Nonlinear localized and propagating modes in metamaterials

George P. Tsironis[1], Nikos Lazarides[1], Mario I. Molina[2]
[1]Department of Physics, University of Crete, and FORTH, P. O. Box 2208, 71003 Heraklion, Greece
Tel: 0035 2810 39 43 01, email: gts@physics.uoc.gr
[2]Departamento de Física, Facultad de Ciencias, Universidad de Chile, Casilla 653, Santiago, Chile
Tel: (56 2) 978 7275, email: molina.mi@gmail.com

Abstract:

Discrete magnetic metamaterials (MMs) comprised, e.g. of periodically arranged nonlinear split-ring resonators (SRRs), may support highly localized excitations in the form of discrete breathers (DBs) [1]. In practice, the SRRs can become nonlinear by the insertion of nonlinear electronic components into their slits [2]. Recently, a novel MM comprised of two types of SRRs was investigated theoretically and it was demonstrated that in the nonlinear regime such binary MMs are suited for the observation of phase-matched parametric interaction and enhanced second harmonic generation [3]. The binary structure of the SRR lattice allows for generation of DBs through direct external induction by a frequency-chirped incident field [4-6]. That method has been applied succesfully for DB generation in experiments on dielement cantilever arrays [7]. MMs are driven by alternating fields and thus it is expected that dissipative DBs are relevant to these type of experiments when nonlinearity is present. We have generated numerically dissipative DBs in a model nonlinear binary MM with frequency-chirped driver for several parameter sets [4-6]. Since it is in principle possible to construct a binary MM with strong on-site nonlinearity, we propose that an experiment with frequency-chirped applied field can lead to dissipative DB generation. DB generation.

Moreover, we have investigated the transmission of power in SRR arrays driven at one end. We have found that the incoming power can be transmitted effectively for frequencies not only within the linear band, but also within other narrow frequency intervals, where nonlinear resonances appear. Importantly, the power is transfered by breather-like, resonant excitations, that are continually formed in the array.

References:

1. N. Lazarides, M. Eleftheriou, and G.P. Tsironis, Phys. Rev. Lett. 97, 157406 (2006).
2. I.V. Shadrivov, A.B. Kozyrev, D. van der Weide, and Yu.S. Kivshar, Appl. Phys. Lett. 93, 161903 (2008).
3. M.V. Gorkunov, I.V. Shadrivov, and Yu.S. Kivshar, Appl. Phys. Lett. 88, 071912 (2006).
4. M.I. Molina, N. Lazarides, and G.P. Tsironis, Phys. Rev. E 80, 046605 (2009).
5. N. Lazarides, M.I. Molina, and G.P. Tsironis, Acta Phys. Pol. A 116, 635-637 (2009).
6. N. Lazarides, M.I. Molina, and G.P. Tsironis, Physica B, in press.
7. M. Sato *et al.*, Phys. Rev. Lett. 90, 044102 (2003).