A force sensor for local measurements based on trapped atom interferometry

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We report on the recent progress on an experiment which aims at measuring short range forces with a high sensitivity force sensor based on trapped atom interferometry. In our setup, $^{87}\text{Rb}$ cold atoms are trapped in a vertical optical lattice. For shallow lattice depths, stimulated Raman transitions can be used to induce coherent transport between adjacent Wannier-Stark states [1], allowing us to perform atom interferometry to measure with a very high sensitivity the Bloch frequency [2, 3].

The spatial resolution of the sensor was recently improved to a few microns by cooling the atomic sample down to ultracold temperatures by evaporative cooling in a crossed dipole trap. Using now a much denser atomic sample, we have to face effects arising from atomic interactions [4], which reduce the coherence time of the interferometer, when based on spatially separated atomic wavepackets. We show how to mitigate these effects in order to preserve the sensitivity of the sensor. We have demonstrated a state-of-the-art relative sensitivity on the Bloch frequency of $8.10^{-8}$ after one hour of integration, which corresponds to an uncertainty in the energy difference between adjacent wells of 45 µHz only.

By realizing the experiment close to the surface of a mirror, such a sensitivity will allow to measure the Casimir-Polder force at distances of order of a few µm with a relative uncertainty better than 0.1%.

References