Quantum non-Gaussian motion of atoms: fundamental test & force sensing

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The talk will report recent theoretical and experimental achievements opening the door to highly non-Gaussian quantum mechanics of single atoms. This territory is challenging for investigation, both theoretically and experimentally. We will briefly present recent theoretical and laboratory activities, mainly the experimental tests of the faithful hierarchy of quantum non-Gaussianity beyond limits of optical methods [1,2], for multiphonon states of a single atom and their sensing capabilities [2]. The talk will conclude with other related results and the following challenges in theory and experiments with atoms, mechanical oscillators and superconducting circuits to stimulate discussion and further development of this field.

References

[1] Lukáš Lachman, Ivo Straka, Josef Hloušek, Miroslav Ježek, and Radim Filip, Phys. Rev. Lett. 123, 043601 (2019)
[2] Lukáš Lachman and Radim Filip, Phys. Rev. Lett. 126, 213604 (2021)
[3] Lukáš Podhora, Lukáš Lachman, Tuan Pham, Adam Lešundák, Ondřej Čip, Lukáš Slodička, Radim Filip, Quantum -Gaussianity of multi-phonon states of a single atom, arXiv:2111.10129

Figures

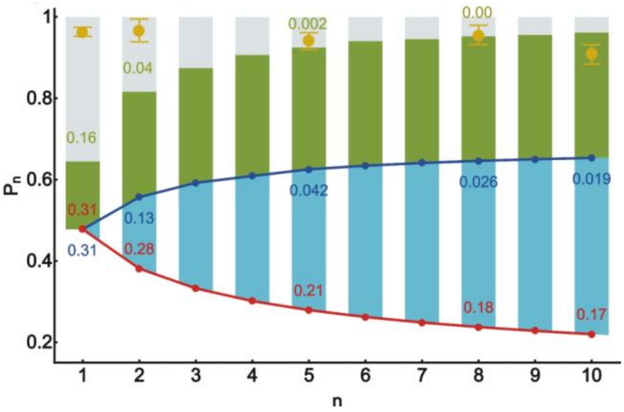

Figure 1: Experimental characterization of the Fock states of mechanical motion. The yellow points represent the measured populations Pn for experimentally generated states. Blue points represent the thresholds for a genuine n-phonon QNG. The associated blue numbers quantify the thermal depth of genuine n-phonon QNG - a maximal mean number of thermal phonons that keeps the measured states above the genuine n-phonon QNG thresholds. Similarly, the red points identify thresholds for observing the essential QNG aspects, and the associated red numbers determine their thermal depth. The green bars depict the force estimation capability of a specific model of noisy Fock states, where the probability P(n) exceeding the presented threshold values certifies a metrological advantage against the previous ideal Fock state in the force estimation. At the same time, the corresponding numbers quantify a thermal depth of this advantage for the measured states.