Gravity Resonance Spectroscopy with Ultracold Neutrons as a Tool to Test Dark Sector Models

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While being very successful, general relativity and the standard model of particle physics – presently forming the basis of our understanding of the universe – seem incomplete due to their incapability to adequately describe dark energy and dark matter. Slowly being accepted, this fact has fueled a surge in developments of possible modifications of these two theories. While astronomical observations provide us with tests at large scales, most alternative theories also predict deviations from Newton's law at small distances. Accordingly, numerous laboratory experiments have been devised to perform respective tests. In this respect, neutrons offer many advantages over other test bodies. With their vanishing electric charge and negligible polarizability, they evade many of the technical difficulties typically plaguing high precision measurements with atoms, molecules, or macroscopic objects. Over the past decade, the qBounce collaboration has developed gravity resonance spectroscopy (GRS) with ultracold neutrons as a tool to search for non-Newtonian forces on the micrometer scale. GRS relies on the quantum states of neutrons in the gravitational field of the Earth – thereby representing a purely quantum mechanical test of gravity with no classical elements. Using this technique, we were able to set tight limits on several candidate models aiming to explain dark sector effects. In the present talk, we give an overview of the development of GRS up to the recently achieved realization of Ramsey-type GRS that will allow us to search for non-Newtonian forces with the hightest sensitivity to date.