Title: Study of quasiperiodic nonlinear metastructures for vibroacoustic energy trapping

Titre : Etude de métastructures quasi-périodiques non-linéaires pour le piégeage de l'énergie vibroacoustique

Supervisors:

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1. Context

The deviation of linear periodic structures (imperfections) from the ideal has been observed to cause Anderson localization[1] for which the energy is confined near the disorder and the dynamic behavior of the structure changes. This phenomenon has attracted much recent attention in many applications in physics because of its important role in the qualification as well as quantification of system operations[2]. Particularly, in mechanical, civil and aerospace engineering, Mester and Benaroya[3] addressed a large review for different methods of analysis of linear periodic and near-periodic structures.
Moreover, one of the most popular localization phenomena, that have attracted the interest of physicists, is the nonlinear energy localization. Such localized energy excitations, called intrinsic localized modes (ILMs), also known as "discrete breathers" or "lattice solitons" can occur in defect-free periodic nonlinear structures[4,5], and have an exceptional stability against disturbances[6]. Therefore, solitons play a fundamental role in the properties of energy transport for a variety of fields such as optics, acoustics, and hydraulics. In mechanical engineering, among several periodic structures, the coupled pendulums have been the first focus of intensive research for more than thirty years and from different points of view, mainly in terms of nonlinear dynamics and intrinsic localized modes[7,8]. The second focus deals with granular media to study the wave propagation and Hertzian contact[9,10]. It has been particularly shown that homogeneous granular chains possess complex nonlinear dynamics, including nonlinear energy transfer and localization phenomena[11], and that the speed of propagation of the traveling waves is smaller than the corresponding speed of the soliton[12].

2. Objectives and main tasks

The objective of the internship is to model and simulate the vibroacoustic behavior of quasi-periodic nonlinear metastructures by combining two properties: (i) near-periodicity which enables to confine the energy close to the imperfections and (ii) distributed or localized nonlinearities allowing the creation of multimode solution branches to enlarge the frequency bandwidth and formation of solitons for energy transport improvement. These properties will be exploited to establish design rules for the implementation of a vibroacoustic energy harvester. The internship program includes the main following tasks:

1- Establish the dynamic continuum model of a nonlinear VEH based on periodic metastructures with imperfections (quasiperiodic).

2- Derive the discrete elementary equivalent model (spring-mass-damper) of the periodic/quasiperiodic system including localized or distributed nonlinearities.
3- Transform the discrete model into a nonlinear Schrödinger equation to determine the intrinsic localized modes (solitons).
4- Establish the link between the solutions of Schrödinger equation and the solutions of the discrete model.
5- Establish some design rules for a VEH implementation.

3. Host Laboratory

FEMTO-ST Institute, Department of applied Mechanics, Besançon, France
https://www.femto-st.fr/fr

4. Duration

6 months from 01/02/2020 (or 01/03/2020) to 31/07/2020 (or 31/08/2020)

Financial gratification: around 560 €/ month

5. Perspective

Possibility of pursuing a PhD on a project, following this internship, funded by EUR EIPHI (https://gradschool.eiphi.ubfc.fr)

References (Non-exhaustive list)

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