



Frequency Bin Quantum Photonics

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Entanglement and encoding in discrete frequency bins – essentially a quantum analogue of wavelength-division multiplexing – represents a relatively new degree of freedom for quantum information with photons. In this talk I discuss biphoton frequency combs, generated either by spontaneous four-wave mixing (SFWM) from on-chip microring resonators or by spectral filtering of spontaneous parametric down conversion (SPDC) in second order nonlinear crystals. Potential advantages include generation of high dimensional units of quantum information (qudits), which can carry multiple qubits per photon, robust transmission over fiber, frequency parallelism and routing, and compatibility with on-chip implementations, as well as hyperentanglement with other photonic degrees, e.g., time-frequency hyperentanglement. Since the initial experiments less than two years ago, frequency bin quantum photonics has been advancing rapidly [1-8]. In this talk I will discuss a method using pulse shapers and phase modulators in order to mix different frequencies and perform two photon interference experiments for characterization of the frequency-bin entanglement. Similar components (pulse shapers and phase modulators) may be used to manipulate the frequency-encoded quantum states; this will be described in another talk by our collaborators at Oak Ridge National Labs. I will also discuss the use of time bins and frequency bins as independent degrees of freedom in a quantum encoding fashion to realize what we believe to be the first deterministic two qudit gates. Finally, I comment briefly on potential applications and on prospects for realization of integrated frequency bin quantum photonics.

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