Matter-Wave Interferometry for Quantum Sensing

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This work focuses on phenomena of light-matter interaction shaped by the presence of an optical ring cavity with applications in quantum sensing for gravimetry based on matter interferometry. Ultracold strontium atoms (in the order of 1 μK) within a ring cavity in the bad cavity regime constitute the experimental setup and two distinct approaches were adopted for the comprehension of the system's operation. The first involved simulations of Ramsey-Bordé pulse sequence, specifically the $\pi/2$-π-$\pi/2$-spin echo sequence using the 689 nm transition of strontium. The sequence is commonly employed in matter interferometers and the simulations provided insights for future measurements. The expected precision of our system is within $\Delta g/g < 10^{-8}$, showcasing its potential accuracy. The second approach focused on monitoring Bloch oscillations resulting from the interaction between atoms and cavity light, which induces a frequency proportional to the external force, in our case, gravity. Efforts were made during the experiment towards confirming the system's regime, leading to a significant observation of nonlinear Normal-mode splitting due to high saturation in the strong coupling regime, exhibiting a bistable behaviour.