Constraining the Casimir-Polder force via the scanning angle method

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The Casimir–Polder (CP) force is a universal atom–surface interaction arising from quantum vacuum fluctuations. Dominant at the nanoscopic scale and inherently short-ranged, this interaction provides a sensitive probe of QED models of the quantum vacuum, while also offering a way to constrain possible non-Newtonian gravitational forces that could otherwise be screened by the CP interaction. Precision measurements therefore enable stringent tests of both QED and short-range gravity at these scales. In this work we employ atomic diffraction through a nanograting such that the CP contribution is contained in the diffraction pattern.

Currently, the precision of our measurements is limited by uncertainties in the exact geometry of the nanogratings. To overcome this, we have implemented an angular-scanning method of the nanograting that allows us to improve the knowledge of the grating geometry by combining geometric constraints from the scan with predictions from different CP models like the Multiple Scattering Expansion (MSE).

This improved knowledge of the grating geometry enables more precise measurements of the CP potential and opens the way to tests of short-range interaction models. In a preliminary study of non-Newtonian gravity, modeled by a Yukawa-type potential above an infinite surface, we showed that differential measurements of diffraction patterns obtained with two different nanogratings can exclude part of the Yukawa parameter space, thereby constraining hypothetical deviations from Newtonian gravity.

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