Defect Modes, Fano Resonances and Embedded States in Magnetic Metamaterials

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Abstract We consider a simplified model of a nonlinear magnetic metamaterial, consisting of a weakly-coupled, periodic split-ring resonator (SRR) array capable of nonlinear capacitive response. We analyze three related problems: (a) The calculation of localized modes around simple magnetoinductive impurities located at the surface or at the bulk of the array, in closed form for both, linear and nonlinear cases. (b) The scattering of magnetoinductive waves across internal (external) capacitive (inductive) defects coupled to the SRR array and the occurrence of Fano resonances, and how to tune them by changing the external parameters of the system. (c) Description of a method for building a stable localized magnetoinductive mode embedded in the linear band of extended states.

1 Introduction

Metamaterials (MMs) are novel artificial materials characterized for having negative dielectric permittivity and negative magnetic permeability over a finite frequency range, endowing them with unusual electromagnetic wave propagation properties [1, 2]. One of the most studied MMs is a metallic composite structure consisting of arrays of wires and split-ring resonators (SRRs). The theoretical treatment of such structures relies mainly on the effective-medium approximation where the composite is treated as a homogeneous and isotropic medium, characterized by effective macroscopic parameters. The approach is valid, as long as the wavelength of the electromagnetic field is much larger than the linear dimensions of the MM

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