High rate quantum key distribution

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It is now well established that the nonclassical features of entangled photons can be used to enable a provably secure quantum communication (QC) channel. There have been many proof-of-principle quantum key distribution (QKD) experiments and now even a few vendors of first-generation commercial systems. However, one limitation of all of these is speed – the final secret key rates are much lower than one would like for a practical system. One reason is that nearly every implementation to date has used only binary encoding (e.g., polarization ‘qubits’ in a 2-dimensional Hilbert space), which transmits at most one secret bit per photon (and actually less, due to quantum error checking for an eavesdropper).

One method to improve the rate of secret key transmission is to send multiple bits per photon (bpp). For example, if each photon is allowed to appear in one of 1024 time-bins or spatial ‘pixels,’ then a single detection event in principle could yield \( \log_2 1024 = 10 \) bpp. I am part of an interdisciplinary team of researchers that is developing a free-space quantum key distribution system that will be of transmitting over 10 bpp at a data rates in excess of \( 10^9 \) bits per second (bps).

In this talk, I will review our approach to this problem, which involves entanglement in multiple degrees of freedom, including polarization, time bin, and spatial mode, with error checking taking place in a restricted sub-space. I will then focus on our preliminary approach to developing a very high brightness source of polarization entangle photons and on high speed single photon detection with low deadtime using multi-pixel avalanche photodiodes.