earth ion-activated solids	NSF	$110k	PI
2010	Development and characterization of novel bio- and nano-photonic materials for classical and quantum information processing	MSU VP Office	$7,500	
		Total Contracts:	$5,057k	

Curriculum Vitae

Carla M. Riedel

Department of Physics
Montana State University
Bozeman, Montana 59717

Phone: 406-994-6178
FAX: 406-994-4452
e-mail: `riedel@physics.montana.edu`

POSITION: Adjunct Assistant Professor of Physics

RESEARCH INTERESTS

Experimental Subatomic Physics: intermediate-energy hadronic interactions, reaction dynamics, nuclear structure.

Numerical Analysis: simulations of particle interactions in microscopic and macroscopic physical systems; analysis of data from intermediate-energy particle spectrometers.

Scientific instrumentation: development for application to subatomic physics research.

EDUCATION

1996 Ph. D. in Physics, University of Minnesota - Minneapolis.

1988 B. S. in Physics and in Mathematics, University of Wisconsin - Madison.

AWARDS

1999 U. S. Department of Defense Nuclear Stockpile Stewardship Excellence Award

1990-1991 U. S. Department of Education National Needs Fellow

1988-1989 Graduate School Fellow, University of Minnesota - Minneapolis

1988 Graduation With Distinction, University of Wisconsin - Madison

1984-1988 National Merit Scholar

PROFESSIONAL EXPERIENCE

2002–present Adjunct Assistant Professor, Montana State University - Bozeman

1999–2001 Assistant Professor, University of Montana - Missoula

1998–1999 Visiting Assistant Professor, University of Montana - Missoula

1994–1998 Postdoctoral Research Associate, Los Alamos National Laboratory

1989–1994 Graduate Research Assistant, University of Minnesota - Minneapolis

1988–1989 Teaching Assistant, University of Minnesota - Minneapolis

1987–1988 Undergraduate Research Assistant, University of Wisconsin - Madison

SELECTED PUBLICATIONS

"Measurement of ^{4}He(p,n) at 100 and 200 MeV: Analysis with recoil-corrected continuum shell model," C. M. Riedel, D. Dehnhard, M. Palarczyk, *et al.*, *Phys. Rev. C* **69**, 024616 (2004).

"Experimental Study of the ^{12}C($K^-_{stopped}, \pi^\circ$)$^{12}_{\Lambda}$B Reaction," M. W. Ahmed, X. Cui, A. Empl, *et al.*, *Phys. Rev. C* **68**, 064004 (2003).

"Analyzing powers for π^-p elastic scattering at 279 MeV", G. J. Hofman, J. Breitschopf, K. Craig, *et al.*, *Phys. Rev. C* **68**, 018202 (2003).

"The Construction and Operating Characteristics of a Cathode Strip Chamber System Designed to Measure the Reaction Vertices of a Stopping Kaon Beam," M. W. Ahmed, D. Androic, I. Bertovic, *et al.*, *Nucl. Instrum. Methods Phys. Res. A* **469**, 95 (2001).

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"Measurements of asymmetries of pion single charge exchange on polarized ^{3}He at 200 MeV," Q. Zhao, G. Burleson, S. Blanchard, *et al.*, *Phys. Rev. C* **60**, 024001 (1999).

"An 800-MeV proton radiography facility for dynamic experiments," N. S. P. King, E. Ables, Ken Adams, *et al.*, *Nucl. Instrum. Methods Phys. Res. A* **424**, 84 (1999).

"Cross sections and analyzing powers for the ($\vec{\text{p}}$,n) reaction on ^{3}He and ^{4}He at 200 MeV," M. Palarczyk, C. M. Riedel, D. Dehnhard, *et al.*, *Phys. Rev. C* **58**, 645 (1998).

"Polarization Transfer Observables in πd Elastic Scattering," G. Suft, P. Amaudruz, E. Boschitz, *et al.*, *Phys. Lett.* **425B**, 19 (1998).

"Polarization Transfer Observables in πd Elastic Scattering," W. Kretschmer, A. Glombik, G. Suft, *et al.*, *Nucl. Phys.* **A631**, 524c (1998).

"Evidence for Δ^- components in nuclei," C. L. Morris, J. D. Zumbro, J. A. McGill, *et al.*, *Phys. Lett.* **419B**, 25 (1998).

"Asymmetries for elastic scattering of $\pi^\pm$ from polarized ^{3}He at Δ resonance energies," M. A. Espy, J. M. O'Donnell, B. Davis, *et al.*, *Phys. Rev. C* **56**, 2607 (1997).

"Asymmetries for Elastic Scattering of π^+ from Polarized ^{3}He and the Δ-Neutron Spin-Spin Interaction," M. A. Espy, D. Dehnhard, C. M. Edwards, *et al.*, *Phys. Rev. Lett.* **76**, 3667 (1996).

"The ^{4}He(p,n)^{4}Li* Reaction at 100 and 200 MeV: Implications for the mass-four system and for astrophysics," C. M. Edwards, M. Palarczyk, D. Dehnhard, *et al.*, *Phys. Lett.* **368B**, 39 (1996); **380B**, 493(E) (1996).

"Inclusive Scattering of 500-MeV Pions from Carbon," J. D. Zumbro, C. L. Morris, J. A. McGill, *et al.*, *Phys. Rev. Lett.* **71**, 1796 (1993).

"Quasifree pion scattering at 500 MeV," J. E. Wise, M. R. Braunstein, S. Høibråten, *et al.*, *Phys. Rev. C* **48**, 1840 (1993).

"Pion Double Charge Exchange on ^{16}O at $T_\pi = 300$–500 MeV," D. P. Beatty, G. R. Burleson, M. Rawool-Sullivan, *et al.*, *Phys. Rev. C* **48**, 1428 (1993).

"Search for an η bound state in pion double charge exchange on ^{18}O," J. D. Johnson, G. R. Burleson, C. Edwards, *et al.*, *Phys. Rev. C* **47**, 2571 (1993).

"A Beamline for Layered Synthetic Microstructure Studies," J. Boudry, C. Riedel, B. Edwards, M. Lagally, R. Redaelli, F. Cerrina, C. Falco, J. H. Underwood, and M. Hettrik, *Nucl. Instrum. Methods Phys. Res. A* **266**, 351 (1988).

Curriculum Vitae – V. Hugo Schmidt

Professor of Physics Emeritus
Montana State University
Bozeman, MT 59717

Phone: (406) 994-6173
Fax: (406) 994-4452
Email: schmidt@physics.montana.edu

Education

B.S. Washington State University, 1951, Mechanical Engineering
Ph.D. University of Washington, 1961, Physics

Previous Positions

Assoc. Prof. of Physics, Montana State University, 1/1964 to 6/1973
Asst. Prof. of Physics, Valparaiso Univ., Valparaiso, IN, 2/1961 to 1/1964
Assoc. Research Engineer, Boeing Co., Seattle, WA, 8/1955 to 1/1957
Mech. Design Engineer, Gilfillan Bros., Los Angeles, CA, 8/1953 to 9/1954
1/Lt., USAF, Wright-Patterson AFB, OH, 7/1951 to 6/1953

Patents

"Pulse Modified Camera," U.S. Patent No. 2,792,767, May 21, 1957.
"Piezoelectric Wind Generator," U.S. Patent No. 4,536,674, Aug. 20, 1985.

Memberships

Fellow, American Physical Society
Senior Member, IEEE
Member, American Association of Physics Teachers

Awards

Sigma Xi Outstanding Research Award, 1979.
Wiley Research Award, 1981.
Mershon Research Award, 1983.
Fulbright Research Award, Yugoslavia, 1986-87
Associate Member, Jozef Stefan Institute, 1987 to present
Award for Excellence in Research and Teaching, 1984 & 1999

Selected Relevant Publications: (out of 175 refereed publications)

"Laminar flow and total pressure effects in solid oxide fuel cell electrode pores and their effects on voltage-current characteristics," V. Hugo Schmidt, R. R. Chien, and Laura M. Lediaev, accepted for publication in *Proceedings of the 32nd International Conference and Exposition on Advanced Ceramics and Composites*, Daytona Beach, Florida, January 18-23, 2009.

"Glycine-nitrate synthesis and characterization of $Ba(Zr_{0.8-x}Ce_xY_{0.2})O_{2.9}$," R. R. Chien, V. Hugo Schmidt, S.-C. Lee, C.-C. Huang, and Stachus P. Tu, accepted for publication in *Proceedings of the 32nd International Conference and Exposition on Advanced Ceramics and Composites*, Daytona Beach, Florida, January 18-23, 2009.

"*In Situ* x-ray diffraction and Raman spectroscopy of LiF-added $Ba(Zr_{0.7}Ce_{0.1}Y_{0.2})O_{2.9}$ ceramics," C.-S. Tu, S. C. Lee, C.-C. Huang, R. R. Chien, V. H. Schmidt, and C.-L. Tsai, accepted for publication in *Proceedings of the 32nd International Conference and Exposition on Advanced Ceramics and Composites*, Daytona Beach, Florida, January 18-23, 2009.

"Pressure and gas concentration effects on voltage vs. current characteristics of a solid state fuel cell and electrolyzer," V.H. Schmidt and L.M. Lediaev, Adv. in Solid Oxide Fuel Cells IV, Wiley, Hoboken, NJ, 2009, pp. 105-115.

"Anode-pore tortuosity in solid oxide fuel cells found from gas and current flow rates," V.H. Schmidt and C.-L. Tsai, J. Power Sources 180, 253-264 (2008).

"Dynamic first-principles molecular-scale model for solid oxide fuel cells," V.H. Schmidt, ECS Transactions, vol. 6, issue 21, Design of Electrode Structures, 2008, pp. 11-24.

"Determination of anode-pore tortuosity from gas and current flow rates in SOFC's," V.H. Schmidt, C.-L. Tsai, and L.M. Lediaev, Adv. in Solid Oxide Fuel Cells III, Wiley, Hoboken, NJ, 2008, pp. 129-140.

"In-situ temperature-dependent x-ray diffraction study of $Ba(Zr_{0.8-x}Ce_xY_{0.2})O_{3-\delta}$ ceramics," C.-S. Tu, R.R. Chien, S.-C. Lee, C.-L. Tsai, V.H. Schmidt, A. Keith, S.A. Hall, and N.P. Santorsola, Adv. in Solid Oxide Fuel Cells IV, Wiley, Hoboken, NJ, 2009, pp. 117-123.

"Piezoelectric Response and Origin in (001) $Pb(Mg_{1/3}Nb_{2/3})_{0.70}Ti_{0.30}O_3$ Crystal," C.-S. Tu, C.-M. Hsieh, V. Hugo Schmidt, R. R. Chien, and H. Luo, *Applied Physics Letters* **93**, 172905 (2008).

"Field-Induced Intermediate Orthorhombic Phase in (110)-cut $Pb(Mg_{1/3}Nb_{2/3})_{0.70}Ti_{0.30}O_3$ Single Crystal," C.-S. Tu, V.H. Schmidt, R. R. Chien, S.-H. Tsai, S.-C. Lee, and H. Luo, *Journal of Applied Physics* **104**, 094105 (2008).

"Nanotwin and phase transformation in tetragonal $Pb(Fe_{1/2}Nb_{1/2})_{1-x}Ti_xO_3$ single crystal," C.-S. Tu, C.-T. Tseng, R. R. Chien, V. Hugo Schmidt, and C.-M. Hsieh, *Journal of Applied Physics* **104**, 054106/1-4 (2008).

"Intermediate phases in rhombohedral $Pb(Mg_{1/3}Nb_{2/3})_{1-x}Ti_xO_3$ crystal," C.-S. Tu, H.-T. Chuang, S.-C. Lee, R. R. Chien, V. H. Schmidt, and H. Luo, *Journal of Applied Physics* **104**, 024110/1-6 (2008).

"Nanotwins and phases in high-strain $Pb(Mg_{1/3}Nb_{2/3})_{1-x}Ti_xO_3$ crystal," C.-S. Tu, C.-M. Hsieh, R. R. Chien, V. H. Schmidt, F.-T. Wang, and W. S. Chang, *Journal of Applied Physics* **103**, 074117/1-8 (2008).

"Electric-field-induced domain structures and phase transitions in PMN-PT single crystals," V. H. Schmidt, R. R. Chien, and C.-S. Tu, PART 2 FIELD-INDUCED EFFECTS AND DOMAIN ENGINEERING, *Handbook of Advanced Dielectric Piezoelectric and Ferroelectric Materials: Synthesis, Characterisation and Applications*, edited by Z.-G. Ye, Woodhead Publishing Limited, Abington Hall, Abington, Cambridge, CB1 6AH, England, ISBN 1 84569 186 5, March 2008. (Book)

"Electric-field- and temperature-induced phase transitions in high-strain relaxor-based ferroelectric $Pb(Mg_{1/3}Nb_{2/3})_{1-x}Ti_xO_3$ single crystals," **Plenary Lecture** by V.H. Schmidt, 5th Internat. Seminar on Physics of Ferroelastic Crystals, Voronezh, Russia, Sept. 10-13, 2006, appears in R.R. Chien, V.H. Schmidt, C.-S. Tu, F.-T. Wang, I.-C. Shih, L.-W. Hung, and H. Luo, *Ferroelectrics* **359**, 99-110 (2007).

"Nano and microscopic polar clusters in high-strain ferroelectric $Pb(B' B'')_{1-x}Ti_xO_3$ crystals," V. Hugo Schmidt, R. R. Chien, C.M. Hung, W.S. Chang, C.S. Tu, and L.C. Lim, **Invited Talk** at XVI Int'l Mat'ls Research Congress-2007, Cancun, Mexico Oct. 28-Nov. 1, 2007.

"Electric-field- and temperature-induced phase transitions in high-strain relaxor-based ferroelectric $Pb(Mg_{1/3}Nb_{2/3})_{1-x}Ti_xO_3$ single crystals," R. R. Chien, V. Hugo Schmidt, C.-S. Tu, F.-T. Wang, I.-C. Shih, L.-W. Hung, and H. Luo, *Ferroelectrics* **359**, 99-110 (2007).

"Field-induced orientational percolation to a ferroelectric phase in relaxor $Pb(In_{1/2}Nb_{1/2})_{1-x}Ti_xO_3$," C.-S. Tu, R. R. Chien, C.-M. Hung, V. Hugo Schmidt, F.-T. Wang, and C.-T. Tseng, *Physical Review B* **75**, 212101/1-4 (2007).

"Electric-induced dielectric anomalies and optical birefringence in $Pb(Zn_{1/3}Nb_{2/3})_{1-x}Ti_xO_3$," Chi-Shun Tu, F.-T. Wang, R. R. Chien, V. H. Schmidt, and L. C. Lim, *Journal of Applied Physics* **100**, 074105/1-6 (2006).

"Electric-field- and temperature-induced phase transitions in high-strain ferroelectric $Pb(Mg_{1/3}Nb_{2/3})_{0.67}Ti_{0.33}O_3$ single crystal," R. R. Chien, C.-S. Tu, V. H. Schmidt, and F.-T. Wang, *Journal of Physics: Condensed Matter* **18**, 8337-8344 (2006).

"Direct observation of ferroelectric domains and phases in (001)-cut $Pb(Mg_{1/3}Nb_{2/3})_{1-x}Ti_xO_3$ single crystals under electric-field poling," R. R. Chien, V. Hugo Schmidt, C.-S. Tu, and F.-T. Wang, *Journal of Crystal Growth* **292** 395-398 (2006).

"Electric-field poling effect on thermal stability of monoclinic phase in $Pb(Mg_{1/3}Nb_{2/3})_{0.74}Ti_{0.26}O_3$ single crystal," R. R. Chien, V. H. Schmidt, and C.-S. Tu, *Journal of Crystal Growth* **287**, 454-457 (2006).

"Dielectric and photo-voltaic phenomena in tungsten doped $Pb(Mg_{1/3}Nb_{2/3})_{1-x}Ti_xO_3$ crystal," Chi-Shun Tu, F.-T. Wang, R. R. Chien, V. H. Schmidt, T.-M. Hung, and C.-T. Tseng, *Applied Physics Letters* **88**, 032902/1-3 (2006).

"Temperature dependent phase transitions in PZN-7%PT single crystal," R. R. Chien, V. Hugo Schmidt, Chi-Shun Tu, F.-T. Wang, and L. C. Lim, *Ferroelectrics* **339**, 115-120 (2006).

"Prior poling effect on thermal phase stability in (110)-cut $Pb(Mg_{1/3}Nb_{2/3})_{0.74}Ti_{0.26}O_3$ single crystal," R. R. Chien, V. H. Schmidt, C.-S. Tu, and F.-T. Wang, *Journal of Applied Physics* **98**, 114106/1-5 (2005).

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"Temperature- and electric-field-dependent domain structures and phase transformations in (001)-cut tetragonal $Pb(Mg_{1/3}Nb_{2/3})_{1-x}Ti_xO_3$ (x=0.40) single crystal," R. R. Chien, V. H. Schmidt, L.-W. Hung, and C.-S. Tu, *Journal of Applied Physics* **97,** 114112/1-4 (2005).

"Electric-field effects of dielectric and optical properties in $Pb(Mg_{1/3}Nb_{2/3})_{0.65}Ti_{0.35}O_3$ crystal," C.-S. Tu, F.-T. Wang, R. R. Chien, V. H. Schmidt, and G. F. Tuthill, *Journal of Applied Physics* **97**, 064112/1-5 (2005).

"Phase stability after an electric-field poling in $Pb(Mg_{1/3}Nb_{2/3})_{1-x}Ti_xO_3$ crystals," C.-S. Tu, R. R. Chien, F.-T. Wang, V. H. Schmidt, and P. Han, *Physical Review B* **70**, 220103/1-4 (R) (2004).

"Temperature-and electric-field-dependent polarization rotations in (211)-cut $Pb(Mg_{1/3}Nb_{2/3})_{0.69}Ti_{0.31}O_3$ (PMNT31%) single crystal," C.-S. Tu, L.-W. Hung, R. R. Chien, and V. H. Schmidt, *Journal of Applied Physics* **96**, 4411-4415 (2004).

"Temperature- and electric-field-dependent phase transformations in (001)-oriented $Pb(Mg_{1/3}Nb_{2/3})_{0.6}Ti_{0.4}O_3$ single crystal", R.R. Chien, V.H. Schmidt, C.-S. Tu, and L.-W. Hung, *Proceedings of the 14th IEEE International Symposium on Applications of Ferroelectrics--ISAF-04*, FE1-F-1, pp. 89-94 (2004). (**Invited Talk**)

"Thermal stability of ferroelectric phases after a prior electric-field poling in $Pb(Mg_{1/3}Nb_{2/3})_{1-x}Ti_xO_3$ crystals," C.-S. Tu, R.R. Chien, F.-T. Wang, V.H. Schmidt, and P. Han, *Phys. Rev. B* (*R*) **70**, 220103 (2004).

"Elastic, piezoelectric, and dielectric properties of $0.58Pb(Mg_{1/3}Nb_{2/3})O_3$-$0.42PbTiO_3$ single crystal," H. Cao, V.H. Schmidt, R. Zhang , W. Cao, H. Luo, *J. Appl. Phys.* **96**, 549 (2004).

"Field-induced polarization rotation in (001)-cut $Pb(Mg_{1/3}Nb_{2/3})_{0.76}Ti_{0.24}O_3$," R.R. Chien, V.H. Schmidt, C.-S. Tu, L.-W. Hung, and H. Luo, *Phys. Rev. B* **69**, 172101 (2004.

"Phase coexistence of temperature-dependent phase transformation in relaxor ferroelectric $Pb(Mg_{1/3}Nb_{2/3})_{1-x}Ti_xO_3$ single crystal," R. Chien, V.H. Schmidt, C.-S. Tu, and L.-W. Hung, *Ferroelectrics* **302**, 335 (2004).

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"Polarization rotation and monoclinic phase in relaxor ferroelectric PMN-PT crystal," V.H. Schmidt, R. Chien, I.-C. Shih, and C.-S. Tu, *AIP Conference Proceedings of Fundamental Physics of Ferroelectrics 2003* **677**, 160 (2003).

"E-field and temperature dependent transformation in <102>-cut PMN-PT crystal," C.-S. Tu, L.-W. Hung, R. Chien, and V.H. Schmidt, *AIP Conference Proceedings of Fundamental Physics of Ferroelectrics 2003* **677**, 152 (2003).

"Phase transformation via a monoclinic phase in relaxor-based ferroelectric crystal $(PbMg_{1/3}Nb_{2/3}O_3)_{1-x}(PbTiO_3)_x$," C.-S. Tu, V.H. Schmidt, I.-C. Shih, and R. Chien, *Phys. Rev. B* **67**, 020102(R) (2003).

"Orientation dependences and E-field effect in relaxor-based ferroelectric crystal $Pb(Mg_{1/3}Nb_{2/3})_{0.68}Ti_{0.32}O_3$," C.-S. Tu, C.-L. Tsai, J.-S. Chen, and V.H. Schmidt, *Phys. Rev.* B **65**, 104113 (2002).

"Dielectric, hypersonic and domain anomalies of $(PbMg_{1/3}Nb_{2/3}O_3)_{1-x}(PbTiO_3)_x$ single crystals," C.-S. Tu, C.L. Tsai, V.H. Schmidt, H. Luo and Z. Yin, *J. Appl. Phys.* **89**, 7908 (2001).

"Phases and domain structures in relaxor -based ferroelectric $(PbMg_{1/3}Nb_{2/3}O_3)_{0.69}(PbTiO_3)_{0.31}$ single crystal," C.-S. Tu, L.-F. Chen, V.H. Schmidt, and C.L. Tsai, *Jpn. J. Appl. Phys.* **40** (part 1), No. 6A, 4118 (2001).

"Phase transitions and domain structures in relaxor-based ferroelectric $(PbZn_{1/3}Nb_{2/3}O_3)_{0.915}(PbTiO_3)_{0.085}$ single crystal," C.-S. Tu, V.H. Schmidt and I.C. Shih, *Ferroelectrics Letters* **28**, 5/6, (2001).

"Dielectric and Relaxation Behaviors of $(PbMg_{1/3}Nb_{2/3}O_3)_{0.67}(PbTiO_3)_{0.33}$ Single Crystal," C.-S. Tu, V.H. Schmidt, H. Luo, and F.-C. Chao, *Ferroelectrics Letters* **27**, 49 (2000).

"Light Scattering and Dielectric Measurements in $(PbMg_{1/3}Nb_{2/3}O_3)_{0.67}(PbTiO_3)_{0.33}$ Single Crystal," V.H. Schmidt, C.-S. Tu, C.-H. Yeh, H. Luo, and F.-C. Chao, AIP Conf. Proc. **535**, 240 (2000).

"Pressure-Induced Crossover from Long-to Short-Range Order in $Pb[(Zn_{1/3}Nb_{2/3})O_3]_{0.905}(TiO_3)_{0.095}$ Single Crystal," G.A. Samara, E.L. Venturini, and V.H. Schmidt, *Appl. Phys. Lett.* **76**, 1327 (2000).

"Phase Coexistence in Proton Glass," V. H. Schmidt, *J. Korean Phys. Soc*. **32**, S803-S806 (1998). (**Invited Talk** at 9th Internat. Meeting on Ferroelectricity, Seoul, Aug. 1997.)

"Random Barrier Height Model for Phase Shifted Conductivity in Perovskites," V.H. Schmidt, G.F. Tuthill, C.-S. Tu, T.V. Schogoleva, and S.C. Meschia, *Ferroelectrics* **199**, 51 (1997).

Richard James Smith
Department of Physics
Montana State University, Bozeman, MT 59717
Tel. (406) 994-6152 Fax: (406) 994-4452
e-mail: smith@physics.montana.edu
http://www.physics.montana.edu/Ionbeams/ionbeams.html

Education: Ph.D., 1975 - Iowa State University; Solid State Physics
B.A., 1969 - St. Mary's College, Winona, Minnesota

Previous Positions:

2008 to present: Professor and Head, Physics Dept., Montana State University
1990 to 2008: Professor, Physics Department, Montana State University
1987 to 1988: Visiting Scientist, FOM Institute for Atomic and Molecular Physics, Amsterdam, the Netherlands
1980 to 1989: Associate Professor, Physics Department, Montana State University
1978 to 1980: Asst. Scientist, Physics Department, Brookhaven National Laboratory
1975 to 1977: Research Associate, Physic Department, Montana State University

Research Interests: Ion-solid interactions; atomic structure of solid surfaces and buried interfaces; hydrogen absorption; oxidation of metals; solid oxide fuel cells

Awards: MSU Alumni and Chamber of Commerce Award for Excellence in Teaching - 1982
Wiley Award for Outstanding Research at Montana State University – 1998
Provost's Award for Undergraduate Research/Creativity Mentoring - 2007

Member: American Physical Society
American Vacuum Society
American Association of Physics Teachers

Current grants:

"All-Ceramic Anode Development for Aerospace Based Solid Oxide Fuel Technology"
NASA EPSCoR (Angela Desjardins, PI) Stephen Sofie (Science PI) with 3 co-PIs
$1,500,000 for 3 Years Start date: 9/1/2009

"Study of Silicon Transport in Low Purity/Low cost Insulation Materials for Solid Oxide Fuel Cells" SECA Coal-based Program subcontract through Siemens Power Generation
PI: Stephen Sofie with 2 co-PIs $300,000 for 3 Years Start date: 6/1/2008

Papers presented at conferences: 161 including 17 invited papers

Total Postdoctoral Associates and graduate students advised:
Sabbatical visitors to PI's lab (5), Postdoc.Assoc.(5), Ph.D.(4), M.S.(11), non-degree(9)
Current graduate students in PI's group (4)

Publications: 108 including the following from the last 2 years (2008-2009)

1. “The evolution of composition and structure at metal-metal interfaces: Measurements and Simulations”, R.J. Smith, Chapter 13 (35 pages; 17 Figures) in Applied Computational Materials Modeling: Theory, Simulation, and Experiment, G. Bozzolo, R. D. Noebe, and P. Abel (Eds.) 2007, 600p, Hardcover ISBN:978-0-387-23117-4.

2. “Thermal and chemical stability of epitaxial Fe films grown on the Ti-stabilized Al(100) surface”, C. V. Ramana, W. Priyantha, and R. J. Smith, and Bum-Sik Choi, Surface Science **602** (2008) 534–544.

3. “Interface Intermixing of Al/Fe and Fe/Al Multilayer Systems and the role of Ti as a Stabilizer Layer Using Rutherford Backscattering Spectrometry (RBS) and X-ray Reflectrometry (XRR)”, W. Priyantha , H. Chen , M. Kopczyk , R.J. Smith, A. Kayani, A. Comouth , M. Finsterbusch , P. Nachimuthu , D. McCready, J. Appl. Phys. **103**, 014508 (2008).

4. “Advanced PVD Protective Coatings for SOFC Interconnects”, P. Gannon, M.C. Deibert, V. Gorokhovsky, P. White, R.J. Smith, H. Chen, J. Lucas, International Journal of Hydrogen Energy, 33 (2008) 3991 - 4000.

5. “Simulated Solid Oxide Fuel Cell Interconnect Performance of Crofer 22 APS with and without Filtered Arc Cr-Al-O-N Coatings, P. Gannon, A. Kayani, C.V. Ramana, M.C. Deibert, R.J. Smith, V. Gorokhovsky, Electrochemical and Solid-State Letters, **11**(4) B54-B58 (2008).

6. “Oxidation behavior of stainless steel 430 and 441 at 800ºC in single (air-only) and dual atmosphere (air/hydrogen) exposures”, J. Rufner, P. Gannon, P. White, M.C. Deibert, S. Teintze, R.J. Smith, H. Chen, The International Journal of Hydrogen Energy, 33 (2008) 1392-1398.

7. “Thermal stability and oxidation resistance of TiCrAlYO coatings on SS430 for solid oxide fuel cell interconnect applications", H. Chen, J. A. Lucas, W. Priyantha, M. Kopczyk, R. J. Smith, K. Lund, C. Key, M. Finsterbusch, P. E. Gannon, M. Deibert, V. I. Gorokhovsky, V. Shutthanandan, P. Nachimuthu, Surface and Coatings Technology, 202 (2008) 4820-4824.

8. “Thin film YSZ coatings on functionally graded freeze cast NiO/YSZ SOFC anode supports", P. Gannon, S. Sofie, M. Deibert, R.J. Smith, V. Gorokhovsky, J. Appl. Electrochem., 39 (2009) 497–502.

9. “Fe-Al interface intermixing and the role of Ti, V, and Zr as a stabilizing interlayer at the interface”, W. Priyantha, R. J. Smith, H. Chen, M. Kopczyk, M. Lerch, C. Key, P. Nachimuthu, and W. Jiang, J. Appl. Phys. **105** (2009) 053504.

10. “High Temperature Thermal Stability and Oxidation Resistance of Magnetron-sputtered Homogenious CrAlON Coatings on 430 Steel”, A. Kayani, K.J. Wickey, M.I Nandasiri, A. Moore, E. Garratt, S. AlFaify, X. Gao, R.J. Smith, T.L. Buchanan, W. Priyantha, M. Kopczyk, P.E. Gannon, V.I. Gorokhovsky, AIP Conf. Proceedings, 1099 (2009) 303.

VITA (Summary)

SACHIKO TSURUTA

EDUCATION:

Ph.D.(1964) Columbia University, New York, N.Y.; Physics, (Astrophysics)
M.A.(1959) Columbia University, New York, N.Y.; Physics.
B.A.(1956) University of Washington, Seattle, Washington; Physics.

HONORS AND AWARDS:

Certificate of High Scholarship, University of Washington (1956)
Exchange Scholarship, University of Washington (1954-1956)
University Scholarship, Columbia University (1956-1957)
Graduate Research Fellowship, NASA (1962-1964)
Visiting Professorship, Yamada Foundation (1978-1979)
Wiley Outstanding Research Award, Montana State University (1987)

PROFESSIONAL EXPERIENCE:

1977 - present: Montana State University, Department of Physics, Bozeman, Montana; Professor in Physics (1991-present), Research Professor (1983-1991), Visiting Professor (1980-1983) (p), Visiting Assoc. Professor (1977-1980)(p).
1982 - 1991: The Institute of Space and Astronautical Science (ISAS), Sagamihara, Japan; Theoretical Consultant, Visiting Professor (p).
1982 - present (summers only): Institute of Astronomy, Cambridge University, Cambridge, England; Visiting Scientist (p).
1978 - 1981: University of Tokyo, Department of Physics, Tokyo, Japan; Visiting Professor (p).
1975 - 1988: Max-Planck-Institut für Physik und Astrophysik, München, Germany; Senior Research Physicist (1975-1978), Visiting Professor (1978-1988)(p).
1973 - 1975: University of Sussex, Astronomy Centre, Brighton, England; Research Fellow.
1970 - 1973: NASA, Goddard Space Flight Center, Greenbelt, Maryland; National Academy of Science/National Research Council Research Associate; and University of Maryland, Department of Physics and Astronomy, College Park, Maryland; Senior Research Associate.
1964 - 1970: Smithsonian Astrophysical Observatory, Cambridge, Mass.; Physicist.
1965 - 1969: Harvard College Observatory and Harvard University, Department of Astronomy, Cambridge, Mass.; Associate.
(p) means "part of the period"

OTHER RELEVANT PROFESSIONAL ACTIVITIES: (Summary only)

Heavily engaged in research in various fields of astrophysics - including neutron stars, black holes, active galactic nuclei, Population III stars, and gravitational waves, in addition to teaching.

Organized various meetings: including 7th Pacific Rim Conference, Lijiang, China, April 2011; 5th Pacific Rim Conference, Sojong, Korea, November 2005; The 4th Sakata/Hayakawa Memorial Lecture, Nagoya, Japan, December 2005; the IAU Symposium 195, Bozeman, Montana, July 1999, as the chair; Conference on Chemical Evolution in the Early Uni-

verse, Harvard University, Cambridge, Mass, September 1995; Neutron Star Session in The Seventh Marcel Grossmann Meeting, Stanford, California, July 1994; The US-Japan Seminar on Neutron Stars, Kyoto, Japan, November 1990; The 20th Yamada International Conference, Tokyo, March 1988; Conference on Cosmogonical Processes, Boulder, Colorado, March 1985; Workshop on High Energy Astrophysics, The Third Marcel Grossmann Meeting, Shanghai, September 1982, etc.

Served in various professional committees, both within Montana State University (MSU) and outside; grant proposal review panels including NASA's ASCA, GRO, ATP, ADP, LTSA, etc., editorial board, etc., and as a referee of NSF proposals and various journals, including Astrophysical Journal, Astrophysical Journal Letters, Astronomy and Astrophysics, Monthly Notices of the Royal Astronomical Society, Neuvo Cimento, and Physical Review.

Supervised many research students (Ph.D., M.S., and B.S.) and postdocs.

INVITED LECTURES: Gave more than 350 invited talks in meetings.

PUBLICATIONS: more than 250 publications.

Major Recent Publications of S. Tsuruta, of $\sim$ last ten years (refereed journals and invited papers only):

Tsuruta, S. 2010, MNRAS (Monthly Nortices of Royal Astronomical Society), Vol. 401, p. 2706, with J.R. Plowman, D.C. Jacobs, R.W. Hellings, and S.L. Larson

Tsuruta, S. 2010, in The Energetic Cosmos: Suzaku to Astro-H, eds K. Makishima, et al. (AIP), in press

Tsuruta, S. 2009, in Neutron Stars and Pulsars, Astrophysics and Space Science Libruary, Vol. 357, Springer Lecture Series (AIP), 2009, pp 289-318

Tsuruta, S. 2009, Astrophysical Journal (Ap.J.), Vol. 706, p. 1184, with T. Ohkubo, K. Nomoto, H. Umeda, N. Yoshida

Tsuruta, S. 2009, Ap. J., Vol. 691, p. 621, with J. Sadino, A. Kobelski, M. Teter, A. Liebmann, T. Takatsuka, K. Nomoto, and H. Umeda

Tsuruta, S. 2009, JCAP (Journal of Cosmology and Asgtroparticle Physics), Vol. 8, p. 24, with H. Umeda, N. Yoshida, K. Nomoto, M. Sasaki, and T. Ohkubo

Tsuruta, S., Ohkubo, T., Umeda, H., Maeda, K., Suzuki, T., and Rees, M.J. 2008, in Black Holes: from Stars to Galaxies, eds. V. Karas, et. al. (Cambridge University Press)

Tsuruta, S. 2007, in The Seventh Pacific Rim Conference on Stellar Astrophysics, eds. Y.W. Wang et al. (ASPCS), Vol. 362, p. 111

Fukumura, K., Takahashi, K., and Tsuruta, S. 2007, Ap. J., Vol. 657, p. 415 (Astro-ph/0602568)

Takahashi, M., Goto, J., Fukumura, K., Rilett, J., and Tsuruta, S. 2006, Ap. J., Vol. 645, p. 1408 (Astro-ph/0511217)

Tsuruta, S. 2006, in Proceedings for International Symposium on Origin of Matter and Evolution of Galaxies 5 (eds. Kubono, et al.) AIP, p. 163 (Astro-ph/0602138).

Ohkubo, T, Umeda, H., Maeda, K., Nomoto, K., Suzuki, T., Tsurutsa, S., and M. J., Rees 2006, Ap. J., Vol. 645, p. 1352

Fukumura, K, and Tsuruta, S. 2005, in Growing Black Holes: Accretion in a Cosmological Context, eds. Sunyaev et al., (Springer), 2005, p.317

Tsuruta, S. 2004, in Young Stars and Their Environments (eds. Camilo, F., et al.), ASP IAU Symposium Proceedings, Vol. 218, p. 21.

Fukumura, K., and Tsuruta, S. 2004, Ap. J., Vol. 611, p.964
Fukumura, K., and Tsuruta, S. 2004, Ap. J., Vol. 613, p. 700
Tsuruta, S., Parity, March 2004, Maruzen, p. 62
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Tsuruta, S. and Teter, M.A. 2001, in Proceedings of the 20th Texas Symposium (eds. Martel, H. and Wheeler, J.C.), AIP, p. 507.
Tsuruta, S., and Teter, M.A. 2001b, in New Century of X-Ray Atronomy (eds. Inoue, H. and Kunieda, H.) ASP.
Umeda, H., Tsuruta, S., Nomoto, K. and Mineshige, S. 2000, Ap. J., Vol. 534, p. L193.
Weber, M., Martens, P., and Tsuruta, S. 2000, as editors, ASP IAU Symposium Series 195, pp 1 - 492.
Tsuruta, S. 2000, in Stellar Astrophysics (eds. Cheng, K.S., et al.), Kluwer Academic Publishers.
Nomoto, K., Umeda, H., Tsuruta, S. and Mineshige, S. 1999, in Proceedings of October Maryland Meeting, eds. Holt et al.(Univ. of Cambridge Press)
Tsuruta, S. 1998, Physics Reports, Vol. 292, pp 1-130.

Curriculum Vitae

ANTON VORONTSOV

Born: 25 April 1975, Kostroma, Russia
Citizenship: USA, Russia

Address:

Department of Physics
Montana State University
P.O. Box 173840
Bozeman, MT 59717-3840

e-mail: avorontsov@physics.montana.edu
phone: (406) 994-6573
Fax: (406) 994-4452

PROFESSIONAL PREPARATION

- Ph.D., 2004, Northwestern University, Evanston, Illinois, USA
  Thesis: *Theoretical investigations of superfluid ^{3}He films*
- M.Sc. in Physics, *with honors*, 1998, Nizhny Novgorod State University, Nizhny Novgorod, Russia
- B.Sc. in Physics, 1996, Nizhny Novgorod State University, Nizhny Novgorod, Russia

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APPOINTMENTS

- Assistant Professor, 2009-present, Dept. of Physics, Montana State University, Bozeman
- Postdoctoral researcher, 2007-2008, Dept. of Physics, University of Wisconsin-Madison
- Postdoctoral researcher, 2004-2007, Dept. of Physics and Astronomy, Louisiana State University
- Graduate Research Assistant summer position with Dr. M. J. Graf, 2004, Los Alamos National Laboratory, T-CNLS/T-11, Los Alamos, NM

AWARDS

- KITP Scholar, 2010-2012
- International ICAM Junior Exchange Fellowship Track II, for study of superconductors without inversion symmetry, 2006
- Three I2CAM Junior Scientist Travel Awards, 2006, 2008
- Named Khariton Fellowship, 1997-1998, Nizhny Novgorod State University

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GRANTS

- MSU start-up, 2009-present, $130K
- NSF CAREER grant "Theory and modelling of non-uniform superconductors and superfluids", $440K, 2010-2015 (pending, recommended for funding)

RESEARCH INTERESTS

- Unconventional superfluids in strongly confined geometries, surface states;
- Interplay between magnetism and superconductivity, FFLO, SDW+SC, vortex states;
- Magnetically active superconductors and materials without inversion center;

TEACHING EXPERIENCE

- Graduate courses: Electrodynamics-I,II (MSU, 2009)
- Undergraduate courses: Intro to Theoretical Physics (MSU, 2010)
- Invited lecture for graduate students, *Superfluid phases of ^{3}He in bulk and films*, Northwestern University, 22 April 2008
- Teaching Assistant, 2002-2004, Department of Physics, Northwestern University, Evanston, IL, USA
- Teaching Assistant in Physics, 1999-2001, Integrated Science Program, Northwestern University, Evanston, IL, USA

CONFERENCE PRESENTATIONS / SEMINARS - until present: 27, including 3 invited
Selected:

- 2009 Quantum Fluids and Solids International Conference, Evanston, IL
  Competing orders, broken spatial and temporal symmetries in superfluid ^{3}He and novel superconductors
- 2008, August 9, LT-25, Amsterdam, the Netherlands
  Stripe order in superfluid ^{3}He and superconducting films
- 2008, July 14, Workshop SPINS 08, Karlsruhe, Germany
  Surface bound states and spin currents in non-centrosymmetric superconductors

PUBLICATIONS - until present: 23, plus 6 in conf.proc. and 3 pending
Selected:

1. Superconductivity and spin-density-waves in multy-band metals
   A.B.Vorontsov, M.G.Vavilov, A.V.Chubukov [arXiv:1003.2389] *Submitted to PRB*
2. Theory of thermal conductivity in extended-*s* state superconductors: application to ferropnictides
   V. Mishra, A.B. Vorontsov, P.J. Hirschfeld, I. Vekhter, *Phys. Rev. B* **80**, 224525 (2009) [arXiv:0907.4657]
3. Broken translational and time-reversal symmetry in unconventional superconducting films.
   A.B. Vorontsov *Phys. Rev. Lett.* **102**, 177001 (2009) [arXiv:0903.5102]
4. Surface bound states and spin currents in noncentrosymmetric superconductors.
   A.B. Vorontsov, I. Vekhter, M. Eschrig *Phys. Rev. Lett.* **101**, 127003 (2008) [arXiv:0804.2464]
5. Spin relaxation in quantum dots due to electron exchange with leads.
   A.B. Vorontsov, M.G. Vavilov *Phys. Rev. Lett.* **101**, 226805 (2008) [arXiv:0810.4546]

6. Crystalline order in superfluid ^{3}He films.
   A.B.Vorontsov and J.A.Sauls, *Phys. Rev. Lett.* **98**, 045301 (2007) [cond-mat/0601565]
7. Anomalous Attenuation of Transverse Sound in ^{3}He.
   J.P. Davis, J. Pollanen, H. Choi, J.A. Sauls and W.P. Halperin, and A.B. Vorontsov *Phys. Rev. Lett.* **101**, 085301 (2008) [arXiv:0807.2221]
8. Unconventional superconductors under rotating magnetic field II: thermal transport.
   A.B. Vorontsov, I. Vekhter, *Phys. Rev. B* **75**, 224502 (2007) [cond-mat/0702226]
9. Phase Diagram and Spectroscopy of Fulde-Ferrell-Larkin-Ovchinnikov states of two-dimensional d-wave superconductors.
   A.B. Vorontsov, J.A. Sauls and M.J. Graf, *Phys.Rev. B*, **72**, 184501 (2005) [cond-mat/0506257]

Shannon D. Willoughby

211 Lindley Pl.
Bozeman, MT 59715

Phone: (406) 582-0484
willoughby@physics.montana.edu

Education

Ph.D. Physics, Tulane University, 2003
Theoretical investigations of CoPt alloys and superlattices Advisor: James MacLaren

M.S. Physics, Tulane University, 2003

B.S. Physics, University of New Orleans, 1999

Professional Experience

Adjunct Assistant Professor — 2005–present
Department of Physics — Montana State University

Research Scientist/Postdoctoral Fellow — 2003–2005
Department of Chemistry and Geochemistry — Colorado School of Mines

Postdoctoral Fellow — 2004–2005
David Pappas — NIST Boulder

Teaching Experience

Instructor, Physics 101, Montana State University, Fall, Spring and Summer 2005–present

Instructor, Physics 205, Montana State University, Fall 2005, Fall, 2006, Spring 2009

Instructor, Physics 206, Montana State University, Summer, 2008

Instructor, Physics 211, Montana State University, Spring, 2007, 2008, Fall, 2007, 2008

Instructor, Physics 212, Montana State University, Spring 2010

Instructor, Physics 506 (Quantum Mechanics I), Montana State University Spring 2006

Instructor, Physics 300 (Modern Physics) Colorado School of Mines Spring 2004, Spring 2005

Instructor, Chemistry 121 Recitation, Colorado School of Mines Spring 2005

Instructor, Chemistry 513 Colorado School of Mines Spring 2004

Selected Invited Talks

Student Conversations During Clicker Sessions: What Are They Telling Us?, AAPT/AAS, February 2009.

Badass Women Astronomers, Women's History Month talk at Montana State University, March, 2008.

Technology Talks: Clickers and Gender in the Classroom, APS Northwest Meeting, May, 2007.

FeRh: One Funky Alloy, Colorado School of Mines, January, 2005.

Density functional theory: Practical quantum mechanics, Colorado School of Mines, April 2004.

Theoretical investigations of grain boundaries in magnetic materials, NIST Boulder, December 2003.

Ab-initio calculations of magnetic properties near grain boundaries, Vrije University, Amsterdam, The Netherlands, November 2003.

Theoretical investigations of magnetic materials, Los Alamos National Laboratory, September 2002.

Shannon D. Willoughby

Service

Head Teamwork Judge, FIRST Lego League, Montana State University, Jan., 2009, Feb., 2010.

Presenter, Big Sky Science Partnership, Northern Cheyenne Reservation, May, 2008.

Teamwork Judge, FIRST Lego League, Montana State University, Jan., 2008.

Presenter, Expanding Your Horizons, Montana State University, May, 2007, 2008.

Judge, Montana Science Olympiad, Montana State University, Nov., 2006, 2007, 2009.

Publications

Listening to student conversations during clicker questions: what you don't hear may surprise you - M. James and S. D. Willoughby, *submitted* American Journal of Physics.

Exploring gender differences with different gain calculations in astronomy and biology - S. D. Willoughby and A. Metz, American Journal of Physics **77** (7), 651–657 (2009).

Technology talks: Clickers and grading incentive in the large lecture hall - S. D. Willoughby and E. Gustafson, American Journal of Physics **77** (2), 180-183 (2009).

Electronic structure of the dilute magnetic semiconductor $Zn_{0.90}Mn_{0.10}S$ measured by soft x-ray spectroscopy and first principles calculations - T. M. Schuler, R. A. Stern, R. McNorton, S. D. Willoughby J. M. MacLaren, D. L. Ederer, V. Perez-Dieste, F. J. Himpsel, S. A. Lopez-Rivera and T. A. Callcott, **72**, 045211 Physical Review B (2005).

First Principles calculations of FePt, CoPt, Co_3Pt and Fe_3Pt alloys - J. M. MacLaren, R. R. Duplessis, R. A. Stern and S. Willoughby **41**, 4374 IEEE Transactions on Magnetics (2005).

Electronic and magnetic properties of $Fe_{1-x}Cu_xPt$ - S. D. Willoughby, Journal of Applied Physics **95**, 6586 (2004).

Fe_3Pd ferromagnetic shape memory alloys - R. A. Stern, S. D. Willoughby, J. M. MacLaren, J. Cui, Q. Pan and R. D. James, Journal of Applied Physics **93**, 8644 (2003).

Electronic structure calculations of hexagonal and cubic phases of Co_3Pt - S. D. Willoughby, R. A. Stern, R. Duplessis and J. M. MacLaren, Journal of Applied Physics **93**, 7145 (2003).

Effects of grain boundaries on magnetic and recording properties of media - R. H. Victora, S. D. Willoughby, J. M. MacLaren and J. Xue, IEEE Transactions on Magnetics **39**, 710 (2003).

First principles studies of intergrain exchange coupling - J. M. MacLaren and S. D. Willoughby, Journal of Applied Physics **91**, 8147 (2002).

Electronic, magnetic and structural properties of $L1_0$ $FePt_xPd_{1-x}$ alloys - S. D. Willoughby, J. M. MacLaren, T. Ohkubo, S. Jeong, M. E. McHenry, D. Laughlin, S. Choi and S. Kwan Journal of Applied Physics **91**, 8822 (2002).

Electronic and structural properties of Fe_3Pd/Pt ferromagnetic shape memory alloys - R. A. Stern, S. D. Willoughby, A. Ramirez, J. M. MacLaren, J. Cui, Q. Pan and R. D. James, Journal of Applied Physics **91**, 7818 (2002).

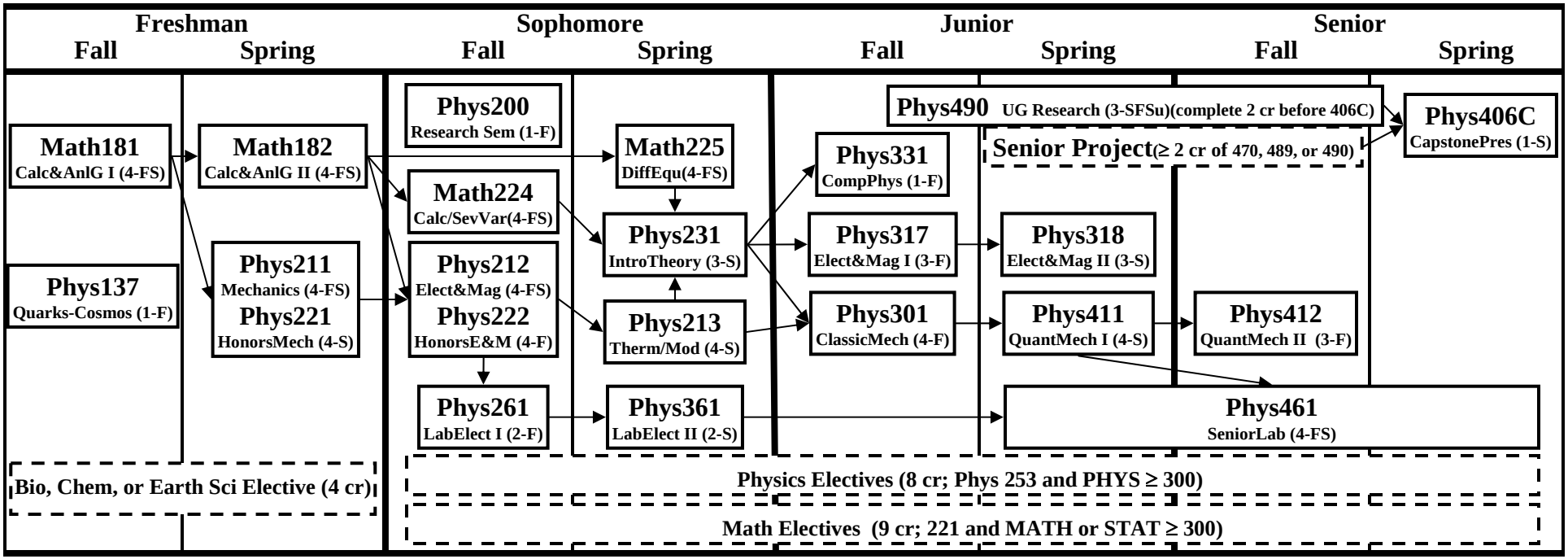
First principles calculations of the electronic structure of $Fe_{1-x}Co_xPt$ - J. M. MacLaren, S. D. Willoughby, M. E. McHenry, B. Ramalingam and S. Sankar, IEEE Transactions on Magnetics **37**, 1272 (2001).

First principles determination of the effects of a grain boundary on the anisotropy and exchange energies in Co_1Pt_5 superlattices - J. M. MacLaren and S. D. Willoughby, Journal of Applied Physics **89**, 6895 (2001).

Appendix 7: Physics Professional Option Flow Chart

Updated 2/7/08

Physics Professional Option (2008-2010)



Physics and Math Electives: Suggested electives. See catalog for other electives

Math Electives (221 and ≥ 300)

Fall

- Math328 Discrete (3-F)
- Math333 LinAlg (3-F)
- Math348 TechAppl I (3-F)
- Math361 AdvCalc I (3-F)

Spring

- Math329 Matrix (3-S)
- Math349 Tech/Appl II (3-S)
- Math362 AdvCalc II (3-S)
- Math416 ModAlg (3-S)

Fall & Spring

- Math221 Matrix (3-FSSu)

See catalog for STAT courses ≥ 300

Other Physics courses to consider

Physics 400 Seminars - P/F

Phys270/289R/290R Indep study/Research

Physics Electives (Phys 253 and ≥ 300)

Fall

- Phys253 Photography (2-F)
- Phys311 SolarAstro (4-F)
- Phys441 SolidState (3-F-a06)
- Phys451 ElementPart (3-F_a06)

Fall & Spring

- Phys470,489 Ind. study/Research (On demand, SFSu)
- Physics 400- Seminars (1-FS) Not P/F

Spring

- Phys312 IntroAstro (4-S-a09)
- Phys341 Relativity (1-S-a07)
- Phys353 Holography (3-S)
- Phys425 ThermoStat (3-S-a07)
- Phys426 ModernOptics (3-S-a08)
- Phys427 LaserAppl (3-S-a07)
- Phys435 Astrophysics (3-S-a08)
- Phys442 NovelMaterials (3-S_a07)

See catalog for pre-requisites for elective courses.

Required Courses

Required Elective Credits

Suggested Electives

Pre-Req → **Co-Req** → **Course**

Course#
CourseName
(# of Credits-Semester Offered)
F=Fall S=Spring Su=Summer
aYY =alternate years
YY=year offered

Senior Project credits also count for Phys 490 or Physics elective requirements.

Note: Phys301 has the option of Phys231 or Math 348 as a pre-req.
2 credits of 490 must be completed before taking Phys406C.

A minimum of 120 total credits is required for graduation; 42 credits must be numbered ≥300.
C- or better is required for all required courses. D-, D, D+, and P credits only count towards electives and 120 total credits.

Appendix 8: Curricula in Physics by Option

Appendix 8: Curricula in Physics by Option

PROFESSIONAL OPTION

Freshman Year	**F**	**S**
M 171--Calculus I	4	
M 172--Calculus II		4
PHYS 137--From Quarks to the Cosmos	1	
Take one of the following:		
PHYS 211--Gen & Mod Phys I		4
PHYS 221--Honors Gen & Mod Phys I		4
Biol,Chem, or Earth Science Electives	4	
University Core and Electives	6	7
	15	**15**
Sophomore Year	**F**	**S**
PHYS 200--Research Programs in Physics	1	
Take one of the following:		
PHYS 212--Gen & Mod Phys II	4	
PHYS 222--Honors Gen & Mod Phys II	4	
M 273--Multivariable Calculus	4	
M 274—Intro to Diffential Equations		4
PHYS 213--Gen & Mod Phys III		4
PHYS 231--Intro Theoretical Phys		3
PHYS 261--Laboratory Electronics I	2	
PHYS 361--Laboratory Electronics II		2
University Core and Electives	4	2
	15	**15**
Junior Year	**F**	**S**
PHYS 301--Classical Mechanics	4	
PHYS 317--Electr & Magnetism I	3	
PHYS 318--Elect & Magnetism II		3
PHYS 331--Computational Physics	1	
PHYS 411--Quantum Mech I		4
Math Electives	3	3
Physics Electives		3
University Core and Electives	4	2
	15	**15**
Senior Year	**F**	**S**
PHYS 406--Capstone Presentations		1
PHYS 412--Quantum Mech II	3	
PHYS 461--Senior Lab	4	
PHYS 490--Undergrad Research/Creative Activity	3	
Math Electives		3
Physics Electives	2	3
University Core and Electives	3	8
	15	**15**

The physics electives are to be selected from PHYS 253 and PHYS courses numbered 300 and above. The mathematics electives are to be selected from M 221 and MATH and STAT courses numbered 300 and above. A minimum of 120 credits is required for graduation; 42 of these credits must be in courses numbered 300 and above.

INTERDISCIPLINARY OPTION

Freshman Year	**F**	**S**
M 171--Calculus I	4	
M 172--Calculus II		4
PHYS 137--From Quarks to the Cosmos	1	
Take one of the following:		
PHYS 211--Gen & Mod Phys I		4
PHYS 221--Honors Gen & Mod Phys I		4
Biol, Chem, or Earth Science Electives	4	
University Core, Elect, & Opt	6	7
	15	**15**

Sophomore Year	**F**	**S**
PHYS 200--Research Programs in Physics	1	
Take one of the following:		
PHYS 212--Gen & Mod Phys II	4	
PHYS 222--Honors Gen & Mod Phys II	4	
M 273--Multivariable Calculus	4	
M 274--Intro to Diffential Equations		4
PHYS 213--Gen & Mod Phys III		4
PHYS 231--Intro Theoretical Phys		3
PHYS 261--Laboratory Electronics I	2	
PHYS 361--Laboratory Electronics II		2
University Core, Elect, & Opt	4	2
	15	**15**

Junior Year	**F**	**S**
PHYS 301--Classical Mechanics	4	
PHYS 317--Electr & Magnetism I	3	
PHYS 411--Quantum Mech I		4
Math Electives	3	3
Physics Electives		3
University Core, Elect, & Opt	5	5
	15	**15**

Senior Year	**F**	**S**
PHYS 406--Capstone Presentations		1
PHYS 490--Undergrad Research/Creative Activity	3	
University Core, Elect, & Opt	12	14
	15	**15**

The physics electives are to be selected from PHYS 253 and PHYS courses numbered 300 and above. The mathematics electives are to be selected from M 221 and MATH and STAT courses numbered 300 and above. A minimum of 120 credits is required for graduation; 42 of these credits must be in courses numbered 300 and above.

PHYSICS TEACHING OPTION

Freshman Year	**Credits**
EDCI 102--In-School Experience	1
HDCF 150IS--Lifespan Human Devlpmt	3
HDHL 106--Drug Hlth Issue for Ed	1
M 171Q--Calculus I	4
M 172Q--Calculus II	4
PHYS 137--From Quarks to the Cosmos	1
Take one of the following:	
PHYS 211--Gen & Mod Phys I	4
PHYS 221--Honors Gen & Mod Phys I	4
Approved elective in Biol,Chem, or Erth Sci	3
University Core and Electives	11
	32
Sophomore Year	**Credits**
EDCI 209--Ed Psy Adol Dev	3
M 273Q--Multivariable Calculus	4
M 274--Intro to Diffential Equations	4
M 242--Methods of Proof	3
Take one of the following:	
PHYS 212--Gen & Mod Phys II	4
PHYS 222--Honors Gen & Mod Phys II	4
PHYS 213--Gen & Mod Phys III	4
PHYS 231--Intro Theoretical Phys	3
PHYS 261--Laboratory Electronics I	2
PHYS 361--Laboratory Electronics II	2
University Core and Electives	3
	32
Junior Year	**Credits**
EDCI 240D--Multi-Cultural Ed	3
EDCI 320--Found of Instr Computing	2
EDCI 360--Found of Assessment	2
HDCF 356--Exceptional Children	3
M 328--Higher Math for Sec Teachers	3
M 329--Modern Geometry	3
STAT 216Q--Introduction to Statistics	3
PHYS 301--Classical Mechanics	4
Take one of the following:	
PHYS 311--Solar System Astronomy	4

PHYS 312--Stars, Galaxies & the Universe	4
University Core and Electives	5
	32

Senior Year	**Credits**
EDSD 301--Paraprofessional Exper	1
EDSD 410--Student Teaching	10
EDSD 413--Professional Issues	2
EDSD 461--Method Teach Sec Science	3
EDSD 466--Teach Content Read Strat	3
M 428--Math Modeling for Teachers	3
PHYS 317--Electr & Magnetism I	3
Physics Electives	5
University Core & Electives	2
	32

The physics electives must be numbered 200 and above. A minimum of 128 credits is required for graduation; 42 of these credits must be in courses numbered 300 and above.

PHYSICS MINOR (NON-TEACHING)

Take one of the following:	
PHYS 211--Gen & Mod Phys I	4
PHYS 221--Honors Gen & Mod Phys I	4
Take one of the following:	
PHYS 212--Gen & Mod Phys II	4
PHYS 222--Hnrs Gen & Mod Phys II	4
PHYS 213--Gen & Mod Phys III	4
PHYS 231--Intro Theoretical Phys	3
Take one of the following:	
PHYS 301--Classical Mechanics	4
PHYS 317--Elect & Magnetism I	3
Physics electives (261 or 300 level or above)	7
	26

Students who complete PHYS 301 require 7 additional physics elective credits. Students who complete PHYS 317 require 8 additional physics elective credits.

Appendix 9: MSU Catalog Department of Physics course descriptions

MSU Catalog: Department of Physics

PHYS 101IN MYSTERIES OF THE SKY
F,S,Su 3 cr. LEC 3
-- An introduction to contemporary astronomy that explores the nature, methods, and limitations of scientific inquiry within the context of our struggle to understand the structure and evolution of the Universe. Topics include the history of astronomy, motions of the night sky, the solar system, stellar evolution, galaxies, and cosmology.

PHYS 102IN MYSTERIES OF THE UNIVERSE
Su 4 cr. LEC 3 RCT 1
-- An introduction to contemporary astronomy that explores the nature, methods, and limitations of scientific inquiry within the context of our struggle to understand the structure and evolution of the Universe. Topics include the history of astronomy, motions of the night sky, the solar system, stellar evolution, galaxies, and cosmology. In addition to lectures, students spend one full class each week working in teams on a series of lab-like exercises designed to reinforce the learning of key concepts. Students may only count one of PHYS 101 and PHYS 102 toward meeting graduation requirements.

PHYS 103IN OUR PHYSICAL WORLD
F 3 cr. LEC 3
PREREQUISITE: High School Algebra.
-- A conceptual survey of topics in physics for non-science majors. Topics include motion, force, momentum, energy, waves, and sound, and may include heat, the structure of matter, relativity, optics, electricity and magnetism, or modern physics. Students will not receive credit if they have passed PHYS 205, PHYS 211, or PHYS 221.

PHYS 137 FROM QUARKS TO THE COSMOS
F 1 cr. LEC 1
-- An introduction to frontier areas of physics, including the "Standard Model" of elementary particle physics, quantum mechanics, and big-bang cosmology. Students explore these topics using order-of-magnitude estimates, dimensional analysis, and simple observations. Intended for physics majors or those considering a major or minor in physics.

PHYS 200 RESEARCH PROGRAMS IN PHYSICS
F 1 cr. LEC 1
-- An introduction to some of the exciting ideas, developments, problems, and experiments of modern day physics.

PHYS 201IN PHYSICS BY INQUIRY
F,S 3 cr. LAB 3
-- An indepth exploration of basic physics principles. Scientific model building and proportional reasoning skills will be developed in the context of properties of matter, observational astronomy, and DC electric circuits. For pre-service elementary teachers.

PHYS 205 COLLEGE PHYSICS I
F,S,Su 4 cr. LEC 3 LAB 1
PREREQUISITE: High school trigonometry or M 160.
-- First semester of sequence. Topics include kinematics and dynamics of linear and rotational motion; work and energy; impulse and momentum; and fluids. Students will not receive credit if they have passed PHYS 211 or PHYS 221.

PHYS 206 COLLEGE PHYSICS II
F,S,Su 4 cr. LEC 3 LAB 1
PREREQUISITE: PHYS 205 or PHYS 211.
-- Second semester of sequence. Topics include simple harmonic motion; electric forces and fields; dc electric circuits; magnetic forces and fields; and magnetic induction and motors. Students will not receive credit if they have passed PHYS 212 or PHYS 222.

PHYS 211 GENERAL AND MODERN PHYSICS I
F,S 4 cr. LEC 3 LAB 1
PREREQUISITE: M 171
-- First semester of a three-semester sequence primarily for engineering and physical science students. Covers topics in mechanics (such as motion, Newton's laws, conservation laws, work, energy, systems of particles, and rotational motion) and in mechanical waves (such as oscillations, wave motion, sound, and superposition).

PHYS 212 GENERAL AND MODERN PHYSICS II
F,S 4 cr. LEC 3 LAB 1
PREREQUISITE: PHYS 211 or PHYS 221; M 182
-- Covers topics in electricity and magnetism (such as Coulomb's law, Gauss' law, electric fields, electric potential, dc circuits, magnetic fields, Faraday's law, ac circuits, and Maxwell's equations) and optics (such as light, geometrical optics, and physical optics).

PHYS 213 GENERAL AND MODERN PHYSICS III
S 4 cr. LEC 3 LAB 1
PREREQUISITE: PHYS 212 or PHYS 222.
-- Covers topics in thermodynamics (such as temperature, heat, laws of thermodynamics, and the kinetic theory of gases) and modern physics (such as relativity; models of the atom; quantum mechanics; and atomic, molecular, solid state, nuclear, and particle physics).

PHYS 221 HONORS GENERAL AND MODERN PHYSICS I
S 4 cr. LEC 3 LAB 1
PREREQUISITE: M 171.
-- The honors section of PHYS 211. The concepts are discussed in more depth and the range of applications is greater.

PHYS 222 HONORS GENERAL AND MODERN PHYSICS II
F 4 cr. LEC 3 LAB 1
PREREQUISITE: PHYS 211 or PHYS 221, M 182.
-- The honors section of PHYS 212. The concepts are discussed in more depth and the range of applications is greater.

PHYS 231 INTRODUCTION TO THEORETICAL PHYSICS
S 3 cr. LEC 3
PREREQUISITE: M 224.
COREQUISITE: M 225, PHYS 213.
-- Mathematical methods essential to the practice of theoretical physics, such as matrices, vector calculus, differential equations, complex variables and Fourier series, with applications to examples from mechanics and electromagnetism.

PHYS 253 PHYSICS OF PHOTOGRAPHY
F 2 cr. LEC 2
PREREQUISITE: High school algebra.
-- Improvement of photographic skills through an understanding of the basic principles of photography. The nature of light and color and the physical principles involved in the operation of a camera will be presented. Unusual effects and recent developments will be discussed. Numerous demonstrations, photographs, and slides will be used to illustrate the principles.

PHYS 261 LABORATORY ELECTRONICS I
F 2 cr. LEC 1 LAB 1
COREQUISITES: PHYS 212 or PHYS 222.
-- Laboratory electronic measurements and analysis, and design of basic linear circuits.

PHYS 270 INDEPENDENT STUDY
On Demand 1-3 cr. IND Maximum 6 cr.
PREREQUISITE: Consent of instructor and approval of department head.
-- Directed study on an individual basis.

PHYS 280 SPECIAL TOPICS
On Demand 1 - 4 cr. Maximum 12 cr.
PREREQUISITE: None required but some may be determined necessary by each offering department.
-- Courses not required in any curriculum for which there is a particular one time need, or given on a trial basis to determine acceptability and demand before requesting a regular course number.

PHYS 289R UNDERGRADUATE RESEARCH/CREATIVE ACTIVITY INSTRUCTION
F,S,Su 1 - 2 cr. RCT May be repeated. Max 4 cr.
COREQUISITE: PHYS 290.
-- Classroom instruction associated with directed undergraduate research/creative activity projects.

PHYS 290R UNDERGRADUATE RESEARCH
F,S,Su 1 - 6 cr. RCT
PREREQUISITE: Consent of instructor and approval of department head.
-- Directed undergraduate research. Course will address responsible conduct of research.

PHYS 301 CLASSICAL MECHANICS
F 4 cr. LEC 4
COREQUISITE: PHYS 213, PHYS 231.
-- Principles of Newtonian, Lagrangian, and Hamiltonian mechanics including single particle motion, systems of particles, rigid body motion, moving coordinate systems, and small oscillations.

PHYS 311 SOLAR SYSTEM ASTRONOMY
F,Su on demand 4 cr. LEC 3 LAB 1
PREREQUISITE: PHYS 205, PHYS 211, or PHYS 221.
COREQUISITE: PHYS 206, PHYS 212, or PHYS 222.
-- Covers the origin and evolution of our solar system, including detailed examinations of the sun, earth, moon, other planets, and satellites. Exciting new discoveries and emerging research results will be integrated into the course. The laboratory operates in a "project mode" and includes experiments with models that can be done indoors as well as with the use of telescopes.

PHYS 312 INTRODUCTION TO ASTRONOMY
S alternate years, to be offered odd years 4 cr. LEC 3 LAB 1
PREREQUISITE: PHYS 205, PHYS 211, or PHYS 221, or the equivalent.
COREQUISITE: PHYS 206, PHYS 212, or PHYS 222, or the equivalent.
-- After reviewing basic classical astronomy on the properties, structure and evolution of stars and galaxies, the course will introduce some hot topics in frontiers of astronomy, such as pulsars, quasars, black holes, and fate of the universe.

PHYS 317 ELECTRICITY AND MAGNETISM I
F 3 cr. LEC 3
PREREQUISITE: PHYS 231 or M 348.
-- Electrostatic fields, dielectric materials, magnetic fields, magnetic materials, and Maxwell's equations.

PHYS 318 ELECTRICITY AND MAGNETISM II
S 3 cr. LEC 3
PREREQUISITE: PHYS 317.
-- Propagation of electromagnetic waves, radiation, and general wave phenomena.

PHYS 331 COMPUTATIONAL PHYSICS
F 1 cr. LEC 1
PREREQUISITE: PHYS 231.
-- Introduction to the use of computational methods in physics. Emphasis will be placed on common methods of casting problems into forms amenable to numerical solution and for displaying numerical results.

PHYS 341 SPECIAL RELATIVITY
S alternate years, to be offered odd years 1 cr. LEC 1
PREREQUISITE: PHYS 211 or PHYS 221.
-- Einstein's theory of special relativity is presented from the modern viewpoint, with emphasis on the geometry of space time.

PHYS 353RN THE ART AND SCIENCE OF HOLOGRAPHY
S 3 cr. LEC 2 LAB 1
PREREQUISITE: Junior standing. M 160 or equivalent M Placement Test.
-- Beginner's course on creating holograms. Pictorial and geometric interpretations of lasers, interference, coherence, film, and holography enable students with limited science and M backgrounds to create their own holographic masterpieces. Lab techniques and documenting the creative process are emphasized.

PHYS 361 LABORATORY ELECTRONICS II
S 2 cr. LEC 1 LAB 1
PREREQUISITE: PHYS 261.
-- Analysis and design of basic digital circuits and advanced laboratory electronic measurements.

PHYS 400 SEMINAR
On Demand 1 cr. SEM 1 Maximum 4 cr
PREREQUISITE: Junior standing and as determined for each offering.
-- Topics offered at the upper division level which are not covered in regular courses. Students participate in preparing and presenting discussion material.

PHYS 401 PHYSICS BY INQUIRY I

Su 3 cr. LAB 3.

PREREQUISITE: Teacher Certification.

-- An in-depth and hands-on exploration of basic physics principles. Scientific model building and proportional reasoning skills will be developed in the context of dc electrics, one and two dimensional kinematics, and dynamics. For middle school and high school science teachers.

PHYS 402 PHYSICS BY INQUIRY II

Su 3 cr. LAB 3.

PREREQUISITE: PHYS 401.

-- An in-depth and hands-on exploration of basic physics principles. Scientific model building and proportional reasoning skills will be developed in the context of light, color, geometrical optics, heat, and temperature. For middle school and high school teachers.

PHYS 403 SPECIAL RELATIVITY ONLINE

S alternate years, to be offered odd years 3 cr. RCT 3

PREREQUISITE: PHYS 212, M 182, Bachelor's degree, and one year teaching experience.

-- This online course addresses the question: In what ways does nature behave differently at high relative speeds than at low speeds? Designed for practicing high school physics teachers. Assignments and discussions use electronic computer conferencing and interactive visual software.

PHYS 404 PHYSICS BY INQUIRY III

Su 3 cr. LAB 3

PREREQUISITE: Science Teacher Certification.

COREQUISITE: PHYS 401.

--PHYS 404 is a continuation of the PHYS 401 experience, but it may also be taken concurrently with PHYS 401. The course will begin with a careful investigation of geometrical optics, leading to an understanding of pinhole cameras, lenses, and prisms. This will be followed by an exploration of magnetic interactions and magnetic materials.

PHYS 406 CAPSTONE PRESENTATIONS
S 1 cr SEM 1
PREREQUISITE: Senior standing; 2 credits of PHYS 470, 489, or 490, and completion of a senior project.
-- Senior capstone course. Participation in this course requires the completion of a senior capstone project that integrates the student's knowledge and skills acquired during the undergraduate curriculum. Results of the senior project will be presented orally and in writing.

PHYS 411 INTRODUCTORY QUANTUM MECHANICS I
S 4 cr. LEC 4
PREREQUISITE: PHYS 301.
-- Historical review, operators, eigenvalue problem, Schrodinger equation, one-dimensional problems, bound and unbound states, harmonic oscillator, and angular momentum.

PHYS 412 INTRODUCTORY QUANTUM MECHANICS II
F 3 cr. LEC 3
PREREQUISITE: PHYS 411.
-- Three-dimensional problems, hydrogen atom, matrix mechanics, spin, perturbation theory, and applications to atomic, molecular, nuclear, and particle physics.

PHYS 425 THERMODYNAMICS AND STATISTICAL PHYSICS
S alternate years, to be offered odd years 3 cr. LEC 3
PREREQUISITE: PHYS 231.
-- Statistical physics and thermodynamics and their applications to physical phenomena. This course is strongly recommended for students intending to study physics in graduate school.

PHYS 426 MODERN OPTICS
S alternate years, to be offered even years 3 cr. LEC 3
PREREQUISITE: PHYS 213 and M 225.
-- Emphasis is on new developments in optics triggered by the laser. Provides a good foundation in wave optics, nonlinear optics, integrated optics, and spectroscopy.

PHYS 427 LASER APPLICATIONS
S alternate years, to be offered odd years 3 cr. LEC 3
PREREQUISITE: PHYS 212.
-- A survey of laser types and properties and applications for scientists and engineers who wish to use lasers in research or technology. Many demonstrations will be used to illustrate the principles.

PHYS 435 ASTROPHYSICS
S alternate years, to be offered even years 3 cr. LEC 3
PREREQUISITE: PHYS 301 and PHYS 317.
-- A survey covering basic problems in modern astrophysics such as stellar structure and evolution, solar physics, compact objects, quasars, and cosmology.

PHYS 441 SOLID STATE PHYSICS
F alternate years, to be offered odd years 3 cr. LEC 3
PREREQUISITE: PHYS 213.
-- A treatment of the classification and electronic structure of solids. Properties of conductors, superconductors, insulators, and semiconductors will be discussed. This course is strongly recommended for students intending to study physics in graduate school.

PHYS 442 NOVEL MATERIALS FOR PHYSICS AND ENGINEERING
S alternate years, to be offered even years 3 cr. LEC 3
PREREQUISITE: Knowledge of introductory solid state physics; PHYS 441 or consent of instructor.
-- Provides basic physical knowledge of advanced natural/artificial materials; ferroelectrics, superconductors, nanotubes, superlattices, photonics materials, materials with giant magnetoresistance and negative susceptibilities, molecular magnets, and biomaterials.

PHYS 451 ELEMENTARY PARTICLE PHYSICS
F alternate years, to be offered even years 3 cr. LEC 3
PREREQUISITE: PHYS 231.
-- A survey of elementary particle physics, beginning with an historical viewpoint and leading up to today's remarkably successful "Standard Model" of quarks, leptons, and guage bosons.

PHYS 461 SENIOR LAB
F,S 4 cr. LAB 4 Maximum 8 cr
PREREQUISITE: PHYS 361.
COREQUISITE: PHYS 411.
-- Introduction to methods, instrumentation, and data acquisition techniques used in modern physics research. Experiments chosen from laser optics, atomic physics, solid-state physics, superconductivity, and nuclear physics.

PHYS 470 INDEPENDENT STUDY
On Demand 1 - 3 cr. IND Maximum 6 cr.
PREREQUISITE: Junior standing, consent of instructor and approval of department head.
-- Directed study on an individual basis.

PHYS 480 SPECIAL TOPICS
On Demand 1 - 4 cr. Maximum 12 cr.
PREREQUISITE: Course prerequisites as determined for each offering.
-- Courses not required in any curriculum for which there is a particular one-time need, or given on a trial basis to determine acceptability and demand before requesting a regular course number.

PHYS 489R UNDERGRADUATE RESEARCH/CREATIVE ACTIVITY INSTRUCTION
F,S,Su 1 - 2 cr. RCT May be repeated. Max 4 cr.
COREQUISITE: PHYS 490.
-- Classroom instruction associated with directed undergraduate research/creative activity projects.

PHYS 490R UNDERGRADUATE RESEARCH/CREATIVE ACTIVITY
F,S,Su 1 - 3 cr. IND May be repeated. Max 6 cr.
PREREQUISITE: Junior standing and signed consent of instructor/ research advisor and acamedic advisor.
-- Directed undergraduate research/creative activity which may culminate in a research paper, journal article, or undergraduate thesis. Course will address responsible conduct of research.

PHYS 500 SEMINAR
On Demand 1 cr. SEM Maximum 8 cr.
PREREQUISITE: Graduate standing or seniors by petition. Course prerequisites as determined for each offering.
-- Topics offered at the graduate level which are not covered in regular courses. Students participate in preparing and presenting discussion material.

PHYS 501 ADVANCED CLASSICAL MECHANICS
F 3 cr. LEC 3
PREREQUISITE: PHYS 301.
-- Lagrangian and Hamiltonian dynamics. Small oscillations. Rigid-body motion. An introduction to continuum mechanics.

PHYS 506 QUANTUM MECHANICS I
S 3 cr. LEC 3
PREREQUISITE: PHYS 412.
-- Ket space and matrix representations. Quantum dynamics and invariance. Path integral methods. Rotations and angular momentum theory. Translation, reflection, and inversion symmetries. Conservation principles and degeneracy.

PHYS 507 QUANTUM MECHANICS II
F 3 cr. LEC 3
PREREQUISITE: PHYS 506.
-- Time-independent and time-dependent perturbations. Identical particles and permutation symmetry. Scattering theory. Applications of quantum mechanics.

PHYS 511 ASTRONOMY FOR TEACHERS
F,S 3 cr. RCT 3
PREREQUISITE: PHYS 206 or PHYS 212, and secondary certification in teaching and two years of teaching experience.
-- This is an online, distance education course primarily intended for science educators. Topics include: the laws of gravity and orbital dynamics, a survey of the solar system, stars and stellar evolution, galaxies, and Big Bang cosmology.

PHYS 512 GENERAL RELATIVITY ONLINE
S alternate years, to be offered even years 3 cr. LEC 3
PREREQUISITE: PHYS 212, M 182, PHYS 403 and Bachelor's degree and one year teaching experience.
-- This online course addresses the theory of general relativity, which underlies our understanding of gravity and the large-scale structure of the cosmos. Designed for practicing high school physics teachers. Assignments and discussions use electronic computer conferencing and simulation software.

PHYS 513 QUANTUM MECHANICS ONLINE
F alternate years, to be offered even years 3 cr. LEC 3
PREREQUISITE: PHYS 212, M 182, EDSD 366 and Bachelor's degree and one year teaching experience.
-- This online course addresses the key ideas behind quantum mechanical observations and devices, including the fundamental behavior of electrons and photons. Designed for practicing high school physics teachers. Assignments and discussions use electronic computer conferencing and simulation software.

PHYS 514 COMPARATIVE PLANETOLOGY: ESTABLISING A VIRTUAL PRESENCE IN THE SOLAR SYSTEM
S 3 cr. LEC 3
PREREQUISITE: EDSD 366 or EDCI 325, professional teaching certification, Bachelor's degree and at least one year K-12 teaching experience, and a background knowledge of astronomy at the level of PHYS 101 (or its equivalent).
-- Establishing a Virtual Presence in the Solar System has been developed and tested as an Internet-delivered course for off-campus students. Its audience consists of practicing elementary and secondary teachers who have experience in teaching general science but have little, if any, formal course work in astronomy. Its goal is to help graduate-level teachers learn solar system astronomy concepts to integrate the new National Science Education Standards and NASA resources into existing instructional strategies. Course participants learn advanced solar system concepts, utilize WWW-resources, communicate with research scientists using the Internet, analyze digital images using image processing software, and organize materials for use in K-12 classroom environments.

PHYS 515 ADVANCED TOPICS IN PHYSICS
On Demand 3 cr. LEC 3 Maximum 6 cr.
PREREQUISITE: Graduate standing.
-- Topics in astrophysics, condensed matter physics, optics, mathematical physics, or particle physics are presented as needed to supplement the curriculum.

PHYS 516 EXPERIMENTAL PHYSICS
F,S 3 cr. LAB 3 Maximum 6 cr.
PREREQUISITE: PHYS 261, PHYS 317, and PHYS 411.
-- Experiments chosen from laser optics and atomic, solid-state, and nuclear physics are carried out in depth to introduce the graduate student to methods, instrumentation, and data acquisition techniques useful for experimental thesis projects.

PHYS 519 ELECTROMAGNETIC THEORY I
S 3 cr. LEC 3
PREREQUISITE: PHYS 318.
-- Electro- and magnetostatics, conservation laws and covariance of Maxwell's equations, and dynamics of relativistic particles and fields.

PHYS 520 ELECTROMAGNETIC THEORY II
F 3 cr. LEC 3
PREREQUISITE: PHYS 519.
-- Radiation by moving charges. Electromagnetic waves in condensed matter and plasma.

PHYS 523 GENERAL RELATIVITY I
F alternate years, to be offered odd years 3 cr. LEC 3
PREREQUISITE: PHYS 519.
-- Tensor calculus, differential geometry, and an introduction to Einstein's theory of gravity. The Schwarzschild solution and black hole physics.

PHYS 524 GENERAL RELATIVITY II
S alternate years, to be offered even years 3 cr. LEC 3
PREREQUISITE: PHYS 523.
-- Advanced topics in gravitation theory such as singularities, cosmological models, and gravitational waves.

PHYS 531 NONLINEAR OPTICS & LASER SPECTROSCOPY
F alternate years, to be offered odd years 3 cr. LEC 3
PREREQUISITE: PHYS 507.
-- Two-level atoms in laser fields and applications to nonlinear optics such as photon echoes, second harmonic generation, and stimulated Raman scattering. Atomic and molecular energy level structure, linear and nonlinear spectroscopy, and applications to gaseous and solid state laser materials.

PHYS 535 STATISTICAL MECHANICS
S alternate years, to be offered even years 3 cr. LEC 3
PREREQUISITE: PHYS 425.
-- Basic concepts of equilibrium statistical mechanics, with application to classical and quantum systems, will be presented as well as theories of phase transitions in fluid, magnetic, and other systems.

PHYS 544 CONDENSED MATTER PHYSICS I
F alternate years, to be offered even years 3 cr. LEC 3
PREREQUISITE: PHYS 425, PHYS 507.
-- Crystal structure and the reciprocal lattice. Quantum theory of electrons and phonons.

PHYS 545 CONDENSED MATTER PHYSICS II
S alternate years, to be offered odd years 3 cr. LEC 3
PREREQUISITE: PHYS 544.
-- Applications to the transport, optical, dielectric, and magnetic properties of metals, semiconductors, and insulators.

PHYS 555 QUANTUM FIELD THEORY
S alternate years, to be offered odd years 3 cr. LEC 3
PREREQUISITE: PHYS 507.
-- Techniques of canonical and path integral quantization of fields; renormalization theory. Quantum electrodynamics; gauge theories of the fundamental interactions.

PHYS 560 ASTROPHYSICS
F alternate years, to be offered even years 3 cr. LEC 3
PREREQUISITE: PHYS 318, PHYS 412, PHYS 425, and PHYS 435.
-- The purpose of this course is to prepare graduate students for thesis-level research in astrophysics, solar physics or related fields. Topics covered include: fluid mechanics, hydrodynamics, plasma physics, radiation processes and stability of equilibrium states.

PHYS 561 MODERN PHYSICS FOR TEACHERS: PARTICLES AND WAVES
Su 3 cr. LAB 3
PREREQUISITE: Secondary teaching certificate; 2 years teaching experience. PHYS 213, PHYS 401, and PHYS 580 (Advanced Physics by Inquiry.)
-- Students in this capstone course will discuss, perform, and analyze several experiments that demonstrate the particle and wave behaviors of light and electrons. Students will develop methods and models for teaching these concepts of modern physics to high school students.

PHYS 565 ASTROPHYSICAL PLASMA PHYSICS
F alternate years, to be offered odd years 3 cr. LEC 3
COREQUISITE: PHYS 520.
-- An introduction to the physics of fluids and plasma relevant to astrophysical plasmas such as the solar corona. Topics covered include: magnetostatics, one-fluid (MHD) and two-fluid approaches, linear waves and insabilities, shocks, transonic flows and collisional effects.

PHYS 566 MATHEMATICAL PHYSICS I
F 3 cr. LEC 3
PREREQUISITE: M 349, M 449, PHYS 301.
-- mathematical methods which find application in physics. Differential equations, contour integration, special functions, integral transforms, boundary value problems, and Green's functions.

PHYS 567 MATHEMATICAL PHYSICS II
S alternate years, to be offered odd years 3 cr. LEC 3
PREREQUISITE: PHYS 566.
-- Theory of computational techniques, and applications such as numerical integration, differential equations, Monte Carlo methods, and fast Fourier transforms.

PHYS 570 INDEPENDENT STUDY
On Demand 1 - 3 cr. IND Maximum 6 cr.
PREREQUISITE: Graduate standing, consent of instructor, approval of department head and Dean of Graduate Studies.
-- Directed research and study on an individual basis.

PHYS 580 SPECIAL TOPICS
On Demand 1 - 4 cr. Maximum 12 cr.
PREREQUISITE: Upper division courses and others as determined for each offering.
-- Courses not required in any curriculum for which there is a particular one time need, or given on a trial basis to determine acceptability and demand before requesting a regular course number.

PHYS 582 ASTROBIOLOGY FOR TEACHERS
F,S 3 cr. Online Lec 3
PREREQUISITE: PHYS 311, PHYS 511, or equivalent; PHYS 205, PHYS 211, or equivalent; BIOL 301 or equivalent; EDSD 366 or equivalent; and Bachelor's degree and minimum of one year of full-time teaching experience at the secondary level or above.
-- Astrobiology is the study of the origin, evolution, distribution, and destiny of life in the universe. It defines itself as an interdisciplinarscience at the intersection of physics, astronomy, biology, geology, and mathematics, to discover where and under what conditions life can arise and exist in the Universe. The course topics will cover the discovery of planetary systems around other stars, the nature of habitable zones around distant stars, the existence of life in extreme environments. These concepts will serve as a foundation to study possible extraterrestrial ecosystems on planets and moons like Mars and Europa.

PHYS 583 THE INVISIBLE UNIVERSE ONLINE: THE SEARCH FOR ASTRONOMICAL ORIGINS
F,S 3 cr. Online Lec 3
PREREQUISITE: PHYS 311, PHYS 511, or equivalent; PHYS 205, PHYS 211, or equivalent; EDSD 366 or equivalent; and Bachelor's degree and minimum of one year of full-time teaching experience at the secondary level or above.
-- This course covers the long chain of events from the birth of the universe in the Big Bang, through the formation of galaxies, stars, and planets by focusing on the scientific questions, technological challenges, and space missions pursuing the search for origins in alignment with the goals and emphasis of the National Science Education Standards.

PHYS 589 GRADUATE CONSULTATION
F,S,Su 3 cr. TUT
PREREQUISITE: Master's standing and approval of the Dean of Graduate Studies.
-- This course may be used only by students who have completed all of their coursework (and thesis, if on a thesis plan) but who need additional faculty or staff time or help.

PHYS 590 MASTER'S THESIS
F,S,Su 1 - 10 cr. IND Maximum credits unlimited.
PREREQUISITE: Master's standing.

PHYS 689 DOCTORAL READING & RESEARCH
On Demand 3 - 5 cr. IND Maximum 15 cr.
PREREQUISITE: Doctoral standing.
-- This course may be used by doctoral students who are reading research publications in the field in preparation for beginning doctoral thesis research.

PHYS 690 DOCTORAL THESIS
F,S,Su 1-10 cr. IND Maximum credits unlimited.
PREREQUISITE: Doctoral standing.

Appendix 10: Selected sections from the Graduate Student Manual

GRADUATE PROGRAMS IN PHYSICS

The Department of Physics grants the degrees Master of Science and Doctor of Philosophy. The general requirements for these degrees as outlined in the MSU Bulletin apply. Every student should examine this Bulletin and be familiar with its requirements.

The following supplements the Bulletin by outlining requirements and policies which apply specifically to degrees granted by the Department of Physics. In exceptional cases, departmental requirements, prerequisites, and time limits may be adjusted. Such exceptions require consent of the Physics Department Faculty in advance.

First year graduate students are required to register for a Fall Semester 1-credit teaching seminar (PHYS 500-01) and a 1-credit research seminar (PHYS 500-15) designed to acquaint the students with the various research areas in the department. These seminars will be presented by persons active in those areas and are designed to aid a student in identifying the particular area or areas he/she would like to pursue. Students are urged to enroll in other seminars of their choice to obtain more in-depth knowledge of particular areas.

First year U.S. students who are not Montana residents should immediately take steps to become legal residents of the State of Montana, to avoid paying nonresident fees in subsequent years. These students should register for a maximum of 6 credits per semester in their first year.

MASTER'S DEGREES

The Department of Physics grants the Master of Science Degree under two options: Plan A (thesis required), and Plan B (without thesis).

PLAN A REQUIREMENTS

1. Course Requirements

   A minimum of 20 credits of acceptable course work is required, which shall include the following:

Physics 500	Teaching Seminar (see above)	1 credit
Physics 500	Research Introduction Seminar (see above)	1 credit
Physics 501	Advanced Classical Mechanics	3 credits
Physics 506	Quantum Mechanics I	3 credits
Physics 519	Electromagnetic Theory I	3 credits
Physics 566	Mathematical Physics	3 credits
Electives	see comment below	6 credits
		20 credits

2. Thesis Requirements

   An acceptable thesis and at least 10 credits of Physics 590 are required.

3. Examinations

   A written Comprehensive Examination is required. A Final Oral Examination is also required, covering the thesis and related areas.

PLAN B REQUIREMENTS

1. Course Requirements

   A minimum of 30 credits of acceptable course work is required, which shall be distributed as follows:

Physics 500	Teaching Seminar (see above)	1 credit
Physics 500	Research Introduction Seminar (see above)	1 credit
Physics 501	Advanced Classical Mechanics	3 credits
Physics 506 & 507	Quantum Mechanics I & II	6 credits
Physics 519 & 520	Electromagnetic Theory I & II	6 credits
Physics 566	Mathematical Physics	3 credits
Electives	see comment below	10 credits
		30 credits

2. Thesis Requirements – None

3. Examinations

   A written Comprehensive Examination is required.

DOCTORAL DEGREE

1. Course Requirements

   A minimum of 40 credits of acceptable course work is required, which shall include the following:

Physics 500	Teaching Seminar (see above)	1 credit
Physics 500	Research Introduction Seminar (see above)	1 credit
Physics 501	Advanced Classical Mechanics	3 credits
Physics 506 & 507	Quantum Mechanics I & II	6 credits
Physics 519 & 520	Electromagnetic Theory I & II	6 credits
Physics 535	Statistical Mechanics	3 credits
Physics 566 & 567	Mathematical Physics	6 credits
Electives	see comment below	14 credits
		40 credits

2. Thesis Requirement

   An acceptable thesis is required. A minimum of 20 credits of Physics 690 is required in addition to the courses listed above.

3. Examinations

   Written and oral Comprehensive Examinations are required as is a Final Oral Examination covering the thesis and related areas.

ELECTIVES

All elective courses must be approved by the student's Graduate Committee and the Physics Department Head. This approval will ensure that the electives represent a coherent block of study of substantial relevance to Physics.

The following limitations normally apply to Elective Courses which may be listed on the Graduate Program for the M.S. or Ph.D. degree in Physics:

A. No more than half of the Elective credits in the above Course Requirements may be at the 400 level in a student's Graduate Program for any graduate degree in Physics. The remaining Elective credits must be at the 500 level.

B. The Electives will include courses in Physics and minor or supporting fields. At least half of the elective credits must be in Physics.

C. Physics 400, 411, 470, 489, 490, 589, 590, 689, 690 cannot be used as Electives in any Physics Graduate Program.

D. Physics 570 is allowed as an Elective to a maximum of 3 credits for an M.S. Program and 6 credits for a Ph.D. Program.

E. No more than 2 credits of non-required seminar courses are applicable as Electives in any Physics Graduate Program.

GRADUATE EXAMINATIONS

One **written** examination is given every year in the last half of August. It serves both as the M.S. Comprehensive Examination and as part of the Ph.D. Comprehensive Examination. The Ph.D. Comprehensive Examination also includes an oral examination. A Final Examination on the thesis and related topics is required for the Plan A M.S. and Ph.D. degrees.

All students must take the written examination within one year of entering. The results of the written examination may be applied to both the M.S. and Ph.D. programs. The written examination may be repeated once, the next time it is offered. Students must select an M.S. or Ph.D. committee and file the appropriate program form during the Spring Semester before taking this examination. Note: Students admitted to the Ph.D. program, who wish to receive the M.S. degree en route to the Ph.D., must inform the Department immediately after arriving on campus. They must select an M.S. committee before taking the written examination, and a Ph.D. committee during the semester in which they apply for the M.S. degree.

Postponement of the written examination is granted only in exceptional cases. Requests for postponement must be submitted to the Graduate Committee no later than April 1 by both the student and the advisor.

For both the Ph.D. and Plan A M.S. degrees, a final **oral** examination is conducted by the student's Graduate Committee. This examination takes place after the thesis has been submitted and covers the thesis and related topics.

M.S. COMPREHENSIVE EXAMINATION

A student attempting to obtain the M.S. degree is allowed two attempts to pass this written examination at the M.S. Comprehensive level.

A student who has passed the Ph.D. written Comprehensive Examination will be deemed to have passed the M.S. Comprehensive Examination.

PH.D. COMPREHENSIVE EXAMINATION

The written and oral portions of the Ph.D. Comprehensive Examination are considered separate examinations, and each must be passed separately.

The physics written comprehensive exam is a test of physics principles and their applications. It is a test of principles of broad utility which any practicing Physicist must know and be able to apply. The written examination consists of fifteen problems, each about an hour in length, drawn from typical undergraduate course work and from our first-year graduate core courses, namely quantum mechanics, electricity and magnetism, classical mechanics, and mathematical methods.

The oral portion of the Ph.D. Comprehensive Examination will be administered by the student's Ph.D. committee. **Students not pursuing an M.S. degree en route to the Ph.D. must take the oral examination by October 1, after the written examination is passed.** Students pursuing the M.S. degree en route to the Ph.D. must take the oral examination during their first semester in the Ph.D. program, normally within one year after passing the written examination. The student's Ph.D. Committee must approve the topic for a short talk to be presented by the student at the beginning of the oral portion of the Ph.D. Comprehensive Examination. The topic, which must be new to the student, should be determined by the student and approved by the committee as early as possible after the written exam is passed, to insure adequate time for the student to study and prepare for the oral exam. The talk will be followed by questions on the talk and other topics. Committee members and the Graduate Representative appointed by The Division of Graduate Education must participate in the oral examination. If failed, the oral examination may be repeated once, six to nine months later.

PHYSICS DEPARTMENT FINANCIAL AID GUIDELINES

Most students admitted to advanced degree programs in the Physics Department are awarded financial aid, in the form of research and teaching assistantships, fellowships, and fee waivers. To receive financial aid, a student must satisfy the requirements of the Division of Graduate Education listed in the Graduate Bulletin, as well as requirements of the Physics Department given below. Satisfaction of these requirements does not guarantee financial aid, although it is the policy of the Physics Department to support as many qualified graduate students as permitted by the available resources. Limited financial assistance is offered in the summer. For foreign students, continuation of financial aid beyond the first year is contingent upon satisfactory performance in spoken English.

CREDIT REQUIREMENTS
Students receiving financial aid must be registered for a minimum of 9 credits during the academic year. Exception: during the first year of residence, domestic students may register for 6 credits in order to earn state residency.

GRADE REQUIREMENTS
Financial aid may be revoked it a student's cumulative grade point average (GPA) falls below 3.0; graduate standing may also be removed in this case (see the Graduate Bulletin).
http://www.montana.edu/wwwdg/cat_grades_courses.shtml

M.S. CANDIDATES
Candidates for the degree of M.S. in Physics will generally be granted a maximum of two years of financial aid including summers. Note that all specific course requirements for this degree can be satisfied in one year. Exception: students selecting the Plan A (thesis) option may apply for research assistantships for up to one academic year beyond the second year of study; generally, teaching assistantships will not be awarded after the second year.

P.h.D. CANDIDATES
Financial aid will be continued beyond two years only if the written Ph.D. Comprehensive Exam is passed at the Ph.D. level by the second attempt.

MANDATORY ANNUAL MEETINGS WITH THE GRADUATE COMMITTEE The Department of Physics requires senior graduate students to hold annual meetings with their graduate committee to discuss progress and plans for completing their Ph.D. thesis. These annual meetings are not intended to be along the lines of the oral comprehensive exam, but are simply intended to be a one hour meeting to have the student and committee discuss progress on and plans for the thesis project. The meetings will also serve as a regular source of input from other members of the committee. The annual meetings are encouraged once a student joins a research group and has formed a Ph.D. committee, but become mandatory beginning with the Spring term of the student's fourth year in the program, that is prior to the student starting his/her 5th year. The student is responsible for scheduling the committee meeting. Attendance of the grad rep at the meeting is desired but not required. Attendance at the meeting for the two nonreaders on the committee is desired but not required. The three readers are required to attend the meeting, or an appropriate substitute found in rare conflicted cases. The grad student will discuss the planned timeline and progress on the thesis at the meeting. After the meeting, the thesis advisor will submit a summary letter to the department head, with copies to the student and other members of the committee, prior to the end of that spring semester. Failure to do this will delay initiation of the GTA or GRA appointment for the following Fall term. Questions regarding this policy should be brought to the Department Head.

TIME RESTRICTION FOR GTA SUPPORT This time restriction would apply to the ninth year after the student enters the program. For example, if a student enters the program in fall 2009, a time restriction would apply to GTA support for the fall semester of 2017. The department will normally not give GTA support to students beyond their eighth year in the graduate program. To request GTA support for semesters after the eighth year would require a letter from the graduate advisor to the department head describing the circumstances that justify the continued GTA support for the student. Moreover, the student could continue on GRA support or personal funds. Our hope is that the mandated annual meetings of the student and his/her committee will mean that the restriction on GTA support rarely comes into play. Questions regarding this policy should be brought to the Department Head.

Appendix 11: Key Performance Indicators (KPI) with FY09 Definitions

Physics

	1999-00	2000-01	2001-02	2002-03‡	2003-04	2004-05*	2005-06	2006-07	2007-08	2008-09#	Weighted Avg % Change /Yr (5 years)	10 year % change
Expenditures	1,534,981	1,383,110	1,513,299	1,674,132	1,585,181	1,604,110	1,654,223	1,758,882	1,844,058	2,362,190		
Faculty FTE	18.0	16.9	17.9	16.6	15.4	16.1	18.3	17.4	16.8	16.3	-0.7%	-9.4%
% Tenure Track	98%	98%	94%	86%	94%	94%	87%	90%	92%	91%	0.0%	-7.1%
GTA FTE	5.8	5.6	5.6	14.5	14.5	17.5	11.5	12.0	14.0	13.5	0.9%	134.0%
SCH Lower	11,270	10,220	10,093	9,937	10,287	9,731	10,095	10,163	9,891	9,690	-1.1%	-14.0%
SCH Upper	708	721	700	919	771	685	741	800	864	847	3.4%	19.6%
SCH Grad	829	793	858	951	885	957	1,106	1,128	1,099	1,117	2.9%	34.7%
Total FY SCH	12,807	11,734	11,651	11,807	11,943	11,373	11,941	12,091	11,854	11,654	-0.5%	-9.0%
Univ Seminar SCH						0	45	48	0	64		
Research SCH						108	160	196	167	130		
% Taught by Ten Track												
SCH Lower			98%	63%	87%	70%	49%	61%	59%			
Sections Lower			92%	59%	93%	75%	64%	69%	67%			
Total SCH/ Faculty FTE	710.7	695.1	650.9	710.8	775.4	706.1	652.5	693.2	705.9	713.4	0.5%	0.4%
w/ GTAs	538.3	521.2	495.5	379.5	399.4	338.4	400.7	410.7	385.0	390.6	0.8%	-27.4%
Undergrad FY FTE	399.3	364.7	359.8	361.9	368.6	347.2	361.2	365.4	358.5	351.2	-0.8%	-12.0%
Graduate FY FTE	34.5	33.0	35.8	39.6	36.9	39.9	46.1	47.0	45.8	46.5	2.9%	34.7%
Total FY FTE	433.8	397.7	395.5	401.5	405.5	387.1	407.2	412.4	404.3	397.8	-0.4%	-8.3%
Expend/Student FTE	3,538	3,477	3,826	4,170	3,909	4,144	4,062	4,265	4,561	5,939		
StudFTE/FacultyFTE	24.1	23.6	22.1	24.2	26.3	24.0	22.3	23.6	24.1	24.4	0.6%	1.2%
w/ GTAs	18.2	17.7	16.8	12.9	13.6	11.5	13.7	14.0	13.1	13.3	0.8%	-26.9%
Fresh/Soph Majors	31	30	23	24	29	27	29	25	31	26	-1.2%	-16.1%
Jr/Sr/PostBach Majors	29	34	38	47	42	38	37	42	47	49	6.3%	69.0%
Second Majors			5	5	5	2	4	4	2	1	-20.7%	
Graduate Majors	46	52	48	47	45	47	53	56	58	59	4.7%	28.3%
Total Majors	106	116	114	123	121	114	123	127	138	135	2.9%	27.4%
Majors/Faculty FTE	5.9	6.9	6.4	7.4	7.9	7.1	6.7	7.3	8.2	8.3	4.0%	40.5%
Bachelor's Degrees	11	8	7	15	16	13	8	19	13	17	23.0%	54.5%
Graduate Degrees	11	11	19	10	12	14	8	11	11	13	9.0%	18.2%
Total	22	19	26	25	28	27	16	30	24	30	14.8%	36.4%

*SCH, FTE, and university seminar counts, and ratios based upon them, changed in FY05 to consistently follow the instructor's appointment rather than the subject code.

‡ Faculty FTE and % Tenure Track calculations changed in FY03 from budgeted FTE to Fall actuals. Graduate FTE assumes each headcount graduate assistant paid through program 01 is .5 FTE

Benefits expenditures were moved from a central budget line to departmental budgets in FY09.

Key Performance Indicators
FY09 Definitions
Contact: Chris Fastnow, Associate Director, Planning and Analysis
cfastnow@montana.edu

Column Definitions

Weighted Avg % Change/Yr (5 Years): The average percent change per year for the last five years in the series, weighted so that the most recent change counts most heavily in the average. This is only calculated for series with the last five years of data available.

10 year % Change: The change between the first year reported and the most recent year, as a percent of the first year reported. This is only calculated for series with ten full years of data available.

Row Definitions

Expenditures: Fiscal Year expenditures in program 01 (Instruction), state funds only. Centralized expenditures (e.g. centralized computing expenditures) are not included. Starting partway through FY09, benefits expenditures were decentralized to the departments. A corresponding jump in expenditures appears in FY09 and will appear in full in FY10.
Source: University Budget Office

Faculty FTE: For FY03 forward, the actual FTE in faculty positions paid in program 01, state funds (as of November payroll). Prior to FY03, this was budgeted FTE.
Source: Employee Snapshot, Office of Planning and Analysis, HR, Office of the Provost, various academic departments

% Tenure-track: For FY03 forward, the actual FTE in faculty positions holding ranks of Assistant, Associate, or Full Professor, paid in program 01, state funds, divided by the Faculty FTE in the line above (as of November payroll). Prior to FY03, this was budgeted FTE in lines with rank.
Source: Employee Snapshot, Office of Planning and Analysis, HR, Office of the Provost, various academic departments

GTA FTE: For FY03 forward, actual headcount GTAs paid in program 01, state funds (as of November payroll), divided by 2. All GTAs are assumed to be .5 FTE for this report. Prior to FY03, this was budgeted FTE in GTA lines.
Source: Employee Snapshot, Office of Planning and Analysis, HR, Division of Graduate Education, various academic departments

SCH Lower, Upper, Grad, Total: Starting in FY05, student credit hours produced by faculty in the department, in Summer, Fall, and Spring terms, as of 15th class day each term. Graduate students taking 400 level courses are counted in the graduate SCH row. Credits follow tenure-track faculty to their home departments or are split across departments if the appointment is split. For example, a course taught by a tenure-track faculty member in Ecology in the BIOL subject code is counted in Ecology. A CLS 101US course taught by a tenure-track faculty member in Electrical and Computer Engineering is counted in ECE. Credits taught by a faculty member with a 30/70 split appointment are split 30/70 regardless of course subject code. Credits taught by adjunct faculty are counted in the department associated with the subject code. These numbers are similar but not identical to those generated in the Provost's Allocation Model and the Delaware Study of Instructional Costs and Productivity.

Prior to FY05, most credit hours were counted in the department associated with the subject code, with some exceptions (notably BIOL and University Seminars), where faculty affiliation was followed.
Source: Registrar's Office, OCHE Data Warehouse, Courses database, departments' instructor reports, Office of Planning and Analysis

Univ Seminar SCH: Student credit hours generated by faculty within the department in university seminar courses (designated with US in the course number), in Summer, Fall, and Spring terms, as of 15th class day each term. Credits follow tenure-track instructors to their home departments. Credits taught by adjunct faculty are counted in the department associated with the subject code (e.g. CLS 101US cresits taught by adjuncts are counted in Dean of Letters and Sciences).
Source: Registrar's Office, OCHE Data Warehouse, Courses database, departments' instructor reports

Research SCH: Student credit hours taught in the department in research courses (designated by R in the course number), in Summer, Fall, and Spring terms, as of 15th class day each term. Credits are counted in the department associated with the subject code in all cases.
Source: Registrar's Office, OCHE Data Warehouse, Courses database

% Taught by Ten Track/SCH Lower: Percent of lower division student credit hours taught by tenure-track faculty in the department. This includes university seminar instruction by tenure-track faculty.
Source: Registrar's Office, OCHE Data Warehouse, Courses database, departments' instructor reports, Delaware Study of Instructional Costs and Productivity, Office of Planning and Analysis

% Taught by Ten Track/Sections Lower: Percent of lower division sections taught by tenure-track faculty in the department. This includes university seminar instruction by tenure-track faculty. In 2001, recitations were considered labs and not included; after 2001, credit-bearing recitations were included.
Source: Registrar's Office, OCHE Data Warehouse, Courses database, departments' instructor reports, Delaware Study of Instructional Costs and Productivity, Office of Planning and Analysis

Undergrad, Grad, Total FY FTE: Student FTE based on SCH reported above. Undergraduate FTE = 30 SCH per year. Graduate FTE = 24 SCH per year. Graduate students taking 400 level courses are counted as graduate FTE.

Expend/Student FTE: ratio of expenditures to total FY FTE.

StudFTE/FacultyFTE and StudFTE/FacultyFTE w/ GTAs: ratio of total student FTE to faculty FTE without and with GTA FTE.

Majors: Headcount of majors in the department, by class standing, as of 15th class day of the Fall semester. Non-degree undergrads are generally counted in the fresh/soph line. Non-degree grads are generally counted in the jr/sr/post-bachelor line. Second majors were included starting in FY2002.
Source: Registrar's Office, OCHE Data Warehouse, Enrollment database, Office of Planning and Analysis

Majors/Faculty FTE: ratio of all majors, including second majors, to faculty FTE (excluding GTAs).

Degrees: Degrees awarded to majors within the department in Summer, Fall, and Spring terms of the academic year. Students earning two degrees are counted in each awarding department.
Source: Registrar's Office, OCHE Data Warehouse, Graduates database, Office of Planning and Analysis

Appendix 12: Delaware Study of Instructional Costs and Productivity for Physics Department

Delaware Study of Instructional Costs and Productivity (FY08)

Report Format
Definitions
Peer Comparison
Graphs

This report presents MSU's submitted scores and comparisons between MSU's departments and the closest comparator matches among participating institutions. All MSU data are based on Fall 2007 (instructional data) and FY 2008 (fiscal data) compiled in the Office of Planning and Analysis in January 2009. Please see the Delaware Study of Instructional Costs and Productivity Definitions for more information.

Report Format:

1. The first Classification of Instructional Program (CIP) code listed in the top left box indicates the code used to submit MSU's departmental data. The remaining CIP code(s) indicate the comparison discipline(s).
2. The first column describes the measure of cost or productivity. The second column presents the mean for participating research institutions within the comparison CIP code, printed in bold. If there is more than one comparison CIP code, the bold column represents a weighted mean score across the disciplines. The first column that appears in bold print serves as the benchmark. The remaining columns on all tables detail MSU's data and department scores relative to the benchmarks. Shaded columns present prior years' data. Please note that ranks can change because of changes in the comparators' data, the comparison group, or the MSU department.
3. Relative scores are calculated as follows: MSU department score/benchmark score. A score below 100% indicates the MSU department scored lower than the mean for research institutions.
4. No relative score is calculated when the comparison group mean is zero or all MSU departments score zero (as in the case of graduate student organized course sections taught by TAs).
5. Ranks within MSU are calculated for the MSU department scores relative to the benchmarks. Highest ratios are ranked 1. Departments with no score or a zero in the comparison group are excluded from the rankings.
6. Abbreviations:
    - SCH = Student Credit Hours
    - FTE = Full Time Equivalent
    - T/TT = Tenured/Tenure-Track
    - OCS = Organized Course Section
7. Faculty FTE and teaching productivity is reported for several categories:
    - Total FTE is all Tenured/Tenure-Track FTE, visiting faculty FTE (not separately shown in this report), and Adjunct FTE as recorded in Banner, plus graduate student FTE calculated according to the definitions. Non-instructional FTE is included in this number. For example, the Math department had about 49 FTE on the payroll as faculty or teaching graduate students.
    - T/TT Total FTE is the full FTE of tenured/tenure-track faculty recorded in Banner, including Extension, Research, and Experiment Station faculty on the tenure-track. Again using Math as an example, 24 of the above FTE were T/TT.
    - T/TT Instr FTE is the full FTE of tenured/tenure-track faculty minus any non-instructional component, as identified by fiscal program through which the faculty is paid. This accounts for faculty with course buyouts from grants or administrative duties or tenured/tenure-track Extension, Experiment Station, and Research Faculty. Math had about one quarter separately budgeted T/TT FTE faculty that fall, leaving

23.77 instructional T/TT FTE.

- Adj Faculty Instr FTE is the full FTE of adjunct faculty. For adjuncts teaching in more than one department, FTE is split according to the funding split. Math had 10.5 FTE Adjunct faculty.
- TAs (cred. bear.) Instr FTE is initially calculated as the number of course sections taught by graduate students, divided by 4 (Delaware's definition of 1.0 FTE). Non-credit bearing TAs are not reported here. This group is responsible for grading, non-credit labs, etc. If a department shows graduate students on the instructional payroll but assigns no credit bearing courses to them, their FTE is counted and reported separately, however they are included in the total for all instructional faculty below. Math had over 14 FTE TAs teaching credit-bearing sections, calculated according to the number of sections taught.
- All Faculty Instructional FTE is the sum of instructional FTEs of Tenured/Tenure-Track, Adjunct, and Visiting (not separately reported here) Faculty, credit-bearing TAs, and non-credit bearing TAs (not separately reported here). The final section of the report is essentially a weighted average of all instructional faculty categories, not the sum of all categories. In the Math example, there were no visiting faculty or non-credit bearing TAs, so the sum of the T/TT, Adjunct, and credit bearing TA FTE yields the total instructional FTE of 48.41.

Expenditure data will not match either the Delaware II grant data or the KPIs. Please see the complete definitions of those reports for clarification.

Please direct any questions to Chris Fastnow in the Office of Planning and Analysis, x2870 or **email** for questions.

Return to regular view

Text-only

Updated: 1/25/2010

Definitions for the Delaware Study of Instructional Cost and Productivity
Fall 2007, FY08

Instructor FTE

We calculate the FTE faculty in three areas – tenured/tenure-track, supplemental, and other regular faculty – from the Banner employee snapshot taken in October of the relevant year. Only positions actually expended are included. FTE is included in Banner, and instructional FTE is determined by multiplying the percent instructional appointment (paid through Program 01) by the recorded FTE.

Rank is determined by the employee file, supplemented by departmental information. All assistant, associate, full and emeritus professors as well as senior administrators who teach courses, are included in the "Tenure/Tenure-Track" category (administrators are not counted in a department's FTE, but their courses are credited to the department). Research faculty and research scientists with rank who teach courses are also included in this category, though their FTE may not appear as "Instructional." Visiting professors are "other regular" (not shown in this report). Adjuncts, non-faculty employees, post-retirement contract faculty, and other non-recurring instructors are classified as "Adjunct."
Source: OPA Employee File October '07, Department (supplemental)

Graduate Student FTE

Absent a consistent metric for tracking graduate assistant FTE in our system, we follow Delaware's protocol: Graduate Student FTE is determined by dividing the number of sections taught by graduate students in the department by 4. Credit-bearing courses taught by graduate students are considered separately from those that do not bear credit (e.g. some labs or recitations). Both are divided by four to calculate FTE.
Source: OPA Courses and Instructor files, verified by departments in the Instructional Activity Reports, based on 15th Class Day, Fall '07

Student Credit Hours (SCH) and Organized Class Sections

Data on credit hours and class sections are taken from the 15th Class Day Reports from the Fall semester generated in Banner and the Planning and Analysis Instructional Activity Report for Fall. In most cases, team-taught or faculty/graduate assistant-taught courses are divided on a percentage basis as identified in the Instructional Activity Report, which is developed from data supplied by the departments. Credit hours for independent studies, dissertation, and thesis research, and other courses not tied to an instructor have been assigned as "Individualized Instruction" to the Tenure/Tenure-Track group of faculty unless specifically assigned in the database to a different type of instructor.

Following Delaware's protocols, credit hours and sections are assigned to the department paying the salary of the instructor. Interdisciplinary or extra-departmental teaching by Tenure/Tenure-track faculty is recorded in the faculty's home department, including teaching in the BIOL rubric, University Seminars, Liberal Studies, American Studies, and others.

Unlike the KPIs, Delaware specifies that Fall semester courses at the 400 level are counted as undergraduate upper division courses even if the students are graduate students. Full year credit hours reported in Part B are based on the KPI data and do contain graduate credit for 400 level courses, therefore, the graduate credit hours for the full year appear higher than expected given the Fall credit hours.
Source: OPA Courses and Instructor files, verified by departments in the Instructional Activity Reports, based on 15th Class Day, Fall '07, KPIs

Organized Course Sections

We record independent study courses, thesis and dissertation hours, and all Music courses ending in 60 as individualized instruction. Following Delaware's instructions, we count all courses labeled in the registrar's database as labs, discussion sections, or recitations bearing zero credit as "Labs." Seminars, lectures, and credit-bearing recitations are counted as "Lectures."
Source: Registrar

Instructional Expenditures

We use FY08 expenditures in program area 01. Program 01 expenditures are further broken down into salary and non-salary. **All** funding sources used for instructional purposes are included in these figures: general fund, tuition, student fees (e.g. program, lab, field trip, and materials fees), grants, contracts, gifts, endowments, federal funding, etc. Grant expenditures are treated in the same way as research grants below. No centralized expenses, like computer lab maintenance, graduate tuition waivers, student services, administration, etc., are included in these amounts. Because our benefits pool was centrally administered in FY08, Delaware automatically calculated a benefit amount for each department, based on reported salaries.
Source: Budget Office, Office of Sponsored Programs

Research Expenditures

We use FY08 Program 02 expenditures and Agricultural Experiment Station expenditures attributable to specific academic departments as our research expenditures. Again, all funding sources, inside and out of the university, are included. Just as the Office of Sponsored Programs reports, expenditures through research centers that are fully contained within an academic department are attributed to that department, e.g. Center for Computational Biology expenditures are attributed to Cell Biology and Neuroscience. We track the PIs attached to expenditures through multidisciplinary research centers. Where the PI is affiliated with an academic department, expenditures are attributed to that department. When there are multiple PIs on a grant, the expenditures are divided equally across the PIs' departments.

Source: Budget Office, OSP, AES

Public Service Expenditures

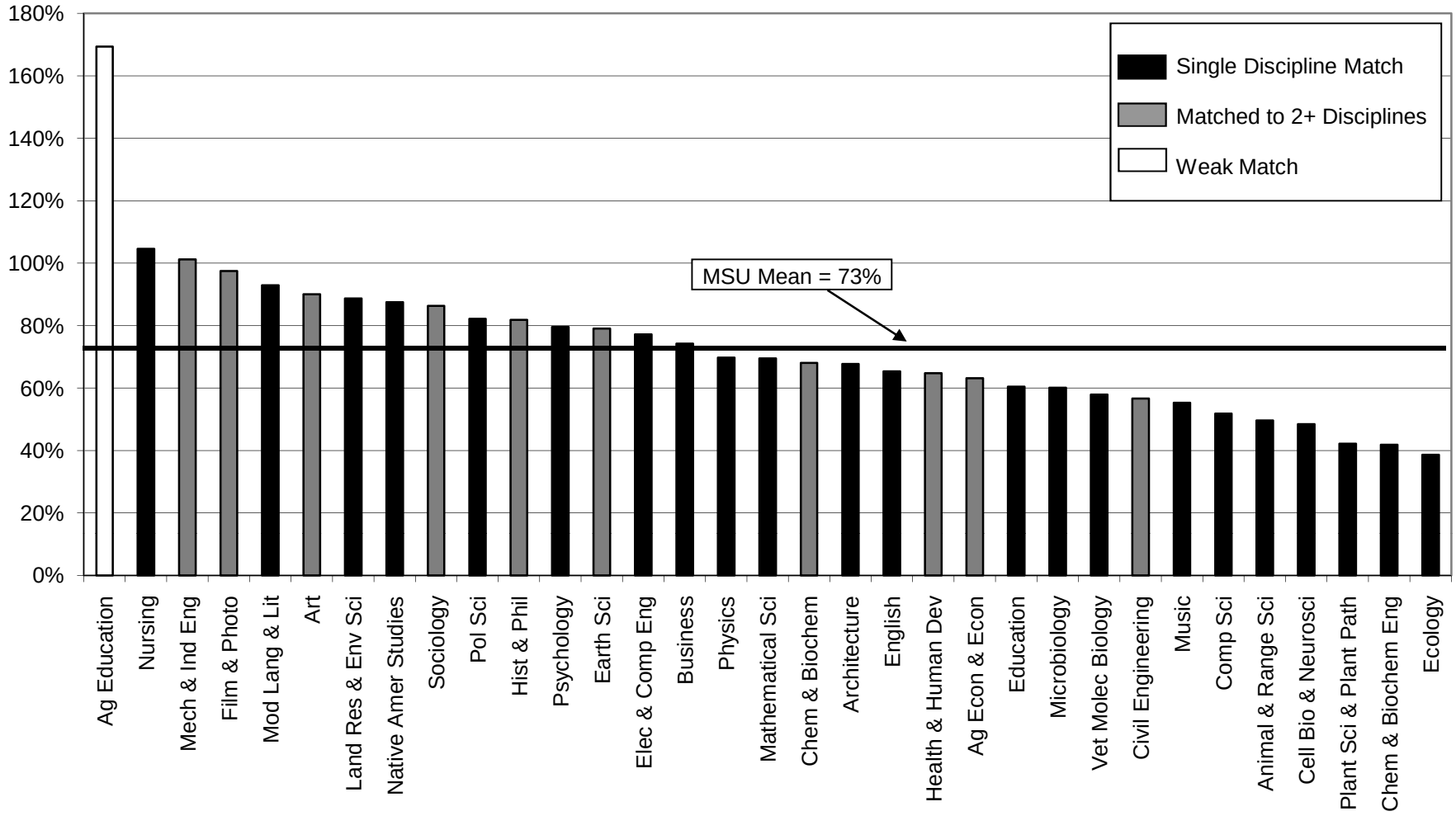
Any expenditure classified as Program 03 in Banner and attributable to an academic department is counted as a public service expenditure. We add to those amounts any spending by the Extension Service that can be attributed to an academic department. Center service expenditures are treated in the same fashion as research expenditures above, with single-department centers receiving credit for those center expenditures and other center expenditures following the PIs' appointments. When there are multiple PIs on a grant, the expenditures are divided equally across the PIs' departments.

Source: Budget Office, OSP, Extension

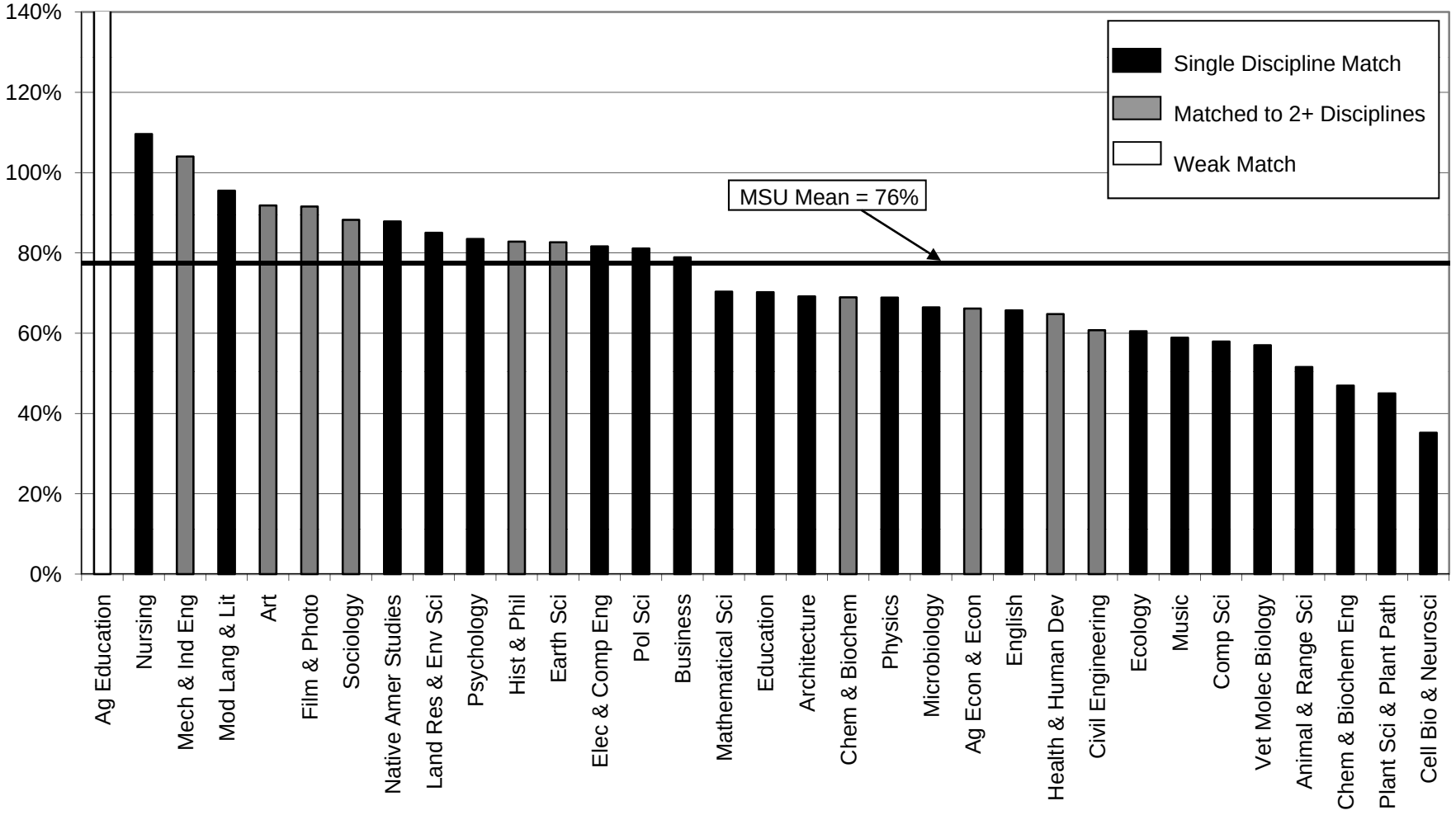
Delaware Study of Instructional Costs and Productivity
Fall 07 (Instruction Data) and FY08 (Fiscal Data)

Physics (Submitted as 40.08, Physics Compared to 40.08)	FY08 40.08 Research Institutions Mean	FY08 MSU Department Score	FY08 MSU Department Score Relative to Benchmark	FY08 Department Relative Score Rank in MSU	FY07 MSU Department Score	FY07 MSU Department Score Relative to Benchmark	FY07 Department Relative Score Rank in MSU	FY06 MSU Department Score	FY06 MSU Department Score Relative to Benchmark	FY06 Department Relative Score Rank in MSU	FY05 MSU Department Score	FY05 MSU Department Score Relative to Benchmark	FY05 Department Relative Score Rank in MSU	FY04 MSU Department Score	FY04 MSU Department Score Relative to Benchmark	FY04 Department Relative Score Rank in MSU	FY03 MSU Department Score	FY03 MSU Department Score Relative to Benchmark	FY03 Department Relative Score Rank in MSU
All Funds Instructional Exp Per SCH	$285	$199	70%	16 of 33	$188	74%	16 of 33	$169	71%	15 of 33	$170	73%	18 of 34	$166	59%	28 of 34	$178	70%	14 of 34
All Funds Instructional Exp Per Student FTE	$8,157	$5,617	69%	20 of 33	$5,308	72%	17 of 33	$4,789	69%	18 of 33	$4,840	71%	22 of 34	$4,756	60%	27 of 34	$5,075	68%	16 of 34
Personnel Cost as % of Instructional Exp	93	98	105%	8 of 33	97	104%	7 of 33	94	102%	16 of 33	94	103%	13 of 34	94	103%	12 of 34	95	102%	18 of 34
Exp on Personnel per SCH	$265	$195	73%	17 of 33	$183	77%	15 of 33	$160	72%	13 of 33	$161	75%	16 of 34						
Exp on Operations/Capital per SCH	$20	$4	22%	27 of 33	$5	31%	26 of 33	$9	56%	15 of 33	$9	50%	20 of 34						
All Funds Research Exp Per FTE T/TT Faculty	$105,250	$275,322	262%	10 of 33	$357,124	379%	5 of 33	$439,866	462%	5 of 33	$430,759	394%	5 of 34	$414,083	317%	3 of 34	$551,831	414%	3 of 34
All Funds Service Exp Per FTE T/TT Faculty	$1,057	$827	78%	11 of 33	$0	0%	19 of 33	$0	0%	22 of 33	$0	0%	18 of 33	$365	34%	17 of 34	$2,737	291%	9 of 34
Total FTE Faculty (all types, all funding)		36.57			36.17			36.16			35.52			34.94			27.9		
Tenured/Tenure-Track Total FTE		23.69			22.98			23.11			21.03			22.67					
Ten/Ten-Track Instructional FTE		15.46			15.10			14.82			14.37			14.23			14.96		
UG SCH taught by T/TT FTE	167	205	123%	17 of 33	216	119%	21 of 33	183	105%	21 of 33	221	120%	22 of 34	318	177%	6 of 34	216	126%	19 of 34
UG Sections (Exc Lab) taught by T/TT FTE	1.1	1.4	127%	19 of 33	0.9	75%	28 of 33	1.1	100%	28 of 33	1.1	92%	33 of 34	1.4	117%	25 of 34	1.1	100%	28 of 34
GR SCH taught by T/TT FTE	19.0	31.0	163%	2 of 31	28.0	133%	2 of 30	29.0	145%	3 of 30	26.0	130%	4 of 31	28.0	117%	2 of 31	24.0	114%	5 of 31
GR Sections (Exc Lab) taught by T/TT FTE	0.5	1.0	200%	3 of 31	0.9	180%	4 of 30	0.9	180%	4 of 30	0.9	180%	4 of 31	1.1	220%	3 of 31	1.3	260%	5 of 31
Total SCH taught by T/TT FTE	192	237	123%	9 of 33	244	121%	15 of 33	212	109%	17 of 33	247	120%	17 of 34	346	164%	3 of 34	240	124%	14 of 34
Total Sections (Exc Lab) taught by T/TT FTE	1.6	2.4	150%	8 of 33	1.8	106%	15 of 33	2.0	118%	12 of 33	2.0	111%	17 of 34	2.4	141%	8 of 34	2.3	128%	15 of 34
Total Sections (Inc Lab) taught by T/TT FTE	2.4	2.9	121%	17 of 33	2.5	109%	17 of 33	2.6	113%	19 of 33	2.7	113%	25 of 34	3.2	139%	12 of 34	3.0	130%	18 of 34
FTE Students Taught by T/TT FTE	13.7	17.2	126%	7 of 33	17.5	122%	10 of 33	15.4	111%	14 of 33	17.6	119%	15 of 34	24.3	160%	2 of 34	17.1	124%	12 of 34
Adj Faculty Instructional FTE		1.33			1.72			2.30			1.49			1.00			0.7		
UG SCH taught by Adj FTE	333	1438	432%	3 of 32	1110	316%	4 of 31	1076	276%	6 of 31	777	207%	9 of 31	34	12%	29 of 31	284.0	103%	22 of 31
UG Sections (Exc Lab) taught by Adj FTE	1.9	7.5	395%	4 of 32	3.5	167%	8 of 31	2.2	96%	23 of 31	2.7	142%	11 of 31	1.0	53%	27 of 31	4.3	215%	6 of 31
GR SCH taught by Adj FTE	8.0	14.0	175%	4 of 30	31.0	182%	1 of 28	9.0	75%	8 of 28	25.0	250%	3 of 28	0.0	0%	12 of 28	55.0	688%	1 of 28
GR Sections (Exc Lab) taught by Adj FTE	0.3	1.5	500%	2 of 28	0.6	120%	3 of 26	0.4	80%	7 of 28	1.3	325%	2 of 27	0.0	0%	12 of 27	1.4	700%	1 of 27
Total SCH taught by Adj FTE	342	1452	425%	4 of 32	1140	314%	1 of 31	1085	263%	6 of 31	802	205%	6 of 31	34	11%	30 of 31	339.0	117%	18 of 31
Total Sections (Exc Lab) taught by Adj FTE	2.2	9.0	409%	4 of 32	4.1	152%	7 of 31	2.6	93%	19 of 31	4.0	182%	2 of 31	1.0	43%	28 of 31	5.7	238%	5 of 31
Total Sections (Inc Lab) taught by Adj FTE	4.6	10.3	224%	9 of 32	6.0	107%	21 of 31	7.5	144%	14 of 31	5.9	113%	15 of 31	3.9	85%	22 of 31	12.0	235%	7 of 31
FTE Students Taught by Adj FTE	23.2	97.5	420%	2 of 32	77.4	304%	1 of 31	72.8	255%	6 of 31	54.6	204%	5 of 31	2.3	11%	30 of 31	25.1	127%	17 of 31
TAs (credit bearing) Instructional FTE		0.50			0.00			0.25			13.00			11.28			1.00		
UG SCH taught by TAs (credit bearing)	174	228	131%	7 of 13	NA			272	137%	5 of 12	7	4%	11 of 14	54	30%	15 of 17	951	440%	2 of 14
UG Sections (Exc Lab) taught by TAs (cred bear)	0.6	0.0	0%	10 of 13	NA			4.0	267%	1 of 12	0.0	0%	11 of 14	0.2	14%	15 of 17	1.7	131%	1 of 14
GR SCH taught by TAs (cred bear)	0.0	0.0			NA			0.0			0.0			0.0			0.0		
GR Sections (Exc Lab) taught by TAs (cred bear)	0.0	0.0			NA			0.0			0.0			0.0			0.0		
Total SCH taught by TAs (cred bear)	174	228	131%	7 of 13	NA			272	136%	5 of 12	7	4%	11 of 14	54	30%	15 of 17	951	440%	2 of 14
Total Sections (Exc Lab) taught by TAs (cred bear)	0.6	0.0	0%	10 of 13	NA			4.0	250%	1 of 12	0.0	0%	11 of 14	0.2	14%	15 of 17	1.7	131%	1 of 14
Total Sections (Inc Lab) taught by TAs (cred bear)	6.4	4.0	63%	11 of 13	NA			4.0	61%	11 of 12	4.0	59%	14 of 14	4.0	63%	17 of 17	1.7	31%	13 of 14
FTE Students Taught by TAs (cred bear)	11.6	15.2	131%	7 of 13	NA			18.1	135%	5 of 12	0.5	4%	11 of 14	3.6	30%	15 of 17	63.4	440%	2 of 14
All Faculty Types Combined Instructional FTE		28.35			28.29			27.87			28.86			26.50			26.43		
UG SCH taught by all faculty FTE	186	184	99%	27 of 33	182	94%	31 of 33	188	97%	28 of 33	153	85%	33 of 34	195	110%	24 of 34	193	115%	23 of 34
UG Sections (Exc Lab) taught by all faculty FTE	1.1	1.1	100%	28 of 33	0.7	58%	31 of 33	0.8	73%	31 of 33	0.7	58%	33 of 34	0.8	73%	31 of 34	0.9	82%	32 of 34
GR SCH taught by all faculty FTE	13.0	18.0	138%	3 of 31	17.0	113%	6 of 30	16.0	123%	5 of 30	14.0	108%	7 of 31	15.0	88%	7 of 31	15.0	107%	7 of 31
GR Sections (Exc Lab) taught by all faculty FTE	0.3	0.6	200%	1 of 31	0.5	167%	4 of 30	0.5	167%	4 of 30	0.5	125%	6 of 31	0.6	150%	4 of 31	0.8	267%	3 of 31
Total SCH taught by all faculty FTE	199	201	101%	23 of 33	199	94%	27 of 33	205	98%	25 of 33	168	84%	32 of 34	210	108%	22 of 34	208	114%	21 of 34
Total Sections (Exc Lab) taught by all faculty FTE	1.4	1.7	121%	18 of 33	1.2	75%	28 of 33	1.3	87%	27 of 33	1.2	75%	29 of 34	1.4	100%	22 of 34	1.7	113%	16 of 34
Total Sections (Inc Lab) taught by all faculty FTE	3.1	3.7	119%	24 of 33	3.3	106%	23 of 33	3.6	120%	20 of 33	3.4	106%	27 of 34	3.6	120%	20 of 34	4.5	150%	15 of 34
FTE Students Taught by all faculty FTE	14.0	14.2	101%	23 of 33	14.0	95%	26 of 33	14.4	99%	24 of 33	11.8	86%	31 of 34	14.7	109%	21 of 34	14.6	116%	18 of 34

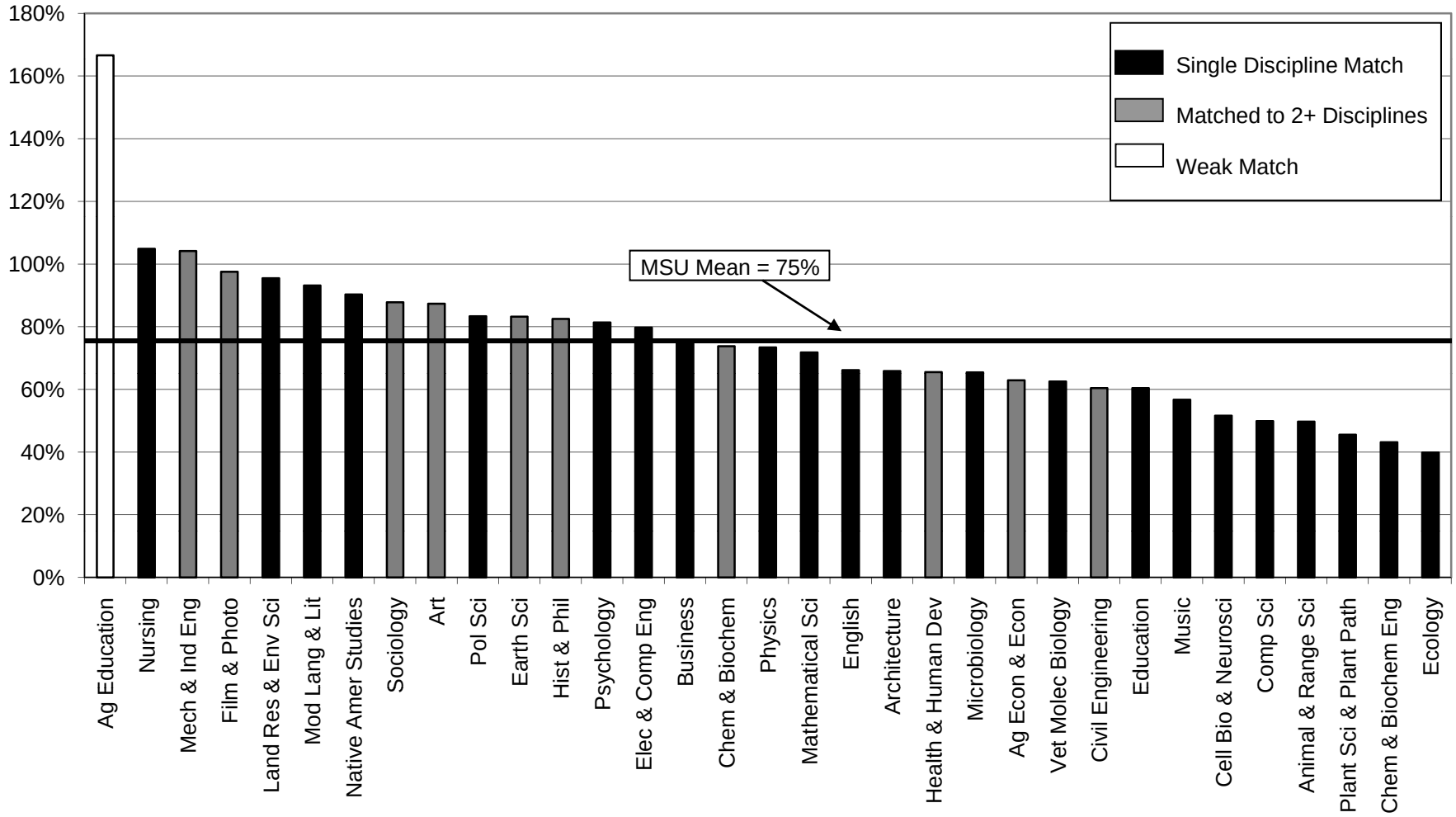
MSU Department Instructional Expenditures per Student SCH as a Percent of Delaware Study Research Institutions Mean, FY 08



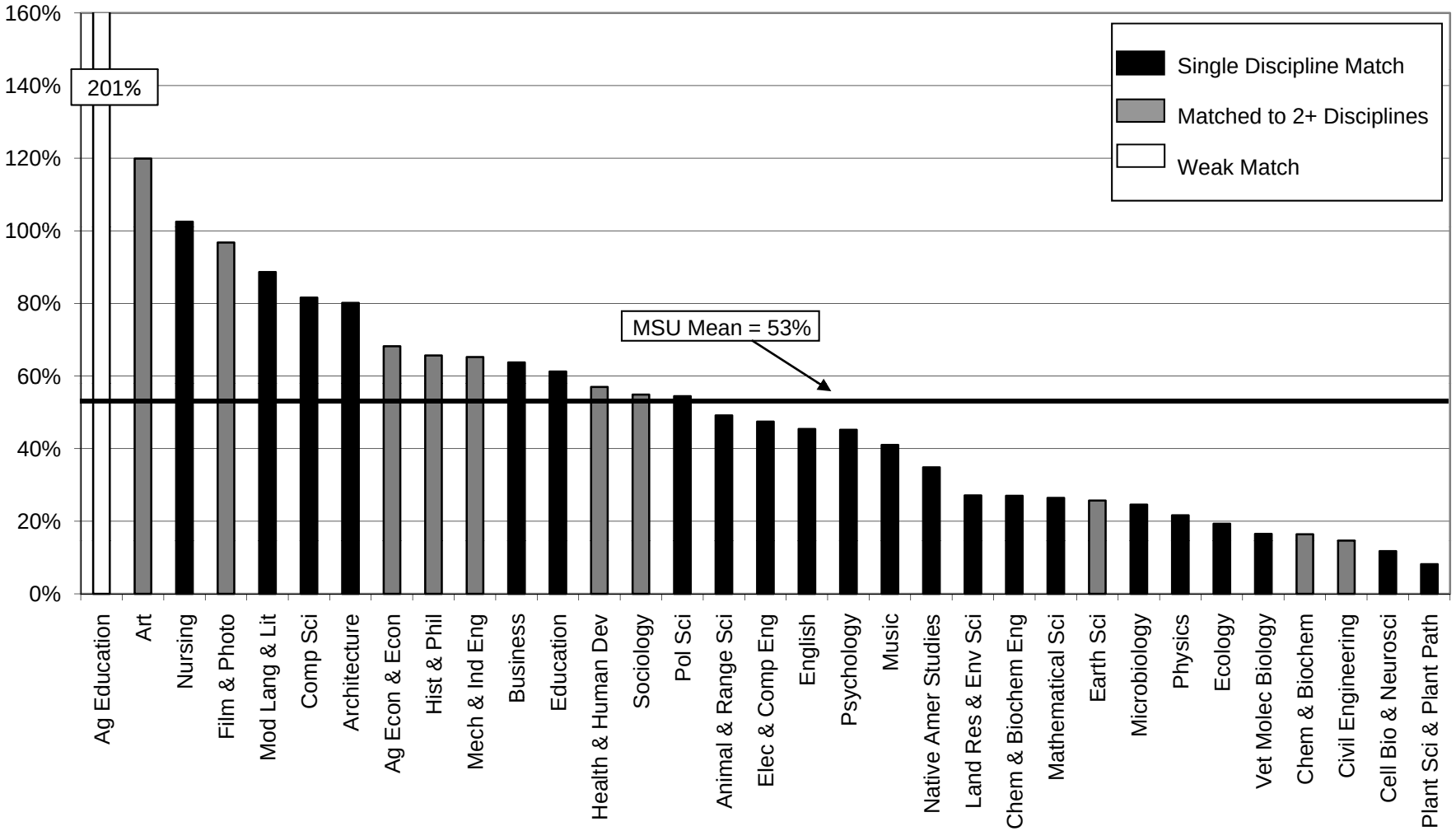
MSU Department Instructional Expenditures per Student FTE as a Percent of Delaware Study Research Institutions Mean, FY 08



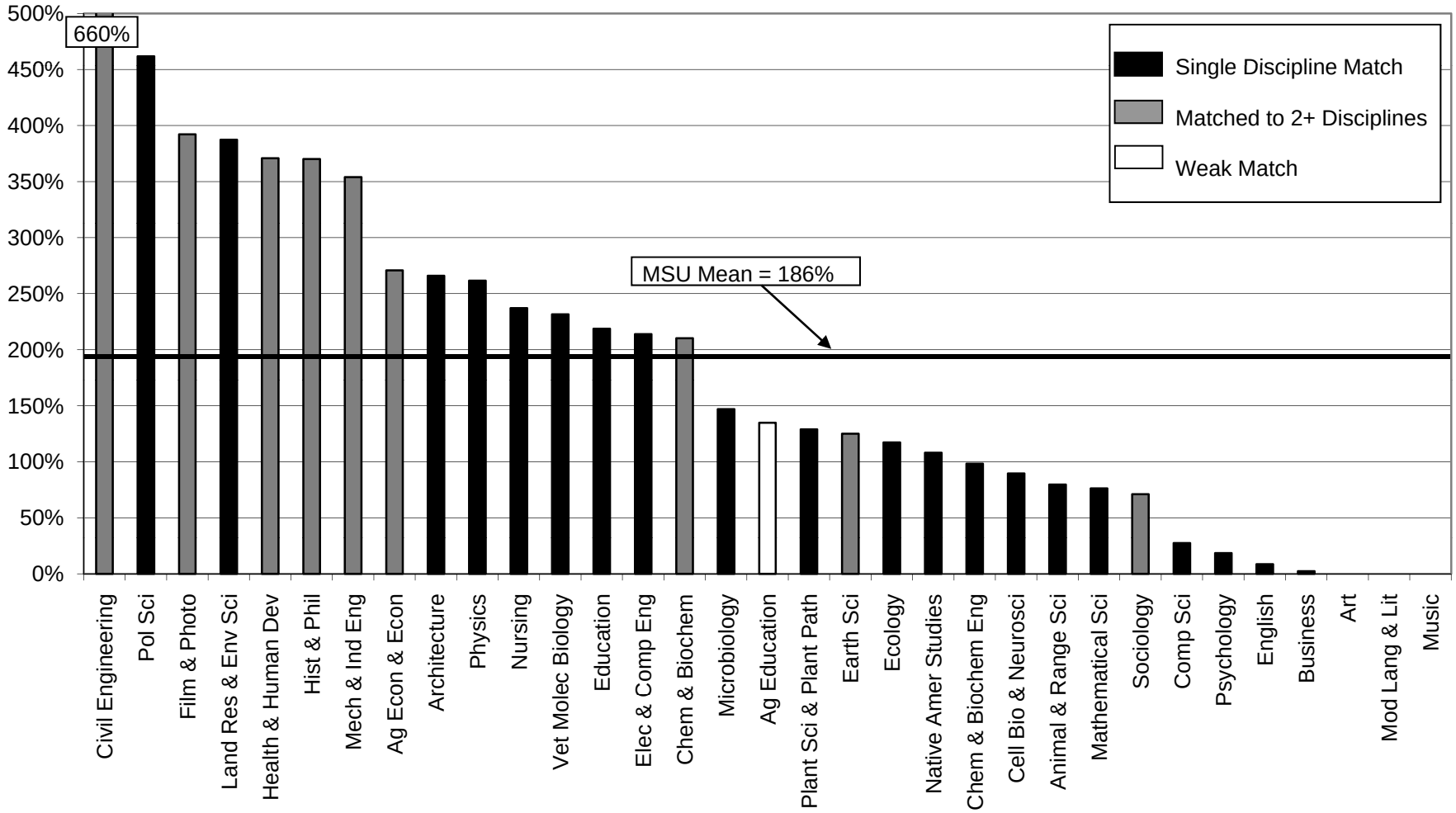
MSU Department Instructional Expenditures per SCH on Personnel as a Percent of Delaware Study Research Institutions Mean, FY 08



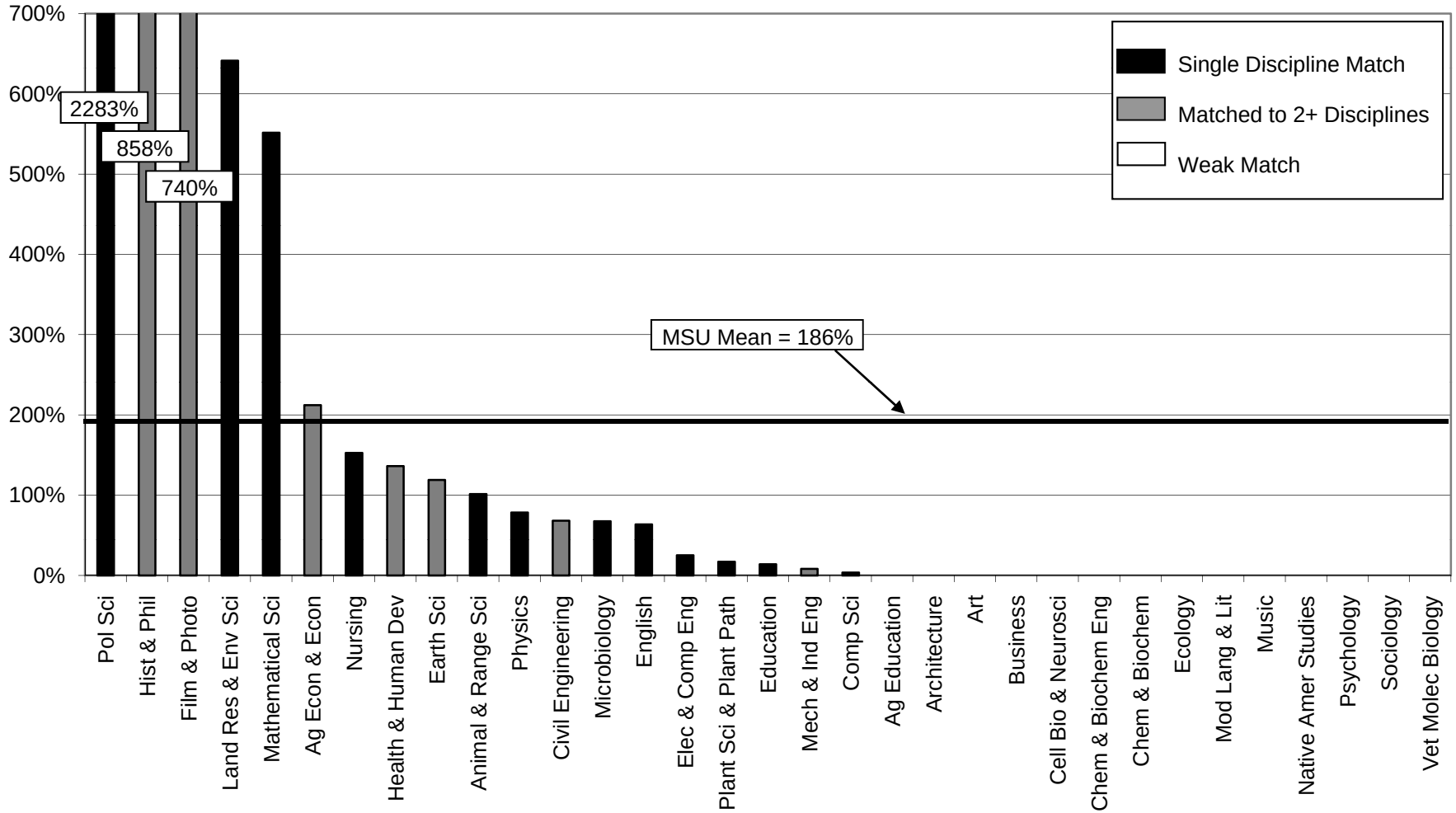
MSU Department Instructional Expenditures per SCH on Operations and Capital as a Percent of Delaware Study Research Institutions Mean, FY 08



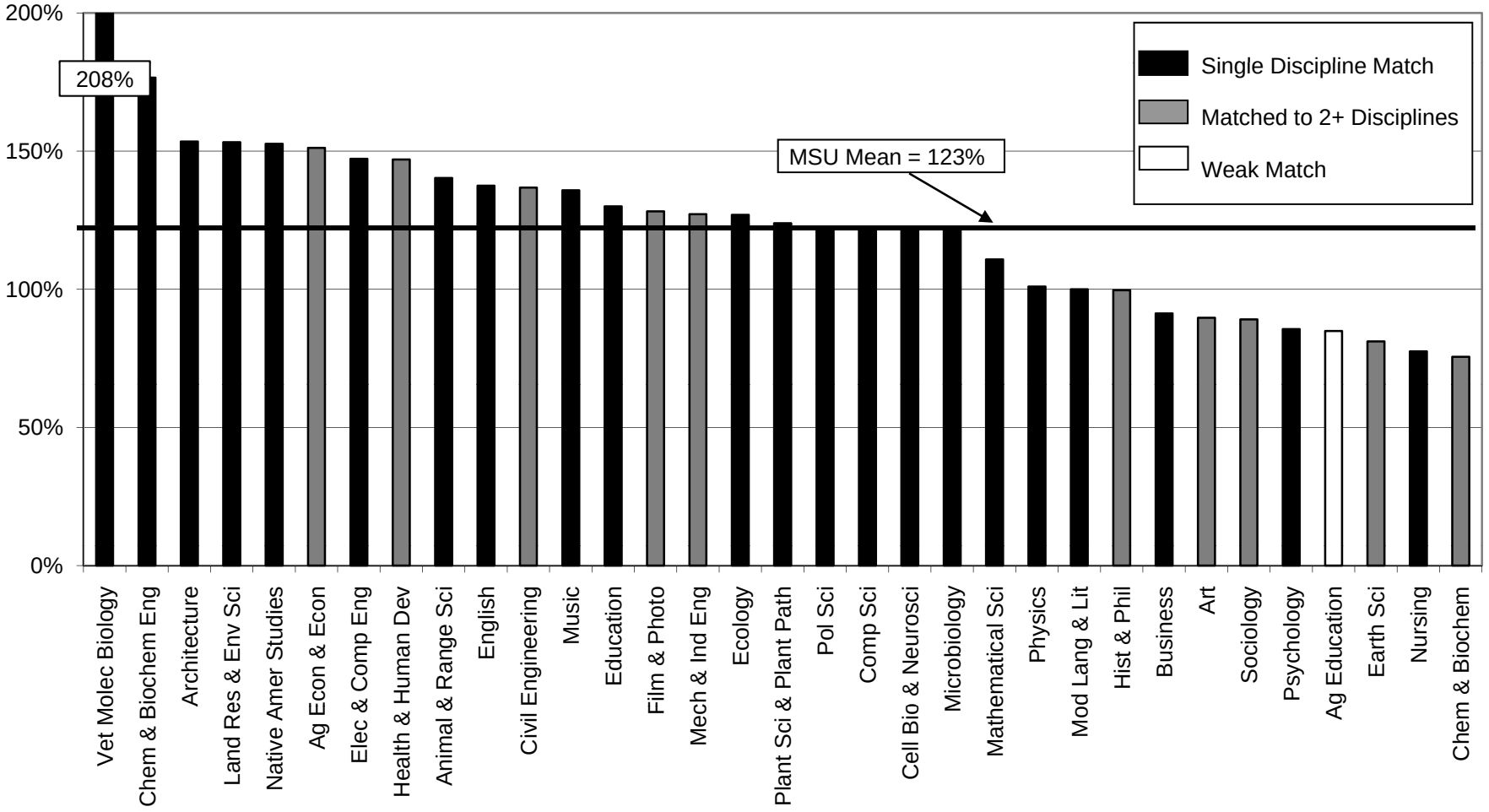
MSU Department Research Expenditures per Tenured/Tenure-Track FTE as a Percent of Delaware Study Research Institutions Mean, FY 08



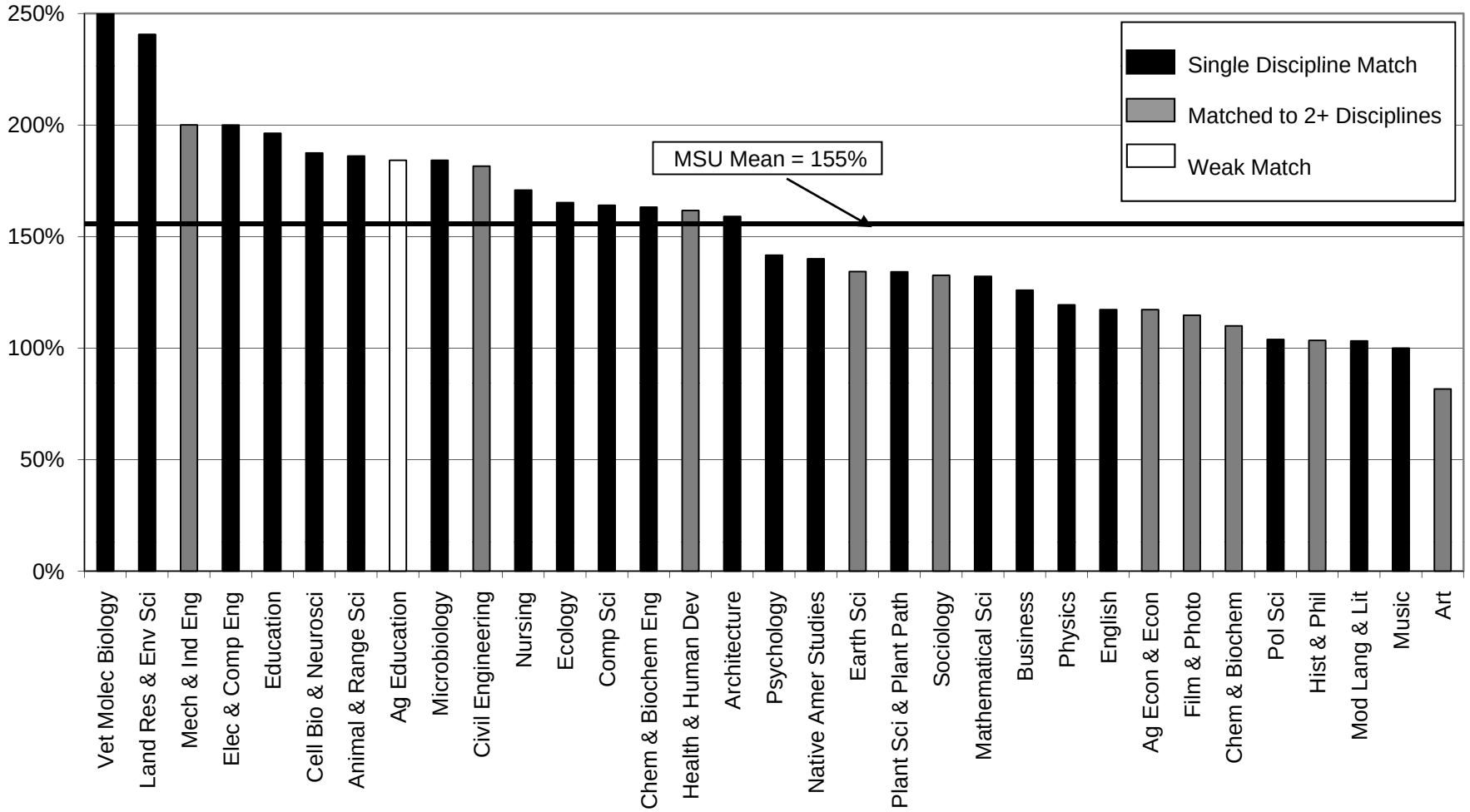
MSU Department Service Expenditures per Tenured/Tenure-Track FTE as a Percent of Delaware Study Research Institutions Mean, FY 08



MSU Department SCH Taught per Instructional FTE (All Instructors) as a Percent of Delaware Study Research Institutions Mean, Fall 07



MSU Department Organized Course Sections (including labs) Taught per Instructional FTE (All Instructors) as a Percent of Delaware Study Research Institutions Mean, Fall 07



Appendix 13: . MSU Physics Department Assessment Plan: 2009-2011

MSU Departmental Assessment Plan
2009-2011

Department: Physics

Department Head: Dick Smith

Assessment Coordinator: Randy Babbitt

Degrees/Majors/Options Offered by Department

Professional Option
Interdisciplinary Option
Physics Teaching Option
Physics Minor (Non-Teaching)

Physics

Assessment Contact

Name : Randy Babbitt, Undergraduate Curriculum Committee Chair
Phone : 406-994-6156
E-mail: babbitt@physics.montana.edu

Degree Objectives

The objectives of the three degree options and the minor in Physics have the same fundamental curricular building blocks. The students in all options follow the same core curriculum up to the level that meets their degree objectives. Thus, a single assessment plan is being used for all three options.

Professional Option: To provide students with a sound background in the fundamentals of physics and mathematics and with the knowledge and problem-solving and analytical skills necessary to succeed as graduate students in physics or other technically oriented field or to succeed in the technical workplace.

Interdisciplinary Option: To provide students with a sound background in the fundamentals of physics and mathematics and with the knowledge and problem-solving and analytical skills necessary to succeed in an interdisciplinary technical workplace.

Physics Teaching Option: To provide students with a sound background in the fundamentals of physics and mathematics and with the knowledge and teaching skills necessary to succeed as a secondary school teacher.

Physics Minor (Non-Teaching): To provide students with a sound background in the fundamentals of physics and to enhance their knowledge and problem-solving and analytics skills.

Department Mission Statement

The Department of Physics is committed to providing the highest quality physics education to students in the campus environment. Meeting this goal requires successful, nationally competitive, research programs that contribute to the body of physics knowledge, improve science communication with the public, and forge links between fundamental knowledge and applied technology for the benefit of the people in the state of Montana.

Expected Competencies

Discipline-Specific Knowledge

Graduates in the Professional Option are expected to have in-depth knowledge in the following areas of fundamental physics
1. Classical mechanics (including the Newtonian, Lagrangian, and Hamiltonian approaches),
2. Electromagnetism (including statics, dynamics, and circuits),
3. Quantum mechanics (including bound state problems, potential scattering, angular momentum, and perturbative methods),
4. Waves and oscillations, and

5. Experimental physics (including basic electronics, data acquisition, data analysis, and experimental design).

Graduates in the Professional Option are also expected to have knowledge at the introductory level in the additional physics topics of physical and geometric optics, laser physics, thermodynamics and statistical physics, solid-state physics, special relativity, atomic physics, nuclear physics, and particle physics. Graduates in the Professional Option are also expected to gain in-depth knowledge of a subset of these additional physics topics from a combination of physics elective coursework, independent study, and undergraduate research experience.

Graduates in the Interdisciplinary Option are expected to have broad-based knowledge in the same fundamental areas of physics as the professional option with reduced emphasis on advanced mechanics, electromagnetism, and quantum mechanics with the addition of core knowledge of one other area of study. Other areas of study include, but are not limited to, chemistry, earth science, biology, business, computer science, math, and electrical, mechanical, industrial, or civil engineering. Graduates in the Interdisciplinary Option are also expected to gain in-depth knowledge of a subset of the additional physics topics from a combination of physics elective coursework, independent study, and undergraduate research experience.

Graduates in the Teaching Option are expected to have broad-based knowledge in the same fundamental areas of physics as the professional option with reduced emphasis on advanced mechanics, electromagnetism, quantum mechanics, and experimental physics. In addition, they will have instructional competencies that meet the state teaching certification standards.

Communication Skills

Graduates are expected to have the ability to present the results of their work in oral and written form, as well as the ability to communicate with members of scientific teams, supervisors, and clients.

Problem-Solving Skills

Students are expected to be able to formulate and solve problems analytically and numerically. Their mathematical skills are expected to include working knowledge of calculus (including vector calculus), ordinary and partial differential equations, and linear algebra, as well as advanced mathematics skills obtained from math elective coursework.

Students are expected to perform supervised research in physics.

Assessment Management Structure

The assessment coordinator is the chair of the Undergraduate Committee. The Undergraduate committee members are appointed each year by the Department Head, with some members continuing and new members joining in order to give a good mix of consistency and fresh ideas. There are typically 5-6 faculty members and 3 undergraduate representatives. The faculty committee members include regular and adjunct faculty, all instructors of undergraduate courses. The student representatives are

physics majors and typically members of the Society of Physics Students, so they bring to the committee the ideas and concerns of the bulk of the physics majors.

The Undergraduate Committee has the responsibility and authority to gather the data generated by the various departmental entities described in this plan. The Undergraduate Committee has the responsibility and authority to adequately document the collected data and for interpret the data. The Undergraduate Committee has the responsibility and authority to make minor changes in the curriculum with the approval of the Department Head. The Undergraduate Committee has the responsibility and authority to make recommendations of major changes and enhancements to the curriculum and to present them to the faculty and the department head. The faculty has the responsibility to review and vote on the changes. The department head is the ultimate authority over the physics curriculum and is responsible for collecting and interpreting some of the data, as spelled out in the plan. The department head also has the responsibility and authority to enforce curriculum changes and the requirements for data taking from those sources spelled out in the plan. The undergraduate Committee has the responsibility and authority to take action to implement changes in the curriculum that have been approved by the department head. The student advisors and department head have the authority to approve an exception to the curriculum when it is in the best interest of the student's education.

The Physics faculty (regular, adjunct, and research faculty) participates by 1) performing assessments in the curriculum courses they instruct, 2) as advisors to the undergraduates (a new advisor is assigned to each class), 3) Attending faculty meetings where the Undergraduate Committee's recommendations of major curriculum changes are presented and votes are taken, 4) Attending the annual student-faculty lunch.

Student Learning Assessment

Discipline-Specific Knowledge

Learning Assessment in courses: Assessment takes place through examinations and assignments that are part of the coursework in each subject area. In the physics community, there is a consensus on key concepts in core physics areas, and these exams and assignments conform to these norms. Assessment of laboratory skills is through observation of lab procedures and the submission of written laboratory reports. These assessments are the responsibility of the instructors of the courses. When appropriate, additional faculty will help critique laboratory projects.

Communication Skills

Learning Assessment in courses: Assessment of communication skills is an on-going process during coursework in physics. Students are expected to submit written work in each course and to participate actively in classroom discussions and presentations. Laboratory courses require increasingly complex written reports. These assessments are the responsibility of the instructors of the courses.

Assessment in capstone course: The capstone 406C course will require written work in the form of abstracts, proposal, and summaries of research work and require oral

presentations of the student's research. Each student's final presentation will be assessed by the instructor of 406C, their faculty research advisor, and other attending faculty.

Problem-Solving Skills

Learning Assessment in courses: Assessment of analytical skills takes place continually through assignment and grading of homework sets and examinations in all physics and mathematics courses. Numerical problem-solving skills are regularly assessed similarly, in particular in PHYS 331, through homework assignments and examinations that include computational tasks pertinent to the subject matter. These assessments are the responsibility of the instructors of the courses.

Learning Assessment of research skills: Students will complete senior projects in PHYS 470, PHYS 489, or PHYS 490 (or the equivalent in another department) that integrate their physics knowledge and problem solving skills. Their research skills will be continually assessed by their research advisors. Research skills will also be assessed during the capstone PHYS 406C Seminar by the instructor of 406C.

Overall Assessment of Knowledge and Skills

Learning Assessment by advisors: The Physics faculty members take an active role in advising undergraduate students. Each incoming class of students is assigned an advisor that follows these students through the program and monitors their progress. It is the responsibility of the advisor to assist each student in developing a program, tailored if needed, that will provide the student with the expected competencies.

Program Assessment

Feedback from Current Students

Society for Physics Students (SPS): The department works closely with SPS. Their officers are encouraged to work with the Department Head, their faculty advisor, and the Undergraduate Committee on any student concerns. Students regularly serve on the department's Personnel and Policy Committee and the Undergraduate Committee.

Students-Faculty Lunch: Each year the Department will sponsor a lunch for all faculty and students to discuss all concerns and successes related to the physics curriculum. The Undergraduate Committee and SPS will organize the event. The Undergraduate Committee will be responsible for collecting the student input and preparing a report to the Department Head.

Interviews and Exit Surveys: Graduating seniors will be interviewed by the Department Head regarding their undergraduate experiences in the physics program and suggestions for programmatic improvement. During these interviews, the students will fill out a form stating their plans after graduation and contact information. The Undergraduate Committee will work with the Department Head to develop a short set of assessment questions to include in the interview. It is the responsibility of the Department Head to set up the exit interviews and to report appropriate comments and contact information to the Undergraduate Committee.

Feedback from Outside Constituencies

Student Awards: The Department Head and staff are responsible for monitoring the college, university, and national honors, scholarships, fellowships, and internships won by our students.

Evaluation of Teaching

Student evaluations of courses: All faculty members are required to distribute student evaluations in each of their classes. Each faculty reads through the evaluations and comments to assess the effectiveness of their teaching. Junior faculty members are required and senior faculty members are strongly encouraged to submit these evaluations to the Department Head. These evaluations are part of the annual reviews, and provide a starting point for mentoring. The Department Head will provide feedback to the Undergraduate Committee, when appropriate, from the undergraduate course evaluations.

Faculty mentors: New faculty members are referred to experienced teaching faculty members to help mentor the new faculty in teaching.

Faculty Teaching Assessment: The faculty's teaching is evaluated by the Department's Policy and Personnel Committee during their retention review and their tenure review. This committee reports their results to the Department Head. The Department Head will provide feedback, when appropriate, from these assessments to the Undergraduate Committee.

Preparation Assessments in Physics Courses: Each upper level course, when appropriate, will have an assessment of preparation at the start of each course that assesses students' training in and retention of skills taught in previous physics classes that are required for success in the current course. The instructor of each course will determine the best assessment tool to carry out the assessment to determine the effectiveness of the overall preparation of the students. Each course instructor is responsible for preparing the assessment tool and passing on a summary of their assessment and comments to the Undergraduate Committee and the Department Head, as appropriate. The undergraduate committee will document and track the assessments and comments, interpret the results, and use these course assessments in assessing the overall curriculum and recommending changes as appropriate.

Syllabi of Physics Classes: The syllabi for all the courses taken by our Physics majors will collected and will be used by the Undergraduate Committee and instructors to review the content of the courses and to review the topics that are being presented. The Undergraduate Committee is responsible for collecting syllabi and including them in the course assessment binder.

Flow Charts of Options: Flow charts showing the typical students course from Freshman to Senior year are reviewed and updated by the Undergraduate Committee each year. It is the responsibility of the Undergraduate Committee to have the most current flow charts for the current and recent past catalogs for all the options put on the department web site for use by students and faculty advisors. The flow charts are very useful to the Undergraduate Committee and the Faculty in assessing the curriculum and evaluating how any changes in the curriculum will affect the overall curriculum.

Curriculum Review and Plan for Utilizing Assessment Data

Information obtained from the assessment instruments described above will be compiled and reviewed by the Undergraduate Committee. The Undergraduate Committee will present a summary of the results with their recommendation at least once a year at a faculty meeting and at a student-faculty lunch. The regular, research and adjunct faculty, undergraduate students, and graduate teaching assistants will have the opportunity to provide input on the assessment process at the faculty meetings and at the student-faculty lunch. A written summary of these discussions and votes taken is maintained on file. Any curriculum changes will be integrated into the program and catalog. The assessment is submitted for posting on the MSU web site.

Undergraduate Committee: The Undergraduate Committee continually reviews the undergraduate curriculum in light of the available assessment information and the changing demands in graduate schools and the workplace. The Undergraduate Committee make recommendations to improve the curriculum to the Department Head and to the Faculty. The Undergraduate Committee is then responsible for implementing changes.

The Undergraduate Committee reviews the assessment plan and its implementation and is responsible for updating the plan as needed to best assess and improve the physics undergraduate curriculum. The Undergraduate committee is responsible for preparing the annual assessment reports and submitting them, with the approval of the Department Head.

Student Advisors: The student advisors of each class get feedback from students on the curriculum. The advisor is responsible for passing on successes, advice, and concerns to the Undergraduate Committee, when appropriate. The student advisors and instructors of undergraduate courses are encouraged to attend Student-Faculty Lunch to help assess the undergraduate curriculum and discuss possible changes to the curriculum.

The Undergraduate Committee will arrange semi-annual meetings with the undergraduate advisors prior to the start of advising periods in Fall and Spring. These meetings will include a review of advising guides, announcements and discussion of most recent changes and updates to the curriculum, and feedback from the advisors about the physics curriculum.

Appendix 14: . MSU Physics Department Assessment Report: Spring 2009

MSU Departmental Assessment Report
Spring 2009

Department: Physics

Department Head: Dick Smith

Assessment Coordinator:
Randy Babbitt, Undergraduate Curriculum Chair

Degrees/Majors/Options Offered by Department

Professional Option
Interdisciplinary Option
Physics Teaching Option
Physics Minor (Non-Teaching)

Physics

Assessment Contact

Name : Randy Babbitt
Phone : 406-994-6156
E-mail: babbitt@physics.montana.edu

Program Assessment

This report is based on assessment plan updated Spring 2007. The next report will address the Spring 2009 updated plan.

Feedback from Current Students

Society for Physics Students (SPS): Undergraduate representatives were on the following departmental committees: Policy & Personnel, Undergraduate committee (3 students), Undergraduate recruiting(3 students), and Computer Committees. The SPS is run by student elected officers and assigned a faculty representative. Their inputs are given in committee meetings, at the student-faculty lunch, and through their representatives on the undergraduate committee, as well as direct communication with undergraduate committee and department head.

Students-Faculty Lunch: The Student-Faculty Lunch was held on April 30, 2009. The following is a summary of the comments. The following is a summary of all the comments expressed during the meeting. The department prefers to list all comments here, even those that represent minority or singular opinions, so the inputs remain well documented. The undergraduate committee takes all inputs seriously and continually looks for ways to address all concerns, as long as a change to address one concern does not diminish the overall curriculum for others. As the lunch and senior interviews are held at the end of the year, these concerns will likely not be considered until the committee meets in Fall.

Two changes were made to UG curriculum were announced (see below for details) 1. The definition of the senior project was developed and put on the web and 2. Included "complex variables" in description of Phys 231.

Phys 301: Should have a pre-requisite 212 and 231. It currently has a co-requisite of 213 and 231. Committee will address this next year. Flow charts need to be changed to reflect physics 301 pre-requisites and co-requisites.

Strongly recommend that students take Math 221 as a math elective during the Freshman year. There are no "real" pre-reqs (Math 176 or 182 is the current on-paper pre-reqs). It also introduces complex variables. According to students, there are two different presentations: one with Maple and one without, and "nobody learns anything" in the Maple version.

Math has introduced honors Math 191/192/234/235, which are taught at a significantly higher level than their non-honors counterparts. The honors classes are also taught by

professors instead of grad students. If we require our majors to take the honors versions, then we need to know whether the enrollments are or will be capped.

Can we merge 490 and 406C? Do university rules prohibit that? The purpose would be to save a credit to be added elsewhere in the curriculum.

Students report too little computer experience. Matlab is seen as not adequate. A need is seen for C or C++. Reports of REU application forms asking in particular about computing experience. We should advise Freshmen to take CS courses. Can we expand "math" electives to include CS classes? Should we add a computer course requirement?

Introduce elder-student advising of Freshmen in the first week of school. One particular topic to be emphasized in this way is curriculum experience -- how to plan for future semesters.

A presentation on adding a new course Phys 322 "Intermediate Physics" course into required physics curriculum was presented and discussed. Comments included:
-Who requires 213 aside from engineers and chemists?
-Would they want to keep 213 after the introduction of 322?
-Would they want to take the new 221-222-322 sequence?
-Is it possible with the 5-5-3 credit load?
-Would they want a restructuring of 213 to better suit their needs?
-Instead of restructing 221 and 222, could we keep them as is and add 322 and a 2-credit thermal class?
- With the addition of Phys 322, can we move 411 back to Fall of Senior year?
- Students contradict the belief of some faculty that GRE performance is compromised by too little exposure to quantum.

Can we offer either Phys 231 or 213 both Fall and Spring semesters to cover transfer or major-changing students?

Moving 221 (and necessarily 213) back to Fall semester: As is, it discourages physics majors because they don't see physics their first semester in college. Also, students pad freshman year with "easy" core courses so there is no padding available later in the curriculum. Can we make Math 181 a co-req? How does that affect later courses, for example Phys 322 (which would then be offered in the Fall of sophomore year, requiring Math 225, etc.)? How would engineers, chemists, etc. be affected? A shift means that we need to teach 222 twice in the first year of change.

The comments and recommendation from the faculty-student lunch will be considered by next year's undergraduate committee in their review of the curriculum.

Exit Surveys: Exits interviews with our seniors, as well as other discussions with undergraduates, were conducted on an individual basis. The following comments were provided to the committee by the department head. In general, the students are generally

pleased with the program. We did not have any courses this past year where a majority of the students felt negatively towards the current course.

The dominant messages from the exit interviews are summarized here:

1. Spread out the Core and the Physics electives. There is no need to rush through the Core in the first year or two. In fact, some core course are of greater value if taken as a junior or senior. Spreading out the Core then makes more room for Physics electives without overdosing on Physics in a given semester.

2. Students feel they need more computer experience

3. Advising: An annual meeting of advisors would help spread the news, tips, and good (and bad) ideas so that students get a consistent advising picture independent of who the advisor is. Also, pair up the freshman majors with upper classmen for an orientation to the program; get the freshman into SPS as soon as possible.

4. Students like 137, but also suggest that moving 211 forward to Fall semester would be good.

Below are all the exit interview questions and specific comments. Comments are not weighed as to number of students that responded with similar input. Some comments are only the views of one student.

1.What are your plans for next year? Contact Info?
Work in Bozeman; headed for grad school; year off then grad school; work at government lab; industry – sustainability; industry – robotics; industry – engineering; grad school in medical physics; look for work in industry;

2. Comments on courses taken?
Electives taken 311, 341(2), 353(2), 425(5), 426 (1), 441(2), 451(2) as electives;
Adjunct teaching our physics major gets very high marks; level of 211-12 too low, take 221, 222; students were not ready for 301; move freshman physics forward to Fall; hard to maintain continuity in 1-credit relativity course; split 425 into thermo and stat mech, too much material; need coherence/continuity in 261/361; consider other texts for 317-18 and 411-12; 231 is a good lead into junior classes; single teacher for 411-12 and 317-18 is better than two different instructors; need more programming, simulation, modeling in 331;
Math441 is good, CS160 is good, CS201 (C++) would have been nice; students would benefit from a logic course; professors very helpful; 261/361 at 2 credits is okay – a lot of work but okay; nice to have some sort of philosophy of science course, something that encompasses at least foundations of epistemology and ethics; 331 not much fun, but foundation is very beneficial; REUs are fantastic and should be pushed at every semester advisor meeting – point students to NSF web site in November;

3. Comments on lab experience?

Like senior lab – could we do a junior lab? Add a lab experience to lectures; don't overdo the lab project in 261 – too much time; writing up experiments is good practice; 211-12 labs could be more challenging; the capstone experience is better than a "senior" lab; liked astronomy labs and senior lab; freshman could be advised into 311 – no need to wait until upper division; liked all lab courses; put more emphasis on lab book and taking notes in lab; 451 and 412 can work nice together;

4. Comments on advising experience?
Should have an advisors meeting at least once or twice a year; tell students to take more electives – push students a bit harder – we are too casual, not doing the students any favors; alert students to careers in Medical Physics; math and physics are too easy in 1st and 2nd years; be willing to allow incoming students to work outside the box; pair the incoming freshman up with seniors for orientation to learn the ropes (several comments on this); spread out your core – no need to take it all at beginning, then can fit in more electives (several comments on this); 1st and 2nd years are critical – talk to students; alert students to 221; get freshman into SPS; take core courses during study abroad; physics advisors can use more preparation; REU, RISE; talk up the REU early on, even to freshman;

> In addition, input from outside the exit interview process provided this feedback: "It would be better if there were higher level courses in certain areas. It's also difficult to plan later years in your study when you have to have so many prerequisites. I think advising needs to be taken more seriously by advisers."

Feedback from Outside Constituencies

> ***Student Awards:*** Student awards are announced on Physics home page and Newsletters. These include:
>
> One student was selected to participate in the first annual U.S. Department of energy Student Energy Research Challenge (SERCh), a national competition held at Oak Ridge National Lab, Oak ridge, TN on Nov. 9-10. His poster described work on Solid Oxide Fuel Cells carried out in the Mechanical Engineering department.
>
> One student was awarded the Undergraduate Physics Scholarship from Montana Space Grant Consortium. This honor reflects the student's past achievements as well as present and future commitment to the aerospace sciences and engineering. There re approximately 1900 Space Grant Scholars and Fellows nationwide.
>
> Number of graduating seniors in Spring 09: 18 (a record high in recent years)
>
> Students graduating with Honors (3.25 GPA or higher): 6
>
> Students graduating with Highest Honors (3.75 GPA or higher): 5

One student was awarded the 2009 Alumni Association/Chamber of commerce Award for Excellence. The Award for Excellence signifies exceptional achievement - both academically and in community leadership - over a student's entire MSU career.

Evaluation of Teaching

Student evaluations of courses: The teaching evaluations were done in every course and evaluations were discussed with instructors during their annual reviews in Spring 09. The undergraduate course evaluations generated no concerns or comments appropriate to be passed on as feedback to the Undergraduate Committee.

Faculty mentors: The new faculty member was connected to past instructors of his first course to aid in his teaching. Also, the DH has agreed to support trips to APS/AAPT sponsored workshops for new faculty to be held in College Park, MD in Nov 2009.

Faculty Teaching Assessment: The teaching evaluations conducted during retention and tenure reviews generated no concerns or comments appropriate to be passed on as feedback to the Undergraduate Committee.

Preparation Assessment in Physics Classes: In Fall of 2008 and Spring of 2009, 8 assessment summaries were received by the committee (212, 261, 301, 311, 451 in Fall 08 and 212, 361, 406C, 425, and 461 in Spring 09). So far, 38 assessments have been carried out and documented. 20 of the 24 classes that have physics pre-requisites have been assessed. The cumulative comments and recommendations from these assessments have been collected into a binder that is available to all instructors. The binder is used by the undergraduate committee in their review of the curriculum.

Syllabi of Physics Classes: The syllabus from all 28 required and elective physics courses of our Physics majors' curriculum have been collected. The syllabus for each course ia included in the course assessment binder with the cumulative preparation assessments for that course. This collection of updated syllabi will be included in updated Spring 2009 assessment plan.

Curriculum Review

Undergraduate Committee: The 08-09 Undergraduate Committee had 5 faculty members and 3 undergraduate representatives. The following actions were taken by the undergraduate committee in 08-09 with respect to assessment and action on the physics curriculum:

-Flow Charts: The flow charts for all options were reviewed and the teaching option in 08-10 catalog was updated. The annual review, updating, and posting of the flow charts for all three degree options will be added to the assessment plan Spring 09 update.

- The senior project is designed to give a student the opportunity to develop, over two or more semesters, skills that are necessary for work in a professional scientific environment. The student will collaborate with a mentor on a project that: is of interest to the student, is either experimental or theoretical in nature, has a defined objective, is primarily based on the

student's own work. (This work normally will be presented in PHYS 406C). It could be an extension of background or historical work completed by the student in PHYS 470 or 489, but must also include 3 credits of PHYS 490; at least 2 credits of 490 must be completed before taking physics 406C (capstone). In PHYS 406C students will be required to complete: i) an APS-style abstract, ii) an APS-style 10-minute oral presentation, iii) a poster session, and iv) a written research report, based on their prior research.

Specific examples of current and past senior projects include: Laser development for specific applications, Conducting spectroscopy or surface measurements of materials, Extending or applying recent theories of quantum information theory, Theoretical work in astrophysics, gravitation, and Analysis and interpretation of astronomical data

-Honors math: Advise incoming Freshman to take Math 191 and 192 (Honors) rather than Math 181 and 182. This is based on the assessments that found students who have taken the honors versions of these courses (191/192/234) are much better prepared than the 181/182 students.

-Catalog changes: "Complex Variables" was added to the description of topics in Physics 231.

-Computer Science 392: An advisory was sent to all physics undergraduate advisors stating that CS392 can be used as a Math elective or a substitute for Physics 331 on a case by case basis. The Undergraduate committee is waiting on more feedback from physics students that take the course before recommending a firm policy and revising the catalog.

-The committee spent considerable effort in developing a proposal for an intermediate physics course. The proposal was presented to the faculty (4/30/09) and at the student-faculty lunch. The committee will consider and address the suggestion, comments, and concerns raised at these meeting to revise the proposal for further consideration.

-GRE Prep: GRE prep sessions were organized and held the Fall of 2008. A GRE prep session will be organized for Fall 2009, for students that are interested.

Student Advisors: A new Freshman advisor was assigned this year, and each of the class advisors cycles up with their students, so each student has the same advisor throughout their MSU education. The student advisors attended and provided input at faculty meetings and student-faculty lunch, as well as directly to the undergraduate committee.

Next year's committee will set up meeting(s) with or provide advising manuals for all the undergraduate advisors prior to the start of advising periods in Fall and Spring. Twice annual meetings with advisors will be added to the Spring 09 update of the Assessment Plan.

Appendix 15: Selected Results from the Career Destinations Survey

Bachelor's Degree Recipients

College of Letters & Science continued...

Employment

	Total Graduates	Respondents* #	Respondents* %	Full Time in Field #	Full Time in Field %	FT Not in Field #	FT Not in Field %	Part Time #	Part Time %	Unemployed #	Unemployed %	Continuing Ed. #	Continuing Ed. %	Continuing Ed. & Employed #	Continuing Ed. & Employed %	Salary	n
French -Teaching	1	1	100	0	0	0	0	0	0	0	0	0	0	0	0	I.D.***	0
German	7	2	29	0	0	0	0	0	0	1	50	0	0	1	50	I.D.***	0
German -Teaching	1	1	100	0	0	0	0	0	0	0	0	0	0	1	100	I.D.***	0
Spanish	18	8	44	2	25	2	25	1	13	0	0	1	13	2	25	$29,984	6
Spanish -Teaching	5	2	40	2	100	0	0	0	0	0	0	0	0	0	0	$25,850	2
Justice Studies	15	9	60	3	33	3	33	0	0	0	0	1	11	2	22	$35,367	7
Philosophy	5	2	40	0	0	0	0	0	0	0	0	0	0	2	100	$24,960	2
Philosophy and Religion	3	1	33	0	0	0	0	0	0	0	0	0	0	1	100	I.D.***	1
Physics –Professional	9	8	89	2	25	0	0	0	0	0	0	4	50	2	25	$60,000	2
Physics –Teaching	1	1	100	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	1
Physics –Interdisciplinary Studies	3	2	67	1	50	0	0	1	50	0	0	0	0	0	0	I.D.***	1
Political Science	27	23	74	6	26	11	48	0	0	0	0	3	13	2	9	$25,973	18
Psychology –Applied Psychology	19	12	63	3	25	4	33	0	0	2	17	2	17	1	8	$26,211	7
Psychology –Psychological Science	26	15	58	3	20	3	20	1	7	1	7	3	20	4	27	$25,987	10
Sociology	26	19	65	5	26	7	37	4	21	2	11	0	0	1	5	$28,449	13
Statistics	4	33	75	0	0	0	0	1	33	1	33	1	33	0	0	I.D.***	0

College of Nursing

Employment

	Total Graduates	Respondents* #	Respondents* %	Full Time in Field #	Full Time in Field %	FT Not in Field #	FT Not in Field %	Part Time #	Part Time %	Unemployed #	Unemployed %	Continuing Ed. #	Continuing Ed. %	Continuing Ed. & Employed #	Continuing Ed. & Employed %	Salary	n
Nursing	168	116	69	101	87	1	1	4	3	5	4	0	0	3	3	$48,177	105

n= total number of respondents reporting salary
* Not all respondents answered all questions. Statistics, therefore, are not always based upon response of the total sample group. Some line items do not total 100% due to respondents indicating they are not currently seeking employment.
**5 year master's programs are reported both in Bachelor and Master's sections
*** I.D. = Insufficient Data

Master's Degree Recipients

College of Letters & Science continued...

	Total Graduates	Respondents*		Full Time in Field		FT Not in Field		Part Time		Unemployed		Continuing Ed.		Continuing Ed. & Employed		Salary	n
		#	%	#	%	#	%	#	%	#	%	#	%	#	%		
Mathematics	9	8	88	4	50	1	13	1	13	0	0	1	13	1	13	$33,192	5
Math Education	9	8	89	5	63	0	0	2	25	0	0	1	13	0	0	$36,950	5
Microbiology	2	2	100	2	100	0	0	0	0	0	0	0	0	0	0	$37,500	2
Physics	9	4	44	0	0	1	25	0	0	1	25	0	0	2	50	I.D.***	1
Public Administration	10	3	30	1	33	1	33	0	0	1	33	0	0	0	0	$38,500	2
Statistics	6	5	83	3	60	0	0	0	0	0	0	1	20	1	20	$46,250	4

College of Nursing

	Total Graduates	Respondents*		Full Time in Field		FT Not in Field		Part Time		Unemployed		Continuing Ed.		Continuing Ed. & Employed		Salary	n
		#	%	#	%	#	%	#	%	#	%	#	%	#	%		
Nursing-Family Nurse Practitioner	11	8	73	6	75	0	0	2	25	0	0	0	0	0	0	$70,173	6

Doctoral Degree Recipients

College of Agriculture

	Total Graduates	Respondents*		Full Time in Field		FT Not in Field		Part Time		Unemployed		Continuing Ed.		Continuing Ed. & Employed		Salary	n
		#	%	#	%	#	%	#	%	#	%	#	%	#	%		
Ecology/ Environmental Sciences	4	2	50	2	100	0	0	0	0	0	0	0	0	0	0	$37,500	2
Land Resources Environmental Science	1	1	100	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	1
Plant Genetics	1	1	100	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	1
Veterinary Molecular Biology	1	1	100	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	1

n= total number of respondents reporting salary
* Not all respondents answered all questions. Statistics, therefore, are not always based upon response of the total sample group. Some line items do not total 100% due to respondents indicating they are not currently seeking employment.
**5 year master's programs are reported both in Bachelor and Master's sections
*** I.D. = Insufficient Data

Doctoral Degree Recipients

College of Education, Health & Human Development

	Total Graduates	Respondents*		Full Time in Field		FT Not in Field		Part Time		Unemployed		Continuing Ed.		Continuing Ed. & Employed		Salary	n
		#	%	#	%	#	%	#	%	#	%	#	%	#	%		
Adult & Higher Education	2	1	50	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	1
Curriculum and Instruction	2	2	100	2	100	0	0	0	0	0	0	0	0	0	0	I.D.***	2

College of Engineering

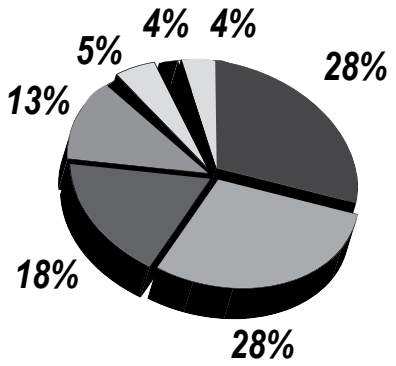
	Total Graduates	Respondents*		Full Time in Field		FT Not in Field		Part Time		Unemployed		Continuing Ed.		Continuing Ed. & Employed		Salary	n
		#	%	#	%	#	%	#	%	#	%	#	%	#	%		
Applied Mechanics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I.D.***	0
Chemical Engineering	3	3	100	3	100	0	0	0	0	0	0	0	0	0	0	$66,000	3
Civil Engineering	1	1	100	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	1
Computer Science	2	2	100	1	50	0	1	50	0	0	0	0	0	0	0	I.D.***	1
Electrical & Computer Engineering	2	1	50	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	1
Environmental Engineering	1	1	100	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	1

College of Letters & Science

	Total Graduates	Respondents*		Full Time in Field		FT Not in Field		Part Time		Unemployed		Continuing Ed.		Continuing Ed. & Employed		Salary	n
		#	%	#	%	#	%	#	%	#	%	#	%	#	%		
Boichemistry	1	1	100	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	1
Chemistry	3	2	67	2	100	0	0	0	0	0	0	0	0	0	0	$47,000	2
Ecology & Environmental Studies	4	1	25	0	0	0	0	0	0	0	0	0	0	1	100	I.D.***	1
Fish and Wildlife Biology	1	1	100	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	1
Mathematics	2	1	50	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	1
Microbiology	3	1	33	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	1
Neuroscience	2	2	100	1	50	0	0	1	50	0	0	0	0	0	0	I.D.***	1
Physics	5	2	40	2	100	0	0	0	0	0	0	0	0	0	0	$50,000	2
Statistics	1	1	100	1	100	0	0	0	0	0	0	0	0	0	0	I.D.***	0

n= total number of respondents reporting salary
* Not all respondents answered all questions. Statistics, therefore, are not always based upon response of the total sample group. Some line items do not total 100% due to respondents indicating they are not currently seeking employment.
**5 year master's programs are reported both in Bachelor and Master's sections
*** I.D. = Insufficient Data

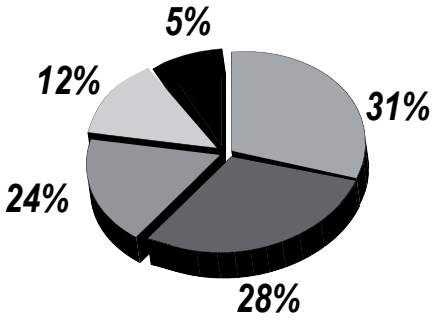
When Graduates Began Job Hunting



n = 1132

28%	Final Semester Before Graduation
28%	After Graduation
18%	Secured Job prior to Graduation
13%	2 Semesters Before Graduation
5%	3 Semesters Before Graduation
4%	More than 3 Semesters Before Graduation
4%	Not Seeking Employment

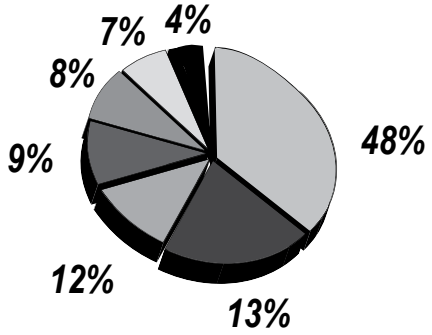
When Graduates Secured Their Positions



n = 1143

31%	0-3 Months after graduation
28%	Final Semester Before Graduation
24%	2 or more Semesters before graduation
12%	4-6 Months after graduation
5%	More than 6 months after graduation

Number of Employees in Employing Organizations



n = 1060

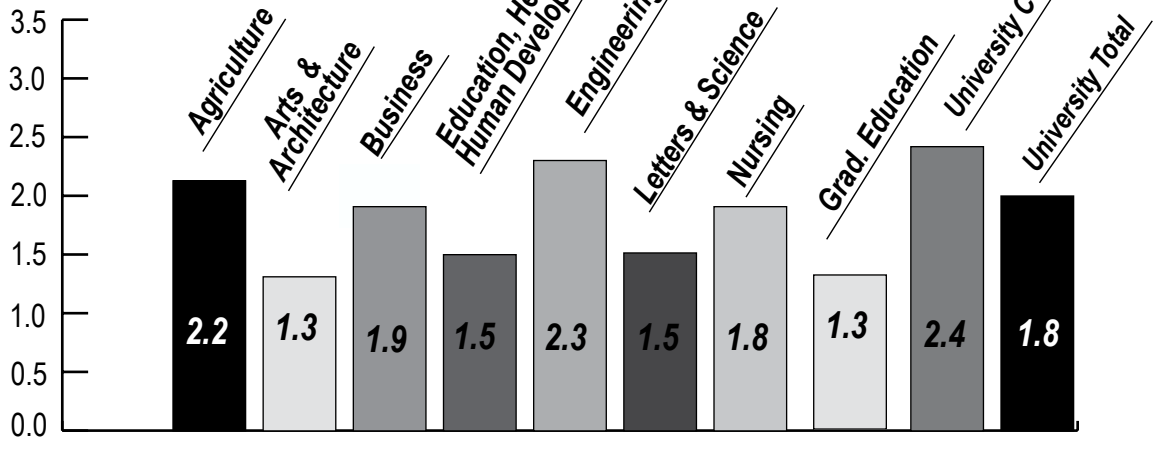
# of Employees	
48%	1000 and up
13%	0-19
12%	100-249
9%	20-49
8%	50-99
7%	500-999
4%	250-499

Job Offers

n = 1135

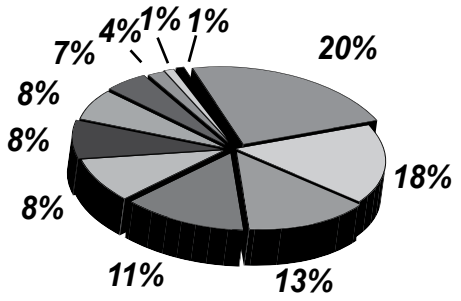
Average Number of Job Offers

Represents average numbers by college and graduate school



How Graduates Found their Jobs

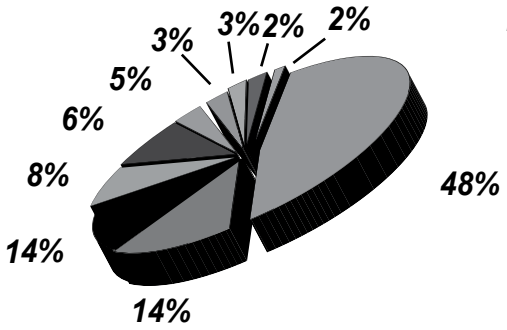
n = 1129



20%	Knew employer or referred by someone employer knew
18%	Internet
13%	Career Services (On-campus interviews, job postings, Career Fair, Career Library, etc.)
11%	Worked for employer prior to graduation
8%	Contacted employer without knowing of opening
8%	Previous experience with employer, but not through Career Services
8%	Answered ad in newspaper, journal, etc.
7%	Other
4%	Referred by faculty or department to an employer not formally visiting MSU
1%	Temporary or employment agency
1%	Flyer or job posting at college

Types of Organizations Employing MSU Graduates

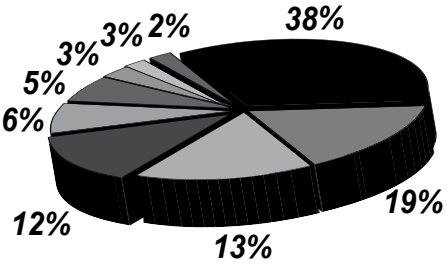
n = 1155



43%	Business or Industry
14%	K-12 Education
14%	Medical/Health Care
8%	Post-Secondary Education
6%	Government
5%	Non-Profit Organization
3%	Self-Employed
3%	Military
2%	Farm/Ranch
2%	Other

Top Factor in Securing Job

n = 1130

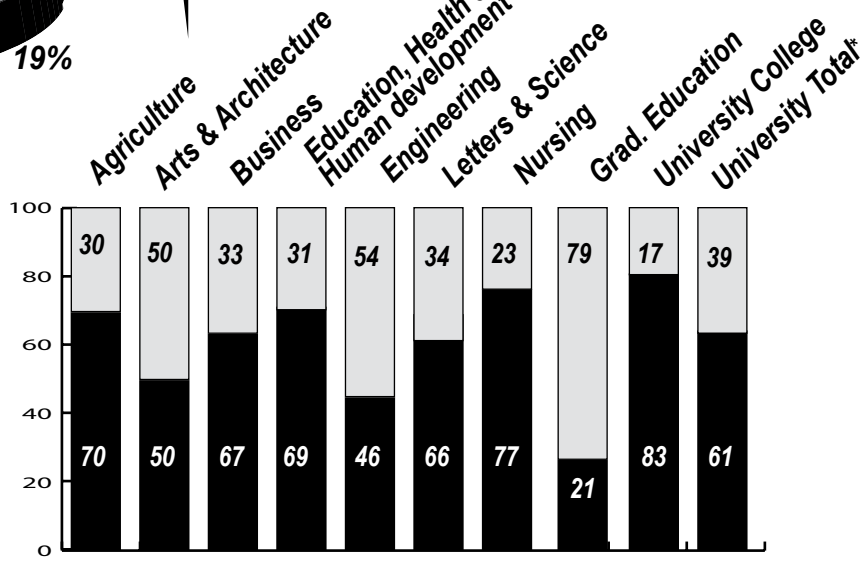


38%	Work experience related to major/internship/cooperative education
19%	Personality or interpersonal skills
13%	Knowing someone who was able to influence the hiring authority
12%	Academic major
6%	Other
5%	An effective job-searching campaign
3%	Extracurricular activities providing skills sought by employer
3%	Willingness to relocate
2%	Above average GPA

In-State vs. Out-of-State Pursuits

Montana Out-of-State

n = 1106



*Includes all majors and all degree levels

Appendix 16: 2009 Faculty Professional Service (off campus)

Appendix 16: 2009 Faculty Professional Service (off campus)

Babbit, W.R.

International Advisory Committee, Holeburning and Single Molecule Conference, Palm Cove, Great Barrier Reef, Queensland, Australia June 21-25, 2009

Program subcommittee member, Optical Processing and Analog Subsystems, OFC/ NFOEC 2009, San Diego, CA, March 24-26, 2009

Cone, R.L.

International Organizing Committee, Conference on Holeburning, Single Molecule, and Related Spectroscopies: Science and Applications 2009, Palm Cove, Australia, June 21 - 25, 2009.

Local Organizing Committee, International Conference on Dynamical Processes in Excited States of Solids, Argonne National Laboratory, IL, June 20-25, 2010.

Cornish, N.J.

Panelist, Cosmology and Fundamental Physics Panel, National Research Council, Decadal Review of Astrophysics

Idzerda, Y.U.

Member, MMM Advisory Committee

Member, NSLS CSX Beamline Advisory Team

Member, Proposal Study Panel. Advanced Light Source

Kankelborg, C.C.

Member/consultant, NASA Solar Probe Plus Standing Review Board

Member/SGE, NASA Heliophysics Subcommittee

Reviewer, Mid-term review board for NASA/NSF/AFOSR Partnership for Collaborative Space Weather Modeling

Member, Beamline Advisory Team, NRL X24C move to NSLS-II

Member, Scientific organizing committee, PXRMS 2010

Longcope, D.W.

Member of NASA Heliophysics Performance Assessment Committee, National Research Council

Elected member, AURA Solar Observatory Council

Member of Committee on Solar and Space Physics, National Research Council

Member representative, Association of Universities for Research in Astronomy (AURA)

Dean, NASA Heliophysics Summer School

Malovychko, G.

Member of IES Silver Medal for Physics/Mat Sciences, International ESR/EPR Society

McKenzie, D.

Member sub-Working Group, Solar-C sub-Working Group

Member Scientific Organizaing Committee, XRT Team Meeting SOC

Member, Education/Public Outreach committee, AAS Solar Physics Division

Qiu, J.

SPD student committee member, SPD/AAS

Rebane, A.

Member, SPIE Conference Scientific Committee

Smith, R.J.

Member, External Review Team, Physics Department, NIU

Tsuruta, S.

Member, Scientific Organizing Committee of International Pacific Rim Conference on Stellat Astrophysics, to be held in April 2011 in Lijiang, China

Associate Editor: editorial board of Reserch in Astronomy and Astrophysics

Associate Editor: editorial board of the World Scientific Publishing Company.