Solitons in combined linear and nonlinear lattice potentials

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We study ordinary solitons and gap solitons (GSs) in the effectively one-dimensional Gross-Pitaevskii equation, with a combination of linear and nonlinear lattice potentials. The main points of the analysis are effects of the (in)commensurability between the lattices, the development of analytical methods, viz., the variational approximation (VA) for narrow ordinary solitons, and various forms of the averaging method for broad solitons of both types, and also the study of mobility of the solitons. Under the direct commensurability (equal periods of the lattices, the family of ordinary solitons is similar to its counterpart in the free space. The situation is different in the case of the subharmonic commensurability, with L_{lin}=(1/2)L_{nonlin}, or incommensurability. In those cases, there is an existence threshold for the solitons, and the scaling relation between their amplitude and width is different from that in the free space. GS families demonstrate a bistability, unless the direct commensurability takes place. Specific scaling relations are found for them too. Ordinary solitons can be readily set in motion by kicking. GSs are mobile too, featuring inelastic collisions. The analytical approximations are shown to be quite accurate, predicting correct scaling relations for the soliton families in different cases. The stability of the ordinary solitons is fully determined by the VK (Vakhitov-Kolokolov) criterion, while the stability of GS families follows an inverted ("anti-VK") criterion, which is explained by means of the averaging approximation.

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