BOSE-EINSTEIN CONDENSATES IN TIME-DEPENDENT OPTICAL LATTICE

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I will present a few experiments performed with rubidium-87 Bose-Einstein condensates in optical lattices. Our setup provides the possibility to change rapidly both the phase and the amplitude of the optical lattice. We have used these possibilities (i) to study the traversal time of a wavepacket through the tunnel barriers of the optical lattice, (ii) to realize micron-size Mach-Zehnder interferometers and (iii) to investigate the dynamics of condensate in phase modulated lattices in various regimes.

1. TUNNEL TRAVERSAL TIME [1]

We will report on the measurement of the time required for a wave packet to tunnel through the potential barriers of an optical lattice. The experiment is carried out by loading adiabatically a Bose-Einstein condensate into a 1D optical lattice. A sudden displacement of the lattice by a few tens of nm excites the micromotion of the dipole mode. We then directly observe in momentum space the splitting of the wave packet at the turning points of the oscillatory motion. In contrast with the methods explored in other fields to deduce the tunnel traversal time, we choose parameters so that roughly half the wave packet tunnels through the barrier. Using both the quasi-isochronism of oscillations in the lattice and the packet that has not tunneled as a reference, we infer precisely the duration of the tunneling process and measure the delay between the reflected and the tunneled packets for various initial displacements. The tunnel barriers act therefore as beam splitters. Using such atomic beam splitter twice, we realize a chain of coherent micron-size Mach-Zehnder interferometers at the exit of which we get essentially a wave packet with a negative momentum, a result opposite to the prediction of classical physics.

2. PHASE MODULATED OPTICAL LATTICES

The dynamics of Bose-Einstein condensates in phase modulated optical lattices is very rich. One can distinguish different regimes depending on the relative time scales of the frequency of modulation and that of the tunneling rate. For large modulation frequency, the periodic potential has its strength simply renormalized. We demonstrate how this feature can be used to tune the lattice properties in a very controlled manner. In the opposite limit, the physics is dominated by the tunneling rate renormalization and the emergence of a phase order in space for which the neighbouring wells have opposite phases. I will present our results in these different regimes.

1. A. Fortun, C. Cabrera-Gutiérrez, G. Condon, E. Michon, J. Billy and D. Guéry-Odelin ArXiv: 1603.03655v1 [quant-ph]