Internal resonances in vibration of microstructured solids: influence of dispersion and dissipation

Igor V. Andrianov[1], Bernd Markert[1], Vladyslav V. Danishevskyy[2]

[1] *Institute of General Mechanics, RWTH Aachen University, Germany.*
E-mail: igor_andrianov@hotmail.com , markert@iam.rwth-aachen.de

[2] *Department of Structural Mechanics and Strength of Materials, Prydniprovska State Academy of Civil Engineering and Architecture, Ukraine.*
E-mail: vladyslav.danishevskyy@gmail.com

Abstract

The aim of the paper is to study how the heterogeneity and the viscous damping influence mode interactions in non-linear vibrations of microstructured solids. As an illustrative example, a layered heterogeneous medium are considered. The constitutive macroscopic equation of motion is derived by the higher-order asymptotic homogenisation method. The problem is solved using Fourier series spatial discretisation and the asymptotic method of multiple time scales. The effects of internal resonances and modes coupling are predicted, validated and analysed.

If dispersion and dissipation are neglected, an infinite number of modes are coupled and the obtained system does not allow truncation. From the physical point of view this corresponds to unlimited energy transfers from low- to high-order modes, which is obviously never observed in real engineering structures. It is shown that depending on scaling ratios between the amplitude of the vibrations, the size of the microstructure and the dissipation rate different scenarios of the modes coupling can be realised. If the size of the microstructure and/or the dissipation rate increases, the influence of non-linearity is suppressed. Then the energy transfer to higher-order modes is restricted and truncation to only a few leading modes can provide a reasonable approach. The further increase in dispersion and dissipation eliminates the energy exchange between the modes and the internal resonances become negligible. Additionally to the developed asymptotic solution, a numerical simulation is performed using the Runge-Kutta fourth order method. The obtained numerical and analytical results demonstrate good agreement.

The results presented in the paper can be applied to facilitate the development of new efficient methods of non-destructive testing. Measuring the characteristics of non-linear vibrations at different amplitudes allows one to receive precise information about the internal structure of heterogeneous materials. Changing properties of the microstructure (e.g., using piezoelectric effects or saturation/desaturation of porous media) make it possible to tune the macroscopic dynamic response of non-linear structures. This can be useful for a design of new active control devices and vibration dampers in various branches of engineering.