Localised vibrations in non-smooth systems

Filipe Fontanela[1], Aurelien Grolet[2], Loic Salles[1] and Norbert Hoffmann[1,3]

[1] Imperial College London, SW7 2AZ, London, UK

[2] Arts et Metiers ParisTech, 8 Boulevard Louis XIV, 59000, Lille, France´

[3] Hamburg University of Technology, 21073, Hamburg, Germany

Abstract

Localised vibrations is a very important topic in bladed disks of aircraft engines due to high-cycle-fatigue. In the linear regime, localised states arise due to inhomogeneities from manufacturing variabilities or wear, and this phenomenon is usually referred to as a mistuning problem. In the nonlinear regime, the processes which lead to localised vibrations may go beyond mistuning. It is well-known, for example, that even perfect cyclic and symmetric structures may localise vibrations due to bifurcations.

The research mainly focuses on nonlinear vibrations of bladed disks due to travelling wave excitations. In the smooth case, when nonlinearities arise e.g. due to large deformations, it has been shown that homogeneous periodic states may loose stability and bifurcate to quasiperiodic localised regimes. This phenomenon, widely known in the Physics community as modulation instability, has been extensively studied within the Nonlinear Schrodinger (NLS)¨ equation framework. On the other hand, it is well-known that many structural components in aircraft engines are also subjected to non-smooth nonlinearities arising e.g. from vibroimpacts and frictional dampers. The present work investigates localised states emerging from bifurcations in non-smooth systems, where the development of a NLS-like equation seems more complicated. Therefore, we apply a fully numerical methodology based on the periodic and the quasi-periodic harmonic balance methods, and we demonstrate that localised states bifurcate from homogeneous solutions. The results are qualitatively similar to the smooth case, and the present findings corroborate the idea that localised regimes may appear in a very broad class of nonlinear dispersive systems. Moreover, the present methodology should help to clarify whether or not bladed disks can localise vibrations in operational conditions due to nonlinear dynamics.