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Rigorosum: Quantum state transfer in refractive and diffractive media

High-dimensional, discrete quantum states, also known as qudits, offer several advantages over their two-dimensional counterpart (qubits). For example, in quantum communication, the use of qudits not only increases the amount of information encoded into a single carrier, but also enhances the security of the communication protocols. Spanning a discrete infinite-dimensional Hilbert space, the orbital angular momentum (OAM) of light can be used to realize such high-dimensional quantum systems. However, the rich spatial structure of OAM-carrying modes is extremely fragile with respect to disturbances along the light propagation path.

In this presentation, I will discuss how this fragility affect the transfer of biphoton states entangled in their OAM degree of freedom.

I will first show an analytical expression for the entanglement losses induced by diffraction and use it to investigate how these entanglement losses are influenced by the radial structure of the encoding modes, and how the uncertainty relation for angular position and angular momentum can be used to interpret these phenomena.Then, I will discuss the efficiency of adaptive optics (AO) in mitigating turbulence-induced OAM entanglement losses, for a vast range of atmospheric conditions.

In particular, I will show that the stronger Bell correlations available in higher dimensions are nullified by their faster turbulence-induced decay, but that AO corrections can restore non-locality even for high-dimensional states under moderate turbulence.