A trapped atom interferometer for the measurement of short range forces

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I will present the status of an experiment which aims at performing precise measurements of the interaction forces between an atom and a macroscopic surface, from 0.3 µm to 10 µm, where QED effects are predominant (Casimir-Polder force mainly) [1].
In our experimental apparatus, ^{87}Rb atoms are trapped in a bichromatic optical trap: a vertical blue detuned 1D-optical lattice at 532 nm and a superimposed red detuned fiber laser at 1064 nm for transverse confinement. Stimulated Raman transitions are used to induce tunnelling between adjacent wells [2], allowing to perform spectroscopy of Wannier-Stark states [3] or to create thanks to a sequence of such interrogation pulses different kinds of interferometers (a Ramsey-type interferometer fringe pattern is displayed in Figure 1) [4].

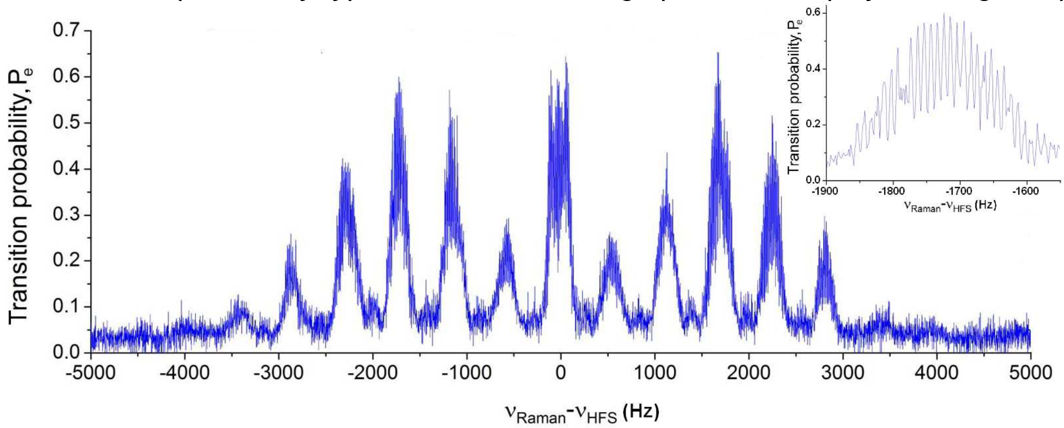

Figure 1 – Ramsey-Raman fringes showing evidence of induced tunneling between up to six neighboring lattice sites, where Rabi envelopes of each transition contain interference fringes (as shown in the inset)

In a first demonstration of principle, our experiment was performed far from the surface of interest, which is set by the retroreflecting mirror of the 1D-standing wave. In that configuration, our interferometer is only sensitive to differences in gravitational energies. We have studied the limitations to the sensitivity in the measurement of gravity, as well as the main systematic effects and have reached a relative sensitivity of $\delta g/g = 1.0 \times 10^{-5}$ at 1 s. This result would lead to a statistical uncertainty in the measurement of the Casimir-Polder potential of 1% for a distance of 5 µm and an integrating time of 30 s.
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