Interactions of Bright Matter-Wave Solitons with a Potential Defect

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Abstract:

Non-dispersive solitary waves (solitons) are ubiquitous in nature. Ultracold atomic systems allow us to study solitons and their interactions in a controlled environment. In our experiments [1, 2] we form bright matter-wave solitons in Bose-Einstein condensate of ^{7}Li atoms. We use the broad Feshbach resonance of ^{7}Li in the $|1,1\rangle$ state to tune the scattering length through zero to small negative values. When the interatomic interactions become attractive a bright soliton can form close to the critical number for collapse. We excite the collective dipole mode of the soliton in a weakly confining axial harmonic potential created by a single focused laser beam, and study its interaction with either a narrow repulsive barrier or an attractive well. Both the barrier and well are formed by a near-resonant, cylindrically focused laser beam that perpendicularly bisects the trapping beam at its focus. Through adjustment of the barrier potential height, the soliton can either be split in two, transmitted, or reflected. When the barrier produces splitting, the fragments will undergo a second interaction at the barrier thus realizing the ingredients of a Mach-Zender type interferometer. We have attempted to observe coherent recombination. A potential well is created by detuning the laser red of the atomic resonance, for which quantum reflection [3] can occur. Through varying the well depth, we investigate reflection, transmission and trapping in the well [4], in which the soliton may exhibit small-amplitude oscillations inside the well.

References:

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