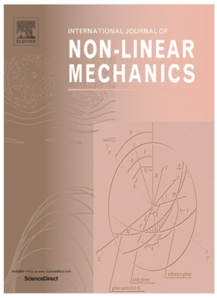
Accepted Manuscript



Propagation of solitons in a two-dimensional nonlinear square lattice

Ramon Zaera, Javier Vila, Jose Fernandez-Saez, Massimo Ruzzene

PII: S0020-7462(18)30232-4
DOI: https://doi.org/10.1016/j.ijnonlinmec.2018.08.002
Reference: NLM 3060

To appear in: *International Journal of Non-Linear Mechanics*

Received date : 30 April 2018
Accepted date : 6 August 2018

Propagation of solitons in a two-dimensional nonlinear square lattice

Ramon Zaera[a], Javier Vila[b], Jose Fernandez-Saez[a], Massimo Ruzzene[c]

[a]*Department of Continuum Mechanics and Structural Analysis. University Carlos III of Madrid. Avda. de la Universidad, 30. 28911 Leganés, Madrid, Spain*

[b]*School of Aerospace Engineering, Georgia Institute of Technology, 275 Ferst Dr, Atlanta, Georgia 30332 - USA*

[c]*School of Aerospace Engineering and School of Mechanical Engineering, Georgia Institute of Technology, 275 Ferst Dr, Atlanta, Georgia 30332 - USA*

Abstract

We investigate the existence of solitary waves in a nonlinear square spring-mass lattice. In the lattice, the masses interact with their neighbor through linear springs, and are connected to the ground by a nonlinear spring whose force is expressed as a polynomial function of the masses out-of-plane displacement. The low-order Taylor series expansions of the discrete equations lead to a continuum representation that holds in the long wavelength limit. Under this assumption, solitary wave solutions are sought within the long wavelength approximation, and the subsequent application of multiple scales to the resulting nonlinear continuum equations. The study focuses on weak nonlinearities of the ground stiffness and reveals the existence of 3 types of solitons, namely a 'bright', a 'dark' and a 'vortex' soliton. These solitons result from the balance of dispersive and nonlinear effects in the lattice, setting aside other relevant phenomena in 2D waves such as diffraction that may lead to a field that does not change during propagation in nonlinear media. For equal constants of the in-plane springs, the governing equation reduces to the Klein-Gordon type, for which bright and dark solitons replicate solutions for one-dimensional lattices. However, unequal constants of the in-plane springs aligned with the two principal lattice directions lead to conditions in which the soliton propagation direction, defined by the group velocity, differs from the wave vector direction, which is unique to two-dimensional assemblies. Furthermore, vortex solitons are obtained for isotropic lattices, which shows similarities with results previously found in optics, thermal media and quantum plasmas. The paper describes the main parameters defining the existence of these solitary waves,