Nonlinear Waves in a Lattice of Magnetic Dipoles

L. Salmerón-Contreras[1], N. Jiménez[2], V.J. Sánchez-Morcillo[3], L.M. Garcia-Raffi[1], R. Picó[3], J.F.R. Archilla[4]

[1]Instituto Universitario de Matemática Pura y Aplicada, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain
[2]Laboratoire d'Acoustique de l'Université du Maine (LAUM) - CNRS UMR 6613, Av. Olivier Messiaen, 72085 Le Mans, France
[3] Instituto de Investigación para la Gestión Integrada de las Zonas Costeras, Universitat Politècnica de Valéncia, C/.Paranimfo 1, 46730 Grao de Gandia, Spain
[4]Grupo de Física No Lineal, Universidad de Sevilla, ETSI Informática, Avda Reina Mercedes s/n, 41012 Seville, Spain

We consider a lattice of nonlinearly coupled oscillators, where the masses interact with their nearest neighbors by repulsive forces. Such physical system is realized experimentally, with an array of cylindrical magnets (magnetic dipoles), forming a nearly one dimensional chain of masses coupled by its magnetic fields. The magnetic moments of neighbor magnets are oriented in the same directions, so they experience repulsive forces dependent on the separation between poles. Each magnet is the mass of a pendulum, which is forced to oscillate around an equilibrium position. This system may be considered as a toy model of matter at the microscopic scale, with atoms or ions interacting via coulomb potentials [1]. The chain of oscillating magnets is set at a distance from a periodic array of fixed magnets, with the same periodicity, that mimics the presence of a neighbour layer of atoms, and results in an additional substrate or onsite potential. We report a theoretical and experimental study of nonlinear waves propagating in the magnetic chain. We study in particular the existence of localized traveling perturbations, in the form of solitons or kinks, that propagate along the chain without distortion [2]. These properties of such localized perturbations are investigated for the bare chain, and also for the chain under effect of the substrate potential. Their principal characteristics, as the amplitude and velocity, are determined and compared with the theoretical modeling. Other features of nonlinear waves explored in the setup are the generation of higher harmonics, subharmonics, or the existence of an acoustic dilatation mode, corresponding to an expansion of the chain induced by the acoustic excitation.

References

[1] J.F.R. Archilla, Yu. A. Kosevich, N. Jiménez, V. J. Sánchez-Morcillo and L. M. García-Raffi, *Ultradiscrete kinks with supersonic speed in a layered crystal with realistic potentials*, Phys. Rev. E **91**, 022912 (2015)

[2] J.F.R. Archilla, N. Jiménez, V.J. Sánchez-Morcillo, L.M. García-Raffi (Eds), *Quodons in Mica: Nonlinear Localized Travelling Excitations in Crystals*, Springer Series in Materials Science, vol. 221 Springer, 2015, ISBN: 978-3-319-21044-5

Tuesday, 15:50, **GM1** Audimax, Building BA