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GRASIAN: Shaping and characterization of the cold hydrogen beam for the forthcoming first demonstration of gravitational quantum states of atoms

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A low energy particle confined by a horizontal reflective surface and gravity settles in gravitationally bound quantum states. These gravitational quantum states (GQS) were so far only observed with neutrons [1,2]. However, the existence of GQS is predicted also for atoms.
The GRASIAN collaboration pursues the first observation of GQS of atoms, using a cryogenic hydrogen beam. This endeavor is motivated by the higher densities, which can be expected from hydrogen compared to neutrons, the easier access, the fact, that GQS were never observed with atoms and the accessibility to hypothetical short range interactions [3]. In addition to enabling gravitational quantum spectroscopy, such a cryogenic hydrogen beam with very low vertical velocity components - a few cm/s, can be used for precision optical and microwave spectroscopy. We report on our methods developed to reduce background and to detect atoms with a low horizontal velocity, which are needed for such an experiment. Our recent measurement results on the reduction of background and improvement of signal-to-noise and finally our first detection of atoms with velocities < 72 m/s are presented. Furthermore, we show simulations which confirm that we can select vertical velocity components in the order of cm/s.

[1] V.V. Nesvizhevsky et al. Quantum states of neutrons in the earth's gravitational field. Nature, 415:297–9, 02 2002.
[2] T. Jenke et al. Q-BOUNCE—Experiments with quantum bouncing ultracold neutrons. Nuclear Instruments and Methods in Physics Research A 8 (2009), pp. 318–321.
[3] I. Antoniadis et al., Short-range fundamental forces. Compt. Rend. Phys. 12, 755 (2011).

Author: KILLIAN, Carina (Austrian Academy of Sciences (AT))

Presenter: KILLIAN, Carina (Austrian Academy of Sciences (AT))

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