SACRAMENTO STATE

Department of Physics and Astronomy
SPRING 2023 Colloquium Series

"Quantum Nanophotonic Hardware with Integrated Color Centers"

Dr. Marina Radulaski

University of California, Davis

Photonic systems are the leading candidates for deterministic quantum sources, quantum repeaters, and other key devices for quantum information processing. Scalability of this technology depends on the stability, homogeneity and coherence properties of quantum emitters. Here, color centers in wide band gap materials offer favorable properties for applications in quantum memories, single-photon sources, quantum sensors, and spin-photon interfaces [1,2]. Silicon carbide, in particular, has been an attractive commercial host of color centers featuring fiber-compatible single photon emission, long spin-coherence times and nonlinear optical properties [3]. Integration of color centers with nanophotonic devices has been a challenging task, but significant progress has been made with demonstrations up to 120-fold resonant emission enhancement of emitters embedded in photonic crystal cavities [4]. A novel direction in overcoming the integration challenge has been the development of triangular photonic devices, recently shown to preserve millisecond-scale spin-coherence in silicon carbide defects [5,6]. Triangular photonics has promising applications in quantum networks, integrated quantum circuits, and quantum simulation. Here, open quantum system modeling provides insights into polaritonic physics achievable with realistic device parameters through evaluation of cavity-protection, localization and phase transition effects [7]. Mapping of this dynamics to gate-based quantum circuits opens door for quantum advantage in understanding cavity quantum electrodynamical (QED) effects using commercial Noisy Intermediate-Scale Quantum (NISQ) hardware [8].

1. V. A. Norman, S. Majety, Z. Wang, W. H. Casey, N. Curro, M. Radulaski, "Novel color center platforms enabling fundamental scientific discovery," *InfoMat*, 1-24 (2020).
2. S. Majety, P. Saha, V. A. Norman, M. Radulaski, "Quantum Information Processing With Integrated Silicon Carbide Photonics," *Journal of Applied Physics* **131**, 130901 (2022).
3. G. Moody, et al., "Roadmap on Integrated Quantum Photonics," *to appear in Journal of Physics: Photonics*, **4**, 012501 (2022).
4. D. M. Lukin, C. Dory, M. A. Guidry, K. Y. Yang, S. D. Mishra, R. Trivedi, M. Radulaski, S. Sun, D. Vercruysse, G. H. Ahn, J. Vučković, "4H-Silicon-Carbide-on-Insulator for Integrated Quantum and Nonlinear Photonics," *Nature Photonics* **14**, 330-334 (2020).
5. S. Majety, V. A. Norman, L. Li, M. Bell, P. Saha, M. Radulaski, "Quantum photonics in triangular-cross-section nanodevices in silicon carbide," *J. Phys. Photonics* **3**, 034008 (2021).
6. C. Babin, R. Stöhr, N. Morioka, T. Linkewitz, T. Steidl, R. Wörnle1, D. Liu, V. Vorobyov, A. Denisenko, M. Hentschel, G. Astakhov, W. Knolle, S. Majety, P. Saha, M. Radulaski, N.T. Son, J. Ul-Hassan, F. Kaiser, J. Wrachtrup, "Nanofabricated and integrated color centers in silicon carbide with high-coherence spin-optical properties," arXiv.2109.04737, *Nature Materials* **21**, 67–73 (2022).
7. J. Patton, V. A. Norman, R. T. Scalettar, M. Radulaski, "All-Photonic Quantum Simulators With Spectrally Disordered Emitters," arXiv:2112.15469.
8. M. K. Marinkovic, M. Radulaski, "Complexity reduction in resonant open quantum system Tavis-Cummings model with quantum circuit mapping", arXiv:2208.12029.

Thursday, March 2, 2023
4:00 – 5:20PM
MND1015
Open & Free to all students, faculty and public