Painted potentials for ultracold atom interferometry in microgravity

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The **ICE** experiment (Interférométrie à source Cohérente pour l'Espace) is a **matter-wave atom interferometer** employing two atomic species, ^{87}Rb and ^{39}K, enabling studies of atomic mixtures and tests of the Weak Equivalence Principle (WEP). It was conceived as a **testbed for future space missions** in fundamental physics, geodesy, and navigation.

ICE employs an **all-optical dipole trap** to confine the atoms, unlike many microgravity experiments based on atom chips. This approach avoids magnetic-field inhomogeneities near surfaces, enables interaction control via Feshbach resonances, improves optical access for interferometry, and facilitates spatial overlap of the two species required for WEP tests [1]. The sensor head is mounted on an Einstein elevator (**microgravity simulator**) which allows to overcome the limitation on interrogation time typically set by free-fall in atomic fountains. The simulator provides **500 ms of weightlessness every 13.5 s**, enabling interrogation times up to 200 ms which enhances the interferometer sensitivity [2]. The setup also enables the production of **ultracold atom sources** during the microgravity phase, including a **Bose-Einstein Condensate (BEC)** of ^{87}Rb, which can further improve the sensitivity of the measurement [3].

In the near future, a **three-dimensional painted potential** will be tested for the rubidium source with the goal of collimating the cloud and applying tailored potentials, enabling the study of different cloud geometries.

[1] J. Le Mener *et al.*, *arXiv* 2602.16645 (2026).
[2] C. Pelluet *et al.*, *Nat. Commun.* **16**, 4812 (2025).
[3] G. Condon *et al.*, *Phys. Rev. Lett.* **123**, 240402 (2019).

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