PhD position at Loughborough University

VIBRATIONS OF PLATES IN AXIAL FLOWS: EFFECTS OF PRE-STRESS OR PRE-DEFORMATION

Loughborough University (UK) / Aix-Marseille Université (FR)

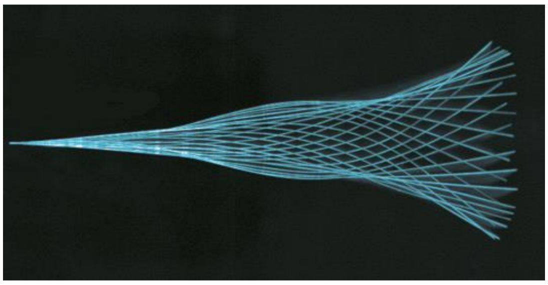

Fig.1 *– Sequence of (superimposed) frames of a fluttering plate in an axial flow coming from the left (Eloy, 2008).*

An elastic structure can start vibrating when the speed of the flow in which it is placed exceeds a certain threshold: this phenomenon is called flow-induced vibrations (Fig.1). These vibrations can be harmful (fluttering of an aircraft wing, vibration of a heat exchanger) or useful (energy harvesting, fish locomotion). The canonical configuration is that of a flat elastic rectangular plate placed in an axial flow (problem of the instability of an elastic flag). The theoretical models of this so-called *fluttering instability* can be classified in two categories according to the aspect ratio of the plate. For large aspect ratios - when the transverse dimension of the plate is large compared to its longitudinal dimension - the problem is almost two-dimensional. In this case, Kornecki et al. (1976) showed that flow can be modelled using the unsteady theory of wings. When the aspect ratio is small, aerodynamic forces can be calculated using the theory of slender bodies (Lighthill, 1960). These studies, conducted in these two asymptotic limits, have more recently been generalized to intermediate aspect ratios by Eloy et al. (2007) and complemented by experimental studies (e.g. Lemaitre et al., 2005) and numerical studies (Michelin et al., 2008). Most of the works mentioned above generally focused on the prediction of the instability threshold and on the characteristics of unstable modes (shape and frequency), with respect to the flow speed, rigidity and size of the plate etc. However, it is not known how the instability of a rigid flag is modified when one departs from the ideal configuration: for instance, if the flow is not parallel to the plate, or if the structure has pre-stress or pre-deformation (Fig.2, below). In such a case the fluid-structure interaction can be difficult to model due to nonlinearities of geometrical nature and flow detachment.

The objectives of this thesis are: (i) to characterize the instability (vibration) induced by the incoming flow on a pre-stress or pre-deformed plate, using a classical approach combining experimental, theoretical and numerical studies; (ii) to control this response by modulating the mechanical or geometric parameters along the plate. This topic has many possible applications in the fields of Automotive and Aeronautics (mechanical noise in vibration, oligo-cyclic or high-cycle fatigue, and structural damage), and Energy Engineering (energy harvesting from wind and marine currents).

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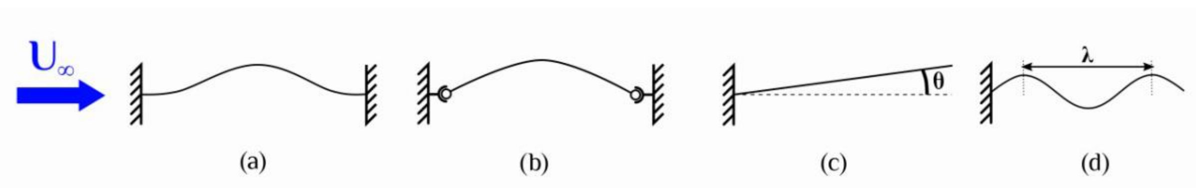

Fig.2 *– Example of configurations that will be studied. (a) bi-clamped pre-deformed plate (rigid joints); (b) bi-clamped pre-deformed plate (ball joints) ; (c) tilted plate (relative to the direction of the flow) ; (d) clamped-free harmonically pre-deformed plate.*

NB: Student will be mostly based at Loughborough University (UK)