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Title:
*q*BOUNCE : Ramsey Spectroscopy Using Gravitationally Bound Quantum States Of Neutrons

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Abstract:
qBounce uses Ultra Cold Neutrons (UCNs) in a mechanical spectrometer using Ramseys method of separated oscillating fields to investigate gravity. The UCNs are trapped by gravity on the surface of mirrors leading to discrete quantum states. By oscillating the mirrors transitions between these states can be induced. Using this method, called Gravity Resonance Spectroscopy (GRS), measurements of the local acceleration for the bound neutron have been performed. This acceleration includes, in addition to gravity, all other interactions that influence the neutron inside the experiment. During this PhD the acceleration of the Earth was determined with the relative precision of $\delta g/g \approx 1 \cdot 10^{-5}$. The improvement from the previous best GRS measurement with the Rabi method gives $\sigma g_{\mathrm{Rabi}}/\sigma g_{\mathrm{Ramsey}} \approx 42$. For the transition $|1\rangle \rightarrow |6\rangle$ the absolute energy resolution of $\Delta E \approx 2.6 \times 10^{-16}\,\mathrm{eV}$ was measured with *q*BOUNCE with unprecedented precision. A measurement using a spin dependent detector could show that neutrons with the spin parallel and anti parallel to g have the same acceleration with a relative precision of $\delta g/g \approx 6.3 \cdot 10^{-4}$. An offset from the expected value of g determined by a falling corner cube measurement of $(g_{\mathrm{measured}} - g_{\mathrm{cornercube}})/\sigma = 7.43$ was found and an in depth analysis of systematic effects was performed, inlcuding numerical simulations. The neutron represents an almost ideal test mass, has no charge and a low polarizability when compared to also neutral atoms. This limits the influence of Van der Waals forces on the bound states. The experiment is located and has been performed at the PF2 beamline at the Institut Laue-Langevin in Grenoble and after 2018, where the first proof of principle of this Ramsey type GRS was published, this thesis was performed.