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Joint estimation of phase and phase diffusion for quantum metrology MIHAI VIDRIGHIN, Imperial College London, GAIA DONATI, MARCO GENONI, XIAN-MIN JIN, STEVEN KOLTHAMMER, MYUNGSHIK KIM, ANIMESH DATTA, MARCO BARBIERI, IAN WALMSLEY, Oxford University —
Phase estimation, at the heart of many quantum metrology and communication schemes, is affected by noise. We have investigated joint estimation of a phase and the amplitude of phase diffusion. The motivation is that the two parameters are not independent, phase estimation depending on calibration of the diffusion amplitude, which may drift in experiments. Also, joint estimation could provide an advantage in estimating the two parameters. For several instances, describing relevant probe states–split single-photons, coherent states or N00N states, we found that the multi-parameter estimation problem can be modelled in a two-dimensional Hilbert space. For these cases, we obtained a trade-off bound on statistical variances of the phase and diffusion amplitude. We found an optimum measurement scheme for states with fixed photon numbers, which has some useful properties; it is robust to calibration imperfections and does not need adaptive phase control. We also used our bound to quantify the effectiveness of an experimental set-up for joint estimation in classical light polarimetry. By numerical searches, we found that joint measurements on subsequent probes can improve joint estimation and we found indications that our bound holds for general states at small diffusion amplitudes.

Mihai Vidrighin
Imperial College London

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