Estimation of multiple parameters encoded in the modal structure of light

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Quantum optical metrology aims at identifying the ultimate sensitivity bounds for the estimation of parameters encoded into an optical field. In many practical applications, such as imaging, microscopy, and remote sensing, the parameter of interest is encoded not only in the quantum state of the field but also in its spatio-temporal distribution, i.e., in its modal structure. In this context, we propose both a theoretical framework and an experimental approach to derive bounds and perform measurements that are quantum-optimal, either in the single or in the multi parameter settings.

We illustrate this with the example of two incoherent sources, in a three parameters scenario, separation, centroid and relative intensity. We perform multi-parameter estimation using a spatial mode demultiplexing technique. We determine separations well below the diffraction limit and achieve sensitive joint estimation of separation, centroid, and relative brightness over a broad range of scene configurations, in a single experimental setting. We further compare different estimators, in particular using an approach based on relative belief ratios.

References

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