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Revealing the unseen with tailored quantum light

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Quantum ghost imaging offers an interesting approach to imaging, harnessing entangled photon pairs to capture images using photons that never directly interact with the object. Traditionally, this technique relies on costly single-photon cameras or pixelated projective masks, where image resolution is fundamentally limited by the pixel size of the detectors or masks. We propose a shift from pixel-based reconstruction to modal-based reconstruction. Unlike conventional pixels, the resolution in this modal framework is no longer dictated by detector limitations but instead by the inherent optical resolution of the system. This means that basis elements can be generated with exceptionally high fidelity, as they are computed externally rather than being constrained by hardware. By capitalising on the unique properties of tailored light modes, we achieve sharper, more accurate image reconstruction while leveraging modal sparsity to further enhance fidelity. Remarkably, even when the chosen mode set is not strictly orthogonal, effective reconstruction remains possible. We illustrate this using phase-only approximations of the Hermite-Gauss (HG) modes, sidestepping the efficiency losses associated with full complex amplitude modulation. By harnessing modal sparsity, we significantly reduce the number of required measurements, allowing fast image convergence even with a non-orthogonal reconstruction set. The result? High-resolution, high-fidelity quantum ghost imaging of complex objects, achieved faster and with fewer measurements, paving the way for breakthroughs in low-light biological imaging.

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