Large-momentum-transfer Bragg interferometer with Strontium atoms

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We report on the first atom interferometer with alkaline-earth atoms based on large-momentum-transfer (LMT) Bragg diffraction in a fountain. Alkaline-earth atoms have properties such as zero total spin in the ground state, narrow optical transitions, and low scattering cross section at ultra-low temperatures which promise unprecedented precision.

The atom we used for the interferometer is ^{88}Sr. The LMT up to 40 $\hbar k$ is realized with composite pulses of two Bragg laser beams detuned about 8 GHz from the $^1S_0 -^1 P_1$ transition of Strontium at 460.862nm (here k is the wave vector of the Bragg laser beams). Typical interferometers are formed with two momentum states separated by 2 $\hbar k$ to 6 $\hbar k$ (1^{st} to 3^{rd} order Bragg diffraction). We have studied the performance of a gravity acceleration measurement with this interferometer, which are shown in Figure 1. A sensitivity of $4 \times 10^{-8} g$ is achieved at 2000 s of averaging. The dominant noise of the system now is the vibration on the retro-reflection mirror for Bragg beams.

This result opens the way to new experiments based on alkaline-earth atoms, for example the of Einstein Equivalence Principle (EEP) test using two kind of atoms such as one alkali atoms and one alkali-earth atoms[1,2], or a combination of a interferometer and Bloch oscillation in a optical lattice[3] to make use of the advantage of low scattering rate for Strontium atoms.

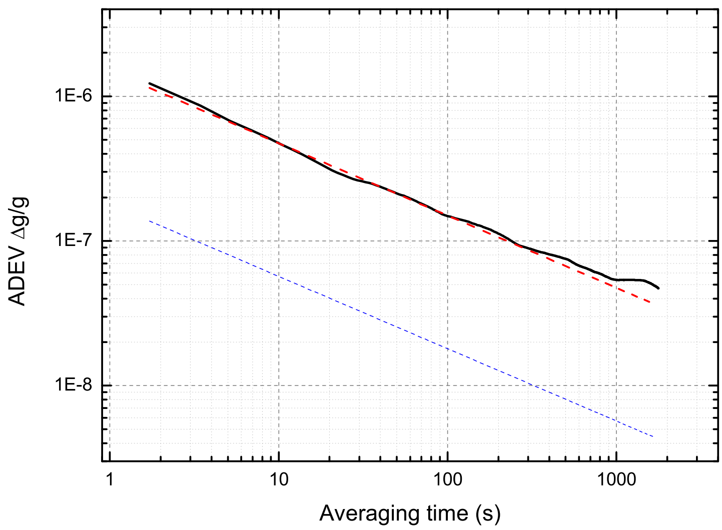

Figure 1: *Allan deviation of the gravity acceleration measurement for a 1^{st} order Bragg interferometer with an interrogation time $T = 30$ ms (black straight line). Estimation of the residual acceleration noise of the retro-reflection mirror (dashed red line), and of the optical phase noise of Bragg beams (dash blue line).*

References

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