Quantum degenerate mixtures for precision atom interferometry

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Abstract

The precision of atom interferometry-based sensors makes them an exquisite tool for performing tests of fundamental theories [1, 2, 3] as well as for metrology, geodesy or inertial navigation. Two examples of timely challenges are a precision test of the weak equivalence principle (WEP) and the detection of gravitational waves.

The sensitivity of an atomic inertial sensor scales quadratically with the time spent by the atoms inside the interferometer and motivates the drive for long free expansions. Several platforms are therefore considered for such an increase, such as drop-towers, fountains, parabolic flights and spacecrafts.

Recently, atom interferometers (AI) fed with single-species Bose-Einstein condensates (BEC) were operated in these long-time regimes [4, 5] by taking advantage of the delta-kick cooling (DKC) technique. These demonstrations point towards a high-accuracy WEP test when combined with a second species in a differential atom interferometry measurement. The source of such an interferometer would naturally be a binary atomic mixture. Although quantum mixtures of ultracold gases received a surge of theoretical and experimental interest, their description as the source of a precision AI have not been considered to our knowledge.

In this talk, we investigate the possible experimental means towards a control over the size by a common collimation of two degenerate species with DKC. Moreover, we analyse the different effects of the interactions in a high-resolution AI and the leading systematics. To illustrate our theoretical treatment, we consider the case of three mixtures of ^{85}Rb/^{87}Rb, ^{39}K/^{87}Rb and ^{41}K/^{87}Rb widely used in atom interferometry measurements.

Keywords: BOSE-EINSTEIN CONDENSATES, QUANTUM MIXTURES, ATOM INTERFEROMETRY, HIGH PRECISION MEASUREMENTS, EQUIVALENCE PRINCIPLE

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