Theory

The neutron in the gravity potential is described by the Schrödinger equation with a linear potential

\[ E_n \psi_n = \left( -\frac{\hbar^2}{2m_n} \frac{\partial^2}{\partial y^2} + m_g g z \right) \psi_n \]

with eigenenergies \( E_n \).

The solutions to this equation are the so-called Airy functions.

Driving transitions leads to a resonance in the transmission curve.

where the velocity spectrum used for the average was measured in 2019.

Abstract

The qBounce experiment investigates gravity at small distances. This is done using high precision frequency based spectroscopic methods. Ultracold neutrons (UCNs) form macroscopic bound states above a flat surface in the gravity potential of the Earth, connecting the quantum mechanical neutron wavefunction and gravity. Using this system we developed techniques for Gravity Resonance Spectroscopy (GRS) [1,2]. We realized a proof of principle with Ramsey’s method of separated oscillating fields with gravitationally bound UCNs [3]. This method can be used to probe any interaction that couples to the neutron and shifts the eigenenergies of the neutron. Previous iterations of the qBounce experiment implemented GRS in a Rabi configuration and set limits on chameleon dark energy, axion-like dark matter and symmetron dark energy scenarios [4].

The qBounce experiment is located at the UCN source PF2 at the Institut Laue-Langevin (ILL) in Grenoble. After achieving the proof of principle for Ramsey-GRS in 2018 and optimising experimental parameters during the first half of 2019, we are prepared to take data at a projected sensitivity of 5\( \times 10^{-16} \text{eV/day} \).

Acknowledgements

Der Wissenschaftsfond

ANR-20-344-007-02

DFG

Priority Programme (SPP) 1491

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