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qBounce: Ultra-cold neutrons bound by Earth's gravity field, a tabletop search for hypothetical gravity-like interactions

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Very slow, so-called ultra-cold neutrons form bound quantum states in the Earth's gravitational field. These neutrons allow the fascinating possibility to investigate gravity at short distances using a simple quantum system. A spectroscopy method for ultra-cold neutrons bound to the surface of mirrors allows to drive transitions between eigen-states of quantum gravitational states. This enables us to measure the transition frequencies with high accuracy. A deviation from the expected gravitational energy states might point to hypothetical gravity-like interactions. Here we present the qBounce experiment, where we implement Ramsey's method of separated oscillating fields by mechanically exciting the neutrons with oscillating mirrors, a method we call Gravity Resonance Spectroscopy (GRS). Multiple transitions have been observed by qBounce in the past. The results of Rabi's Method have been used to constrain chameleon and symmetron dark energy. After extending the experimental capabilities to two separated oscillating mirrors we have succeeded in determining the transition frequency with an energy resolution $\Delta E \approx 10^{-16}$ eV.

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