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Robust quantum key distribution with spatial modes

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Quantum key distribution (QKD) allows the secure sharing of information by exploiting the laws of physics. Traditionally demonstrated with polarisation, there has been novel avenues of research whereby the spatial degree of freedom is employed to increase the bandwidth; that is because spatial modes allow access to a larger state space beyond the qubit, unlike polarisation. However, unlike polarisation, spatial modes are not resilient to atmospheric perturbations; the random fluctuations in of refractive index cause wavefront aberrations that broadens the spectrum of a single mode OAM state. In the context of quantum key distribution, the broadening leads to measurement errors that decrease or compromise the security of the QKD link. Here we present a study of the deleterious effects of atmospheric turbulence on orbital angular momentum- based quantum key distribution protocols. We show that the impact of turbulence on the secret key rate can be mitigated by using spatial modes with high orbital angular momentum content. We attribute the resilience of high OAM states (labelled with l) to the separation in OAM space; the further apart the modes are, i.e., the higher $\Delta l\hbar$, the lower the overlap for given turbulence conditions. Consequently, the range of real-world quantum communication link that employ spatial modes can be significantly extended without compromise on security.

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