Author's Accepted Manuscript

www.elsevier.com/locate/ijmecsci

Investigation of modal interactions and their effects on the nonlinear dynamics of a periodic coupled pendulums chain

Diala Bitar, Najib Kacem, Noureddine Bouhaddi

PII: S0020-7403(16)30961-4
DOI: http://dx.doi.org/10.1016/j.ijmecsci.2016.11.030
Reference: MS3509

To appear in: *International Journal of Mechanical Sciences*

Received date: 19 June 2016
Revised date: 28 November 2016
Accepted date: 30 November 2016

Cite this article as: Diala Bitar, Najib Kacem and Noureddine Bouhaddi Investigation of modal interactions and their effects on the nonlinear dynamics o a periodic coupled pendulums chain, *International Journal of Mechanica Sciences,* http://dx.doi.org/10.1016/j.ijmecsci.2016.11.030

Investigation of modal interactions and their effects on the nonlinear dynamics of a periodic coupled pendulums chain

Diala Bitar, Najib Kacem, Noureddine Bouhaddi

FEMTO-ST Institute, UMR 6174, Department of Applied Mechanics , University of Bourgeon Franche-Comté (UBFC), 24 rue de l'Épitaphe, F 25000, Besançon.

Abstract

The nonlinear dynamics of a weakly coupled pendulums chain is investigated under primary resonance. The coupled equations governing the nonlinear vibrations are normalized and transformed into a set of coupled complex algebraic equations using the multiple scales method coupled with standing wave decomposition. A model reduction method is proposed to calculate the dominant dynamics without significant loss of accuracy compared to the full model. The validity of the proposed semi-analytical method is verified, and its role in identifying the type of the solution branches is highlighted. The modal interactions and their effects on the nonlinear dynamics are studied in the frequency domain in order to emphasize the large number of multimode solution branches and the bifurcation topology transfer between the modal intensities. Basins of attraction analysis have been performed, showing that the distribution of the multimodal solution branches generated by all modes collectively increases by increasing the number of coupled pendulums.

Keywords: Nonlinear dynamics, Periodic structures, Coupled pendulums, Modal interactions, Basins of attraction

1. Introduction

Nonlinear periodic systems are frequently encountered in serval scientific domains such as biology, optics, acoustics and mechanics. For instance, in the field of acoustics, Narisetti *et al.* [1] analyzed the influence of nonlinearity and wave amplitude on the dispersion properties of plane waves in nonlinear periodic materials, particularly in uniform granular media. In optics, Heinrich *et al.* [2] introduced optomechanical cells arrays as a new system to study the collective nonlinear dynamics. Moreover, in micro and nanotechnology, the collective dynamics of coupled nonlinear resonators array have been performed by Lifshitz *et al.* [3] using a discrete model.

In mechanics, the array of coupled pendulums represents a famous example of periodic nonlinear structures which can be described by the sine-Gordon model [4]. The latter is suitable for a large variety of physical systems, which explains the vast research area developed around this field. Several theorems on the existence of oscillatory, rotary,

Email addresses: diala.bitar@femto-st.fr (Diala Bitar), najib.kacem@femto-st.fr (Najib Kacem), noureddine.bouhaddi@femto-st.fr (Noureddine Bouhaddi)