Lab-based Einstein elevator for matter-wave interferometry with ultra-cold atoms

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High-sensitivity tests of fundamental physic using matter-wave interferometry are beginning to reach their limit in ground-based experiments due to the size constraints imposed by Earth's gravity [1]. To circumvent these limitations, a few groups have begun to carry out experiments in microgravity (e.g. in a drop tower [2], a Zero-G plane [3], or sound rocket [4]) in preparation for Space missions, where the full potential of cold-atom-based sensors can be utilized [5]. However, access to these low-gravity environments has so far been very costly in terms of both time and money. In order to perform high-sensitivity atom interferometry experiments in microgravity at an increased repetition rate, we have recently installed a dipole trap for the evaporation of atoms and a 0g simulator in our laboratory. With this new setup we can produce ultra-cold atoms clouds of about 10^4 atoms and perform experiment during up to 500 ms of weightlessness every 12 s. These new elements will be the cornerstones for a new test of the equivalence principle using long baseline interferometry with ^{39}K and ^{87}Rb, and will also open new doors for lab-based tests in microgravity.

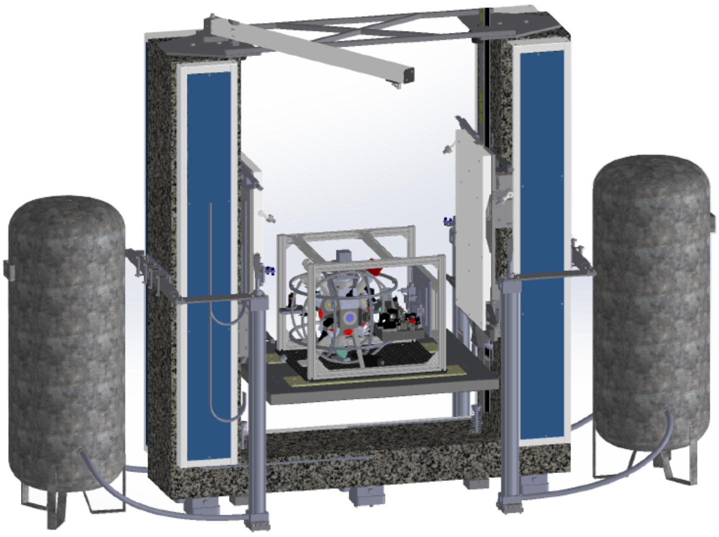

Figure 1: The science chamber situated on the Einstein elevator, which carries out a pre-programmed parabolic trajectory that yields up to 500 ms of weightlessness every 12 s. The platform and payload are guided by two vertically-mounted position-locked air skates, which produce low-friction motion with an excellent acceleration repeatability of 1 mg.

[1] C. Overstreet et al., PRL, 120, 183604 (2017)
[2] H. Müntinga et al., PRL, 110, 093602 (2013)
[3]B. Barrett et al., Nat Comm, 7, 13786 (2016)
[4] D. Becker et al., arXiv arXiv:1806.06679 (2018)
[5] D. Aguilera et al., Class. Quant. Grav. 31, 115010 (2014)