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Characterising laser beams through tubulence using vector beams and a simple quantum trick

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Structure light beams that are tailored in the polarisation and transverse spatial degrees of freedom are ubiquitous to numerous applications and emerging technologies ranging from laser cutting, particle tracking, to high dimensional classical and quantum secure communication. Imperfections in optical elements or perturbations in a propagation medium can degrade the quality of spatial modes therefore limiting the performance of structure light beams in practical applications. For vector beams, where the spatial and polarisation components are coupled in a nonseparable way, spatially dependent perturbations can also indirectly distort the polarisation vector fields. Remarkably, vector beams possess intriguing features such as the ability to behave like quantum entangled particles, where the nonseparable correlations exist between the internal degrees of freedom (polarisation and spatial). Here we show that vector beams can be used to characterise the nonseparability, or equivalently entanglement, between the spatial and polarisation components of modes within the same subspace. By exploiting the parallelism between nonseparability in vector beams and quantum entanglement, we invoke a unique feature inherent to entangled states, namely channel state duality, to map the nonseparability of any spatial mode using a single vector beam. We demonstrate this principle through turbulence and apply it to different mode sets. This method advances the use of nonseparable states of light for the analysis of spatial mode decay through an optical medium.

Apply to be considered for a student ; award (Yes / No)?

Yes

Level for award;(Hons, MSc, PhD, N/A)?

PhD

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