Design of non-linear seismic metamaterials

R. Cilla[1], G. Finocchio[2], Zivieri[2], O. Casablanca[1], B. Azzerboni[1], M. Chiappini[3], F. Garescì[1,*]

[1]Department of Engineering, University of Messina, Italy

[2]Department of Mathematical and Computer Sciences, Physical Sciences and Earth Sciences, University of Messina, Italy

[3]Istituto Nazionale di Geofisica e Vulcanologia, INGV, Roma, Italy

*fgaresci@unime.it

Abstract

A model used to understand seismic metamaterials from a theoretical point of view is based on the concept of the periodic sub-wavelength resonant mass-in-mass system, see Fig. 1. We have already proposed a continuous implementation of those type of seismic metamaterials based on the use of isochronous mechanical oscillators [1]. However, the bandgap of the this device is centered at the resonance frequency of the atomic mass-in-mass element. A key challenge is to achieve a broad extension of the bandgap and a bandgap starting at a frequency as low as possible To reach this result, it has been proposed to exploit the non-reciprocity feature of the chiral materials, introducing in the system hybrid modes [2]. Here, we focus on the possible engineering of the non-linearity of the external spring (k_e in Fig.1) of a mass-in-mass system, we evaluate three cases including an hysteretic k_e value. Starting by the Lagrangian equation of the energy, we obtain the dynamical equations taking into account the relationship of k_e relate to the displacement of the m_e (external mass in Fig. 1). The dynamical equations are then solved numerically. Our results point out that the start frequency of the bandgap can be decreased by 25% by considering $k_e = A\, a\tan(B u_e)$ with proper values of A and B.

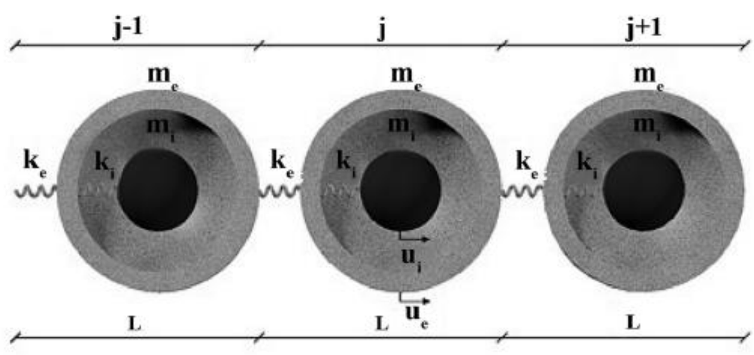

Fig. 1 Sketch of the atom of mass-in-mass periodic system.

References

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