Competition between spin-echo and spin self-rephasing mechanisms in a trapped atom interferometer

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In our experiment, we realize a trapped atom interferometer of ^{87}Rb in a vertical optical lattice. For shallow depths of lattice, stimulated Raman transitions can be used to induce coherent transport between adjacent Wannier-Stark states, allowing us to perform atom interferometry and to measure with very high accuracy the Bloch frequency (figure 1 - left). A careful control of the trapping potential and a symmetrized interferometer configuration lead to a force sensor with a state-of-the-art relative sensitivity on the Bloch frequency of 1.8 10^{-6} at 1 s [1, 2].

An optical dipolar trap has recently been installed to perform evaporative cooling in order to increase the number of atoms per well. Working with much denser and smaller clouds allowed to reduce the coupling and phase inhomogeneities. At densities of a few 10^{12} atoms/cm^3, we observe unexpected behaviour of the contrast, when applying a π-pulse to symmetrize the interferometer (figure 1 - right). These results are due to a competition between the spin-echo technique and a spin self-rephasing (SSR) mechanism based on identical spin rotation effect (ISRE). Originating from particle indistinguishability, SSR has been observed in trapped atomic clocks, where it can enhance the clock's coherence up to several tens of seconds [3]. We propose a model that reproduces well our experimental data and offers a clear insight into this mechanism.

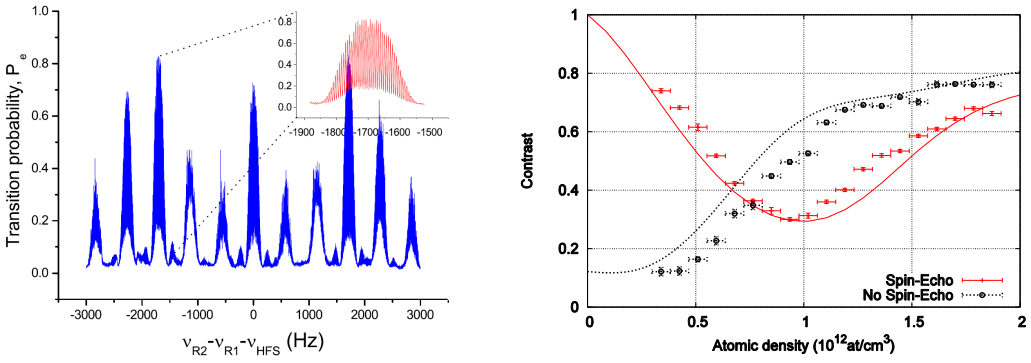

Figure 1: Left : Ramsey-Raman fringes for a lattice depth $U_l = 3.9\,E_r$ showing evidence of transitions between up to five neighboring lattice sites. - Right : Ramsey fringes contrast with (red dots) and without (black circles) spin-echo technique as a function of atomic density. Solid red (dotted black) lines are simulations from our model of the Ramsey contrast with (without) spin-echo.

References

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