Noisy quantum metrology

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Quantum sensor need being able to operate in uncontrolled, if not hostile, conditions. The presence of noise, then, must be cleverly taken into account. Here we discuss some recent investigations on the operation of some quantum metrology protocols in the presence of noise: pros and cons of each one will be illustrated, with a specific attention to those that include noise figures in a multiparameter estimation strategy.

Identifying the properties a system with high precision is the primary goal of sensing: understanding what are the ultimate limits on what is achievable with given resources is the main issue in quantum metrology [1]. In this respect, phase estimation is by far the most investigated example, due to its relevance for practical applications. Choosing the optimal quantum state of the light probe can result in increased sensitivity with respect to what can be accomplished with purely classical means. However, the price to pay is a frailty of such resource states against any ungoverned and unwanted couplings with the external world.

Quantum metrology in the presence of noise requires clever arrangements to restore possible advantages from the use of quantum resources. In any case, a thorough characterization of the actual noise is necessary to implement these strategies, and such characterisation might not be accessible as a pre-calibration, as, for instance, in time-varying cases. It is then important to design parameter estimation protocols that treat both unitary parameters, such as phases, and dissipative parameters, including loss or phase diffusion, with equal importance. Multiparameter estimation has been intensively studied over the last years, showing how a trade-off in the precision on individual parameters comes out in many practical instances. In addition, a multiparameter approach may also result in increased robustness in against small deviations of the designed probes from the optimal states [2].

In this talk we will discuss some recent results on quantum metrology in the presence of noise. We will start by discussing an experiment on the usefulness of ancilla-assisted protocols to mitigate the impact of some models of noise on phase estimation with qubits [3]. We will then proceed to present results on the application of entangling operations for the joint estimation of phase and phase diffusion with two qubits [4]. We will conclude with an estimation experiment in which the multiparameter approach is applited to obtaining a phase shift and, at the same time, a quantification of the quality of the probe that actually employed [5] (Fig. 1).

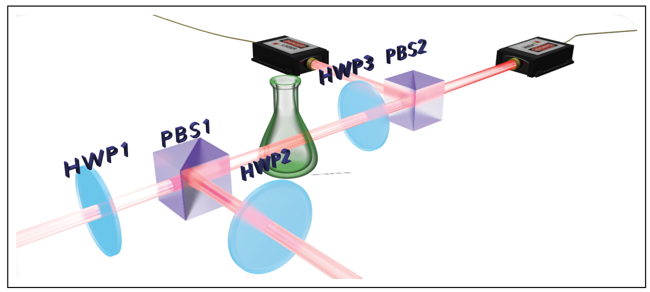

FIG. 1. Experimental set-up: each the two photons of the pair generated via SPDC passes through an half wave plate (HWP1 at 0° and HWP2 at 45°) before being combined on a polarized beam splitter (PBS1). These photons are used to monitor the optical activity of a chiral solution. A wave plate (HWP3) and a second polarizer (PBS2) project the photons onto different polarizations.

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