An ultra-cold atomic source on a microgravity simulator for atom interferometry

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The ICE experiment aims to make a high-precision test of the weak equivalence principle (WEP), which postulates that the acceleration of a body in free fall with a gravitational field is independent of its internal structure and composition. To accomplish this, we use a dual-species atom interferometer composed of ^{87}Rb and ^{39}K [1]. These two species differ in mass by more than a factor two, increasing the sensitivity to possible WEP violations, and they also exhibit convenient transition wavelengths (780 and 767 nm, respectively). Since the best sensitivity achievable on Earth is limited by the free-fall time of the atoms, the full potential of atomic inertial sensors can only be realized in a microgravity environment, where large interrogation times can be achieved with ultra-cold samples. Toward this end, we recently obtained a Bose-Einstein condensate of 2×10^4 ^{87}Rb atoms using an all-optical cooling stage with spatially-modulated dipole beams [2]. We have also installed our experiment on a pneumatically-controlled zero-g simulator, that carries out a pre-programmed vertical parabolic trajectory. This Einstein elevator can produce up to 500 ms of free fall in microgravity with an acceleration repeatability of less than 10 mg. We present recent experimental results with our ultra-cold source, both on ground and on the simulator, where we achieve temperatures of 50 nK in microgravity every 15 s. These two advances will allow us to perform ultra-sensitive WEP tests at long interrogation times in the near future.

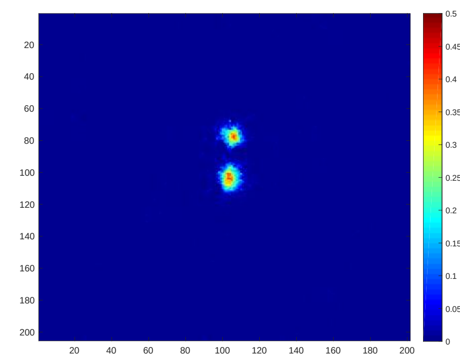

Figure 1: Diffracted ultra-cold atomic clouds after a 40 μs Raman pulse and a free expansion time of 10 ms in 1g.

Keywords: Equivalence principle, atom interferometry, BEC, microgravity

References

[1] B. Barrett et al, Nat. Commun. **7**, 13786 (2016)

[2] R. Roy et al, Phys. Rev. A **93**, 043403 (2016)