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Innovating quantum technologies

The Quantum Frequency Processor for Quantum Networking

Dr. Joseph M. Lukens

Research Scientist & Wigner Fellow

Oak Ridge National Laboratory

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Due to frequency's inherent stability and compatibility with optical fiber, spectral modes provide an attractive Hilbert space for quantum communication and networking. Yet control and processing of such modes can prove quite challenging, typically requiring complicated operations and strong classical pump fields. In this talk, I will describe our paradigm known as the "quantum frequency processor" (QFP), based on frequency-bin qubits, electro-optic phase modulators, and Fourier-transform pulse shapers. After highlighting experiments comprising a universal gate set—punctuated by an aside on Bayesian quantum state estimation—I will hone in on the basic QFP functionalities required for quantum networking, sharing the results of recent experiments in: (i) fully arbitrary control of frequency-bin qubits, (ii) frequency-bin Bell state analysis, (iii) flex-grid entanglement distribution, and (iv) classical all-optical networking. To conclude, I will offer an outlook on opportunities to address current challenges, summarizing the potential of the QFP in quantum networks.



Joseph M. Lukens is a Research Scientist and Wigner Fellow at Oak Ridge National Laboratory. He graduated with a BS from the University of Alabama in 2011 and completed a PhD at Purdue University in 2015, where he conducted research in ultrafast photonics. Funded by a 2019 Early Career Award from the U.S. Department of Energy, Lukens currently studies quantum information, with a focus on systems for frequency-based quantum networking. He has published 31 journal articles and 1 book chapter, with conference presentations including first-place poster at the inaugural Siegmán International School on Lasers, a feature abstract at the CLEO 2013 press luncheon, and top selection at the 2011 IEEE Region 3 Southeastcon Student Paper Competition. Lukens's recognitions include the College of Engineering Outstanding Graduate Student Research Award from Purdue, the Paul Baran Young Scholar Award from the Marconi Society, and, just recently, the Research Accomplishment Award from UT-Battelle for pioneering the invention of the quantum frequency processor. He is a member of the Optical Society (OSA) and IEEE Photonics Society.