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Purdue Quantum Science and Engineering Institute

"From Qubits to Qudits: Time-Frequency Encoded Photons for Quantum Information"

Tuesday, October 22, 2019
3:30 – 4:30 p.m.; MRGN 129

Photonic quantum information processing promises multiple applications ranging from fully secure quantum communications to interconnecting matter-based qubits for distributed quantum computing. Quantum states can be encoded in multiple degrees of freedom (DoFs) of photons, such as polarization, path, time, frequency, and orbital angular momentum. Compared to other DoFs, the frequency domain has the advantage of compatibility with fiber-optical networks, robustness against channel noise, and the capability to encode high-dimensional quantum information (*qudits*). In the past couple of years, our group has demonstrated biphoton frequency combs entangled in time and frequency domains. We have demonstrated single- and two-qubit gates operating on qubits encoded in frequency bins of these photons using a *quantum frequency processor*, consisting a series of Fourier transform pulse shapers and electro-optic modulators. Furthermore, we have demonstrated qudit-based operations in both time and frequency domains, which are used to generate high-dimensional multiparty Greenberger-Horne-Zeilinger (GHZ) entangled states. Finally, we report our recent demonstrations of quantum hopping of high-dimensionally entangled photon pairs in the frequency domain to simulate many-body quantum systems.

Andrew Weiner, the Scifres Family Distinguished Professor of Electrical and Computer Engineering at Purdue University, is best known for pioneering work on programmable femtosecond pulse shaping and ultrafast signal processing. His recent work concerns optical frequency combs as well as multi-frequency and time-frequency quantum optics, including integrated photonics quantum sources. Weiner is a member of the National Academy of Engineering and National Academy of Inventors, was selected as a Department of Defense National Security Science and Engineering Faculty Fellow, and has received the OSA Wood Prize and the IEEE Photonics Society Quantum Electronics Award, among others. He is author of the textbook Ultrafast Optics and recently concluded a six year term as Editor-in-Chief of Optics Express.

Poolad Imany graduated with a B.Sc. in Electrical Engineering from Sharif University of Technology, Tehran, Iran in 2013. He obtained a Ph.D. from the Electrical and Computer Engineering department at Purdue University in May 2019. Poolad is currently a postdoctoral associate in the Ultrafast Optics and Optical Fiber Communications Laboratory at Purdue, under supervision of Prof. Andrew Weiner. Poolad's doctoral and postdoctoral research has been focused on photonic quantum information processing. He has been working on generation and manipulation of *quantum frequency combs*—time-frequency entangled photon pairs with a comb-like spectrum—demonstrating their applications directed towards quantum communications, quantum simulation and quantum computing.

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