# Testing Generalised Uncertainty Principles through Quantum Noise and Trajectories

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According to quantum mechanics, the Heisenberg uncertainty principle restricts measuring both the position and momentum of a particle together with arbitrary precision (where precision is based on the spread of outcomes over many repeated measurements). It has been proposed that, in reality, a generalised uncertainty principle (GUP) holds that imposes a further restriction in the form of a minimal imprecision of position measurements. Such a *minimal length* is found in various quantum gravity theories [1]. GUP's can be derived from modifications of the canonical commutation relation, which may be probed experimentally e.g. [2].

We have investigated how a modified canonical commutator, which gives rise to a GUP, affects macroscopic oscillator motion in a noise bath environment that is typical of sensitive tabletop and interferometric experiments [3]. We find to first order the explicit modified noise spectrum associated with Brownian motion and quantum radiation pressure noise if the oscillator is driven by an optical source. This results in constraints on the GUP via the overall noise spectrum observed in advanced LIGO (aLIGO) and recent experiments that have reported observation of quantum radiation pressure noise on mechanical membranes. We find that current constraints from the spectra close to oscillator resonance frequency or at frequencies in a free-mass limit are comparable to the best available to date. These and related experimental scenarios are optimised to show that by adjusting optomechanical parameters by a few orders of magnitude or with additional external driving of the high quality-factor oscillator new bounds are feasible.

Furthermore, we have studied the trajectories of systems subject to general continuous quantum position measurements, not necessarily through optomechanical interactions, that are modified directly as a function of the canonical commutator [4]. The dynamics are analysed to show that there is a stark contrast in behaviour when the commutator is modified, in particular the exponential growth of the position and momentum covariance matrix moments. Numerical simulations via supercomputers demonstrate this behaviour and are used to assess the bounds achievable in practical experiments.

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