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Towards the first demonstration of gravitational quantum states of atoms with a cryogenic hydrogen beam

At very low energies, an atom above a horizontal surface can experience quantum reflection due to the attractive Casimir-Polder potential. The quantum reflection holds the atom against gravity and leads to gravitational quantum states (GQS), in analogy to what has been observed with ultracold neutrons [1]. The GRASIAN-collaboration pursues the first measurement of GQS of atomic hydrogen. For this purpose, an experiment has been designed and set up at ETH Zurich. In the past year, a cryogenic hydrogen-beam and a pulsed ultraviolet laser detection system were installed and characterized. The interaction region, where the actual GQS-measurement will be performed, is currently being installed.
The use of hydrogen is not only motivated by the fact, that GQS have never been observed with atoms. The enhanced statistics available through the use of hydrogen atoms (versus ultracold neutrons) will increase the sensitivity to deviations from Newtonian Gravity. For instance, short-range forces predicted in extensions of the Standard Model would alter the GQS, and would hence be detectable by a high-precision GQS-measurement. Additionally, the measurement of GQS of hydrogen will serve as a benchmark demonstration for the measurement of gravitational properties of Antihydrogen. Furthermore, the extremely low velocities of atoms in GQS also promise improved accuracies in precision laser and microwave spectroscopy.

[1] V.V. Nesvizhevsky, H.G. Börner, Alexander Petukhov, Hartmut Abele, Stefan Baessler, Frank Ruess, Thilo Stöferle, Alexander Westphal, A. Gagarski, Gennady Petrov, and A. Strelkov. Quantum states of neutrons in the earth's gravitational field. Nature, 415:297–9, 02 2002.

Scientific topic

Fundamental interactions

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