MONTANA STATE UNIVERSITY | College of Letters & Science | Physics Colloquium

Friday, October 7, 2016
4:10 – 5:00 PM
Barnard/EPS 103

Quantum light-matter interfaces based on rare-earth-doped crystals and nano-photonics

Dr. Andrei Faraon
Applied Physics, Materials Science and Medical Engineering
California Institute of Technology
Pasadena, CA
http://www.its.caltech.edu/~faraon/
http://photonics.caltech.edu/

Abstract:

Quantum light-matter interfaces that reversibly map the quantum state of photons onto the quantum states of atoms, are essential components in the quantum engineering toolbox with applications in quantum communication, computing, and quantum-enabled sensing. In this talk I present our progress towards developing on-chip quantum light-matter interfaces based on nanophotonic resonators fabricated in rare-earth-doped crystals known to exhibit the longest optical and spin coherence times in the solid state. We recently demonstrated coherent control of neodymium (Nd^{3+}) ions coupled to yttrium orthosilicate Y_2SiO_5 (YSO) photonic crystal nano-beam resonator. The coupling of the Nd^{3+} 883 nm $^4I_{9/2}$-$^4F_{3/2}$ transition to the nano-resonator results in a 40 fold enhancement of the transition rate (Purcell effect), and increased optical absorption (~80%) - adequate for realizing efficient optical quantum memories via cavity impedance matching. Optical coherence times T_2 up to 100 μs with low spectral diffusion were measured for ions embedded in photonic crystals, which are comparable to those observed in unprocessed bulk samples. This indicates that the remarkable coherence properties of REIs are preserved during nanofabrication process. Multi-temporal mode photon storage using stimulated photon echo and atomic frequency comb (AFC) protocols were implemented in these nano-resonators. Our current technology can be readily transferred to Erbium (Er) doped YSO devices, therefore opening the possibility of efficient on-chip optical quantum memory at 1.5 μm telecom wavelength. Integration with superconducting qubits can lead to devices for reversible quantum conversion of optical photons to microwave photons.

Hosts: Rufus Cone and Charles Thiel

For Biography, see next page.

****** Refreshments served in the EPS second floor atrium at 3:45 ******

Biography:

Dr. Andrei Faraon is an Assistant Professor of Applied Physics, Materials Science and Medical Engineering at California Institute of Technology. After earning a B.S. degree in physics with honors in 2004 at California Institute of Technology, he received his M.S. in Electrical Engineering and PhD in Applied Physics both from Stanford University in 2009. At Stanford, Dr. Faraon was involved with seminal experiments on quantum optics using single indium arsenide quantum dots strongly coupled to photonic crystal cavities in gallium arsenide. After earning his PhD, Dr. Faraon spent three years as a postdoctoral fellow at Hewlett Packard Laboratories. At HP he was involved with pioneering experiments on diamond quantum photonic devices coupled to solid-state spins. He demonstrated the first nano-resonators coupled to single nitrogen vacancy centers in mono-crystalline diamond.

Faraon left HP in 2012 to become an Assistant Professor at Caltech. At Caltech, he set up a laboratory specialized in developing nano-photonic technologies for devices that operate close to the fundamental limit of light-matter interaction. He is focused both on fundamental challenges on how to control the interaction between single atoms and single photons using nano-technologies, and on using nano-photonics to build cutting edge devices for bio-imaging, bio-sensing and photo-voltaic energy harvesting. He is the recipient of the 2015 National Science Foundation CAREER award, the 2015 Air Force Office of Scientific Research young investigator award and the 2016 Office of Naval Research Young Investigator Award.