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Measuring Tidal Phases and Enhancing Precision with Squeezing Techniques

In this talk, I will explore advancements in light pulse atomic interferometry, focusing on novel geometries for measuring ‘tidal phases’ in long baseline atom interferometers (IF) and on the prospects and challenges for achieving enhancements using squeezed states of atoms. First, I will discuss an IF geometry which is exceptionally sensitive to tidal gravitational phases, based on a differential signal of a Mach-Zehnder and a co-located symmetric double-diffraction IF. This geometry holds promise for measuring gravity gradients and spacetime curvature with high-resolution, as will be illustrated in detail on the basis of the VLBAI facility in Hannover. Next, I will also discuss challenges in squeezing enhanced atom interferometry related to losses and inefficiencies in light pulse operations. Based on comprehensive modelling of squeezed states of atoms, accounting for finite momentum width, and realistic scattering matrices of IFs based on Bragg diffraction, we evaluate the expected sensitivity enhancement. Our analysis reveal optimal pulse parameters, demonstrating that proper pulse design is crucial for achieving optimal performance, especially when using entangled states. We identify that moderate squeezing levels, in the low dB range, are most effective for realistic Gaussian pulses and quantify the metrological gain.