The effect of spanwise confinement on the flutter instability of an elastic plate

O. Doaré*, C. Eloy†

When a cantilevered plate lies in an axial flow, it is known to exhibit self-sustained oscillations once a critical velocity of the flow is reached. This phenomenon, called flutter, has been investigated in a large amount of theoretical, numerical and experimental studies, motivated by applications in various engineering fields such as biomechanics, paper industry, aerospace, nuclear engineering or aeronautics. Among the theoretical models attempting to predict the critical velocities, the so-called two-dimensional model[1,2] considers an infinite-span plate. This model was considered to predict reasonably well the experimental instability thresholds if the plate span is almost equal to the width of the channel flow in experiments. But differences are found between experiments and theory[3,4].

To understand this discrepancy, we propose a theoretical/numerical analysis of the effect of the clearance between the plate and the upper and lower walls of the channel. The pressure distribution around an infinite-chord plate is solved in the Fourier space, which allows to develop an empirical model for the pressure jump. This empirical model is then used to compute instability thresholds as function of the channel clearance. Our results then show that the value of the clearance has to be considerably small for the two-dimensional limit to be reached (see figure 1), which explains the difference between experiments and two-dimensional models.

*ENSTA-Paristech, Unité de Mécanique, Chemin de la Hunière, 91761 Palaiseau, France.
†IRPHE, CNRS & Aix-Marseille Université, 49 rue Joliot-Curie, 13013 Marseille, France.

[1] Kornecki et al, Journal of Sound and Vibration, 47(2), 1976
[2] Guo and Païdoussis, Journal of Applied Mechanics, 611, 2000.
[3] Huang, Journal of Fluids and Structures, 20(7) 1995
[4] Aurégan and Dépollier, Journal of Sound and Vibration, 188(1), 1995

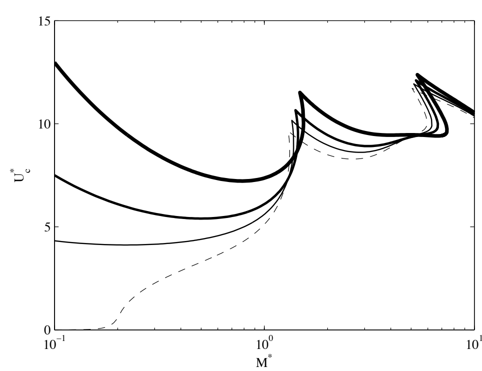

Figure 1: Critical velocity as a function of the mass ratio for a square plate. The different thicknesses correspond to different gaps c: $c/l = \infty$ (thick), $c/l = 10^{-2}$ (medium), $c/l = 10^{-4}$ (thin), $c/l = 0$, 2D limit (dashed).