PhD Thesis Position

Title	Design of biperiodic metastructures for vibroacoustic energy trapping and harvesting		
Project	EUR EIPHI (https://gradschool.eiphi.ubfc.fr)		
Location(s)	FEMTO-ST Institute, Department of Applied Mechanics (Besançon - France)		
Supervisor(s)	Dr Najib KACEM, Pr Ausrine BARTASYTE and Pr Noureddine BOUHADDI		
Start date	01/10/2020	Duration	3 years
Salary	About 1900 euros/month (gross salary)		

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. To our knowledge, the research of the "metamaterials" scientific community is mainly concerned by the passive and/or active functionalization of the periodicity and its impacts on structural damping and band-gap in vibroacoustic problems[4, 5].

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[6, 7], and have an exceptional stability against disturbances[8]. 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[9, 10]. The second focus deals with granular media to study the wave propagation and Hertzian contact[11, 12]. It has been particularly shown that homogeneous granular chains possess complex nonlinear dynamics, including nonlinear energy transfer and localization phenomena[13], and that the speed of propagation of the traveling waves is smaller than the corresponding speed of the soliton[14].

Among the large literature dedicated to the periodic or near-periodic structures, to our knowledge only few studies have dealt with the bi-periodicity, initially proposed by Mc Daniel[15], and are focused on the analysis of the band gap with and without disorder for linear structures[16]. Including nonlinearities in such structures could lead to a complex vibroacoustic behavior for which a dynamic analysis becomes challenging. These fundamental problematics will be addressed for the enhancement and robustness of Vibration Energy Harvester (VEH) performances[17, 18, 19, 20] using piezoelectric transducers based on Lithium Niobate (LiNbO3)[21,22]. Unlike PZT, *LiNbO3* does not contain plumb and can operate in extreme conditions of temperature[23], which is suitable for several applications such as pollution surveillance and SHM.

2. Objective

The objective of the PhD thesis is to develop innovative design of smart systems based on bi-periodic patterns by combining at two scales: (**i**) structure scale, near-periodicity which enables to confine the energy close to the imperfections (**ii**) interface scale, periodicity or structured interface which opens new capabilities in the design of filtering devices for elastic waves and may prelude the possibility of obtaining high-resolution focusing properties for elastodynamic waves[24-25] (**iii**) distributed or localized nonlinearities allowing the creation of multimode solution branches to enlarge the frequency bandwidth[26] and formation of solitons for energy transport improvement[10]. These properties will be highlighted through the implementation and experimental characterization of a VEH prototype based on resonant piezoelectric MEMS arrays.

3. Candidate Profile

The candidate should have a master degree in applied mechanics, physics or applied mathematics. He has to prove his relevant knowledge in the following disciplines: vibrations, nonlinear dynamics and advanced numerical methods. The candidate must perform extensive computer simulations and data analysis. A disposition for numerical work and programming is required. Proficiency in English is important.

4. Application

The application consists of ONE pdf-file comprising:
- Curriculum Vitae (possibly with list of publications)
- Short summary of the master's thesis
- Suggestion of two referees with contact details
- Provide detailed explanation justifying your choice for this PhD project

5. Contacts

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References (non-exhaustive list)

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