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Modulational instability and nano-scale energy localization in ferromagnetic spin chain with higher order dispersive interactions

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Abstract

The nonlinear localization phenomena in ferromagnetic spin lattices have attracted a steadily growing interest and their existence has been predicted in a wide range of physical settings. We investigate the onset of modulational instability of a plane wave in a discrete ferromagnetic spin chain with physically significant higher order dispersive octupole-dipole and dipole-dipole interactions. We derive the discrete nonlinear equation of motion with the aid of Holstein-Primakoff (H-P) transformation combined with Glauber's coherent state representation. We show that the discrete ferromagnetic spin dynamics is governed by an entirely new discrete NLS model with complex coefficients not reported so far. We report the study of modulational instability (MI) of the ferromagnetic chain with long range dispersive interactions both analytically in the frame work of linear stability analysis and numerically by means of molecular dynamics (MD) simulations. Our numerical simulations explore that the analytical predictions correctly describe the onset of instability. It is found that the presence of the various exchange and dispersive higher order interactions systematically favours the local gathering of excitations and thus supports the growth of high amplitude, long-lived discrete breather (DB) excitations. We analytically compute the strongly localized odd and even modes. Further, we employ the Jacobi elliptic function method to solve the nonlinear evolution equation and an exact propagating bubble-soliton solution is explored.

Keywords: Ferromagnet, Modulational instability, Discrete breather, Molecular dynamics simulations.

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