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Transport of High-dimensional Photonic States across a Turbulent Atmosphere

One of the quests of quantum communication is a reliable transmission of high-dimensional photonic quantum states (qudits) through a free-space channel. A common approach to realise qudits is by using light modes carrying orbital angular momentum (OAM). We consider the propagation of photonic OAM qudits encoded in Laguerre-Gaussian modes across a turbulent atmosphere. We find that the fidelity of the propagated state is a non-monotonic function of the state's dimensionality exhibiting a maximum, however, the optimal fidelity values are too low for secure quantum communication. Therefore, we propose an alternative encoding of qudits — into the "eigenstates of atmospheric turbulence". Using this method, we find high-dimensional states that can be transmitted with high fidelity through the atmosphere.