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Precision metrology using weak measurement

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Abstract

We discuss the performance of weak measurement in precision metrology and demonstrate its advantage in practical applications with two examples.

Weak measurement can dramatically amplify a small effect [1], therefore has received increasing interest in metrology. Yet the amplification effect of weak measurement comes at the cost of a reduction in the rate at which data can be acquired, due to the requirement to select almost orthogonal pre- and post-selected states. Therefore whether weak measurement can really enhance the measurement precision or even beat the classical limit has been under debate for long time [2]. Here we investigate two precision metrology schemes using weak measurement. The first one can be viewed as a weak measurement in the phase space. By coupling a single photon with an intense coherent beam, we demonstrate a measurement precision at the Heisenberg limit with the proper pre- and post-selection on the superposition state of the single photon [3]. For the second scheme we study the performance of weak measurement in tracking light beam displacements with a scientific CCD. We show that, with the presence of classical noise and detector saturation that are ubiquitous in CCD arrays [4], weak measurement outperforms conventional measurement in terms of measurement precision. Our results foreshadow the applications of weak measurement in quantum-enhanced metrology.

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