Quantum trajectories without quantum uncertainties.

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Quantum mechanics dictates that a continuous measurement of the position of an object imposes a random quantum back action (QBA) perturbation on its momentum. This randomness translates with time into position uncertainty, thus leading to the well known uncertainty on the measurement of motion. As a consequence, and in accordance with the Heisenberg uncertainty principle, the QBA puts a limitation—the so-called standard quantum limit—on the precision of sensing of position, velocity and acceleration. In this talk I will present the ideas [1] and experimental results [2] for measurement of motion of a mechanical oscillator with the precision not restricted by the QBA. This is achieved by measuring the motion in a special reference frame linked to an atomic spin system with an effective negative mass. Applications to force sensing and gravitational wave interferometry will be discussed.

[1] E.S. Polzik and K.Hammerer. Annalen der Physik. 527, No. 1–2, A15–A20 (2015). K. Hammerer et al, PRL. 102, 020501 (2009).
[2] C. Møller et al. Nature, 547, 191 (2017).