Phonons in a two-dimensional auxetic lattice

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Auxetics are materials and structures displaying a negative Poisson's ratio, meaning that they exhibit a lateral extension, instead of shrinking, when they are stretched. Although in the past two decades there has been considerable developments on systems exhibiting auxetic behaviour, the studies of the modes of vibrations in auxetic structures is still in its infancy.

Here we aim starting a discussion on models of two-dimensional lattices, in which the lattice is represented by a planar network where sites are connected by strings and rigid rods, in order to obtain an auxetic structure. In particular, we discuss a model based on the recently proposed 'rotating squares' structure [1-3], see Fig. 1(a). We show that since the proposed lattice has a basis, translational and rotational mode dispersions are observed displaying a complete bandgap when the ratio of masses in the lattice basis is different from one (Fig.1(b),(c)). In analogy with the behaviour of crystalline lattices, the acoustic mode velocity is strongly reduced when the mass ratio increases.

References:

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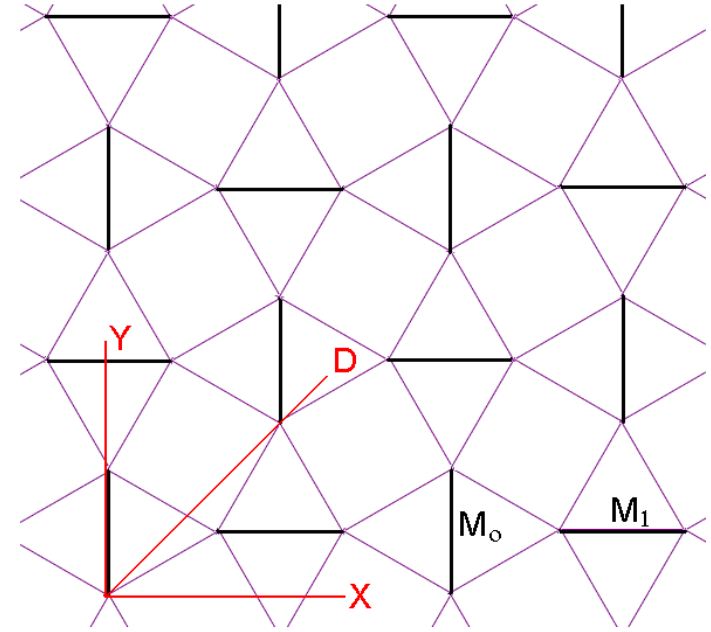
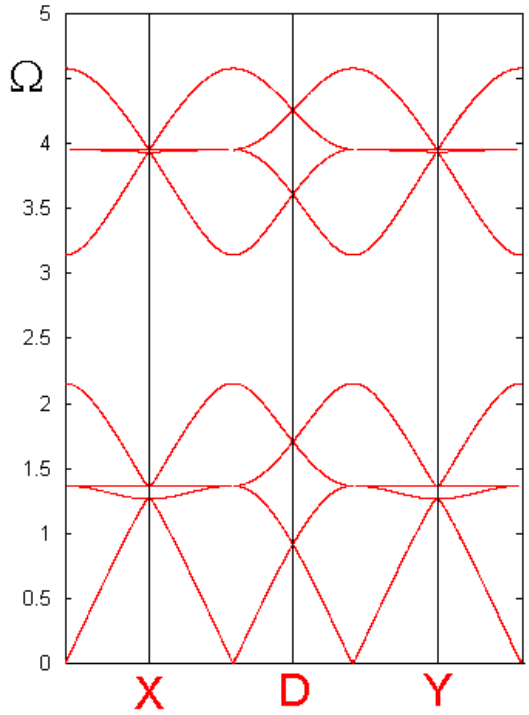
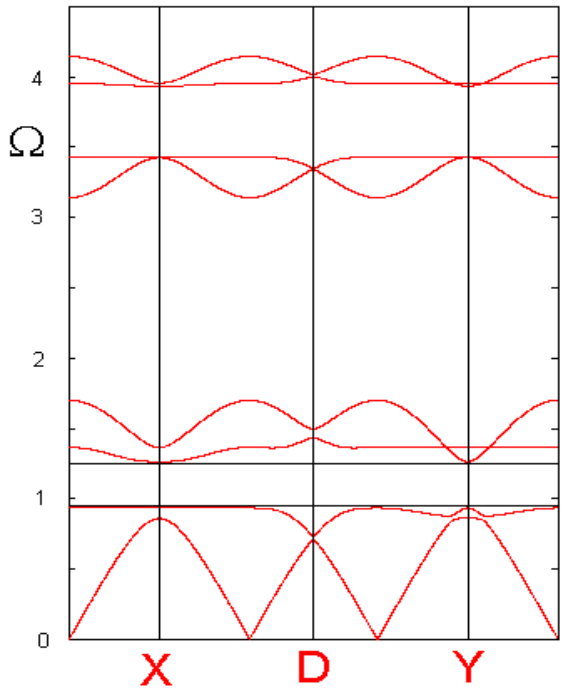


(a)



(b)



(c)

Fig. 1(a): The lattice discussed here where masses are connected with strings; (b) the reduced mode frequencies as a function of wavenumbers along directions X,Y and D, when the units of the lattice basis have the same mass, and (c) the reduced mode frequencies as a function of wavenumbers, when the units of the lattice have different masses (M_1=4M_o). Note the complete bandgap between translational and rotational modes and the lower group velocity of translational (acoustic) modes.