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Perturbation Theory of Dark-Bright solitons in Bose-Einstein condensates

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Abstract

We develop a direct perturbation theory for a coupled dark-bright solitons and we derive the equation of motion for the soliton parameters. In this method, we solve the linearized wave equation around the solitons by expanding its solution into a set of complete eigenfunctions of the linearization operator. Suppression of secular growth in the linearized solution gives the evolution equations of soliton parameters. This method does not rely explicitly on the inverse scattering transform but its connection to the integrable theory is still visible since these eigenfunctions of the linearized equation are simply the squared eigenfunctions of the underlying scattering operator. Moreover, we study the stability of dark-bright solitons. Our analytical results for the small-amplitude oscillations of solitons is in good agreement with results obtained via a Bogoliubov-de Gennes analysis and compares very well with direct numerical computations.

Key words: Solitons, Near-Integrable PDEs, BEC