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Quantum transport with vector beams

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Abstract content
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Using spatial modes of light is poised to be the next step in free-space bandwidth increase in point-to-point optical communication. Light carrying orbital angular momentum (OAM) is being extensively studied for this very purpose as it provides an additional degree of freedom that spans a discrete and infinite dimensional Hilbert space. As such, it would allow an infinite amount of information to be encoded on a photon. The propagation of spatial modes of light is however hindered by atmospheric turbulence which introduces random intermodal coupling, thereby affecting the fidelity of the detected signals. Here we propose a scheme in which vector vortex modes would be for communication instead of OAM modes. In vector vortex modes, the polarization and spatial degree of freedom are non-separable – a fundamental property of quantum entangled states. As the atmosphere is non-birefringent the polarization degree of freedom remains unaffected during propagation. We built an optical setup to generate and detect vector vortex modes using a q-plate. We simulate the atmospheric turbulence with the help of phase plate based on Kolmogorov's theory of turbulence. We determined the intermodal coupling between four nearly degenerate vector modes as well as the energy transfer to higher order spatial modes as result of the turbulence plate. By evaluating the non-separability of the vector modes through a measurement of the concurrence, we showed that the polarization enhances the resilience of OAM modes to atmospheric turbulence.

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