Gravity Resonance Spectroscopy

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We present a resonant spectroscopy technique that induces transitions between the quantum states of a reflected neutron in the Earth's gravitational field. This technique has applications ranging from studying gravitation and related cosmological problems, such as dark matter and dark energy, to developing quantum computers. The object of study is a quantum mechanical wave packet of an ultra-cold neutron. The new method extends Purcell, Rabi, and Ramsey techniques to neutron quantum states in the Earth's gravitational field. This technique is called Gravity Resonance Spectroscopy (GRS), similar to Magnetic Resonance Spectroscopy (MRS). In this technique, a neutron is placed on a reflecting mirror in the Earth's gravitational potential, and transitions between gravitational quantum states are induced by applying mechanical oscillations to the mirror at the proper transition frequency. In the MRS technique, an atom, molecule, or nucleus with a magnetic moment is placed in an outer magnetic field, and transitions between magnetic Zeeman splittings are induced by applying proper radiofrequency oscillations. We observe resonant transitions between several of the lowest quantum states for the first time. GRS's strength lies in its independence from electromagnetic interactions. Using neutrons as test particles bypasses the electromagnetic background induced by van der Waals forces and other polarizability effects, providing a sensitivity several orders of magnitude higher than that of atoms.