Dynamics of Phase-Imprinted Solitons of Ultracold Bosons in an Optical Lattice

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We study the propagation of phase-imprinted solitons of ultracold atoms in an optical lattice using the Bose-Hubbard (BH) model. In the uniform system, the previous work reported that the phase-imprinted soliton propagates in three different ways [1]. Our exhaustive calculations find another way of soliton propagation [2]. We uncover the dynamical phase diagram of these four types of phase-imprinted solitons, namely, in-phase soliton, out-of-phase soliton, wavelet, and hybrid soliton. In the presence of the additional harmonic trap potential, one can have the situation with the superfluid (SF) and Mott-insulator shell structures [3]. Considering the system that consists of the SF-MI-SF shell structure, we investigate the propagation of solitonic excitations created at the SF core. We show that all the four different types of solitons deform into the in-phase soliton before the excitation permeates into the Mott shell. We also demonstrate numerically that the out-of-phase soliton can be injected to the MI shell by additionally imposing the repulsive potential at the center of the trap, which can penetrate the outer SF shell. Finally, we show that each soliton has a characteristic feature in the momentum distribution, which can be observed using the time-of-flight experiment.

References

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