

Controlled dynamics of matter waves in two-dimensional optical lattices

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Abstract:

Controlled manipulation of spatially localized collective excitations of ultracold atomic gases is an attractive idea from the point of view of the developing atomic interferometry and precise measurement techniques based on the use of the Bose-Einstein condensates (BECs). In the recent years optical lattices were suggested as a means of achieving controlled transport of matter waves. In particular, theoretical studies of nonlinearly localized matter-wave solitons, loaded into a rapidly driven one-dimensional asymmetric optical lattice potential, have demonstrated that such an "optical ratchet" supports dynamically stable solitons and enables their mass-dependent transport [1,2].

Transport of matter-wave solitons in two- and three-dimensional trapping geometries is a more complex and challenging task, especially considering the intrinsic instability of the condensate with the negative scattering length and the fact that an optical lattice potential may greatly inhibit the mobility of the localized states. The main challenge is to suggest an efficient method for non-destructive, dynamically controlled transport of the stabilized wavepackets.

In this talk we will review the main features of the nonlinear matter-wave dynamics in a driven potential and present the theory of controlled transport of two-dimensional matter-wave solitons created in a BEC with a negative scattering length. The transport is realized by means of a driven "rocking" two-dimensional optical lattice [3]. Our numerical analysis, based on the mean-field model, and the theory based on the time-averaging approach, demonstrates that a fast time-periodic rocking of the 2D optical lattice enables efficient stabilization, manipulation, and "routing" of nonlinear localized matter wavepackets.

References:

1. D. Poletti et al., Phys. Rev. Lett. 101, 150403 (2008).
2. D. Poletti et al., Physica D 238, 1338 (2009).
3. V.V. Ivanov et al., Phys. Rev. Lett. 100, 043602 (2008).