Flutter Modes of a Flexible Plate in an Air Flow

Souilliez, C., Schouveiler, L. and Eloy, L.
Institut de Recherche sur les Phénomènes Hors Equilibre,
49 rue Joliot-Curie, BP 146, F-13384 Marseille Cedex 13, France.

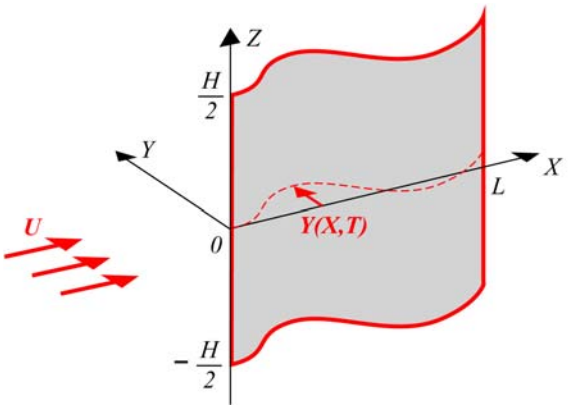

Fig. 1. Sketch of the experiment.

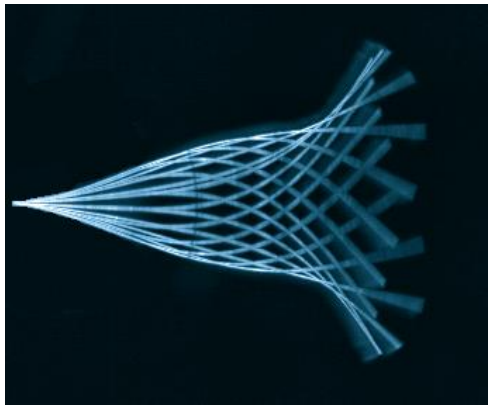

Fig. 2. Flutter for L = 8 cm, U = 8 m/s.

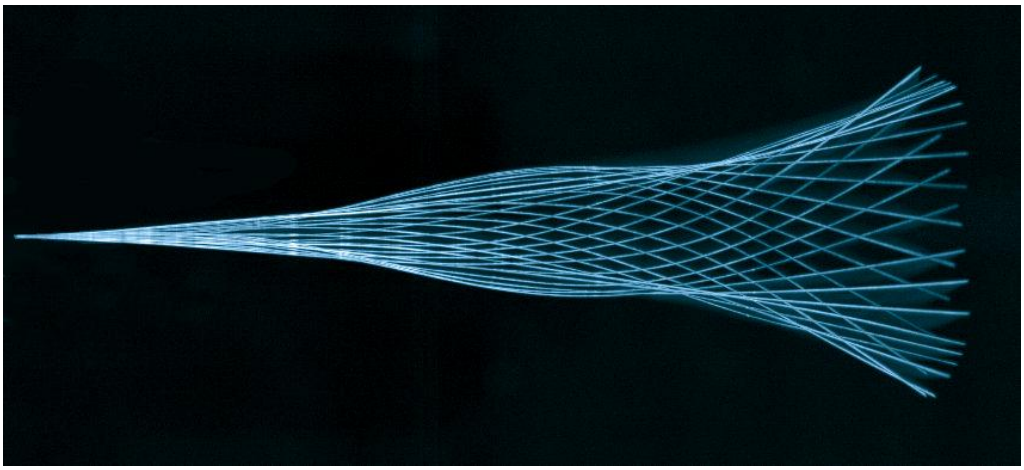

Fig. 3. Flutter for L = 21 cm, U = 2.9 m/s.

The flutter instability resulting from the interaction of a flexible plate with a fluid flow is experimentally investigated. The present visualizations are obtained with two square plates (i.e. of aspect ratio $H/L = 1$, see the sketch of the experiment in Fig. 1.) made in a plastic sheet (of flexural rigidity 4.8 10^{-4} kg m^2 s^{-2}) and of length $L = 8$ and 21 cm. Experiments are performed in the horizontal test section of a low-turbulence wind tunnel. The upstream end of the plate is clamped into a vertical streamlined mast while the three other edges are free. For low velocities U, the plate is planar and parallel to the air flow. Then, as U is increased, two-dimensional flutter of the plate spontaneously appears at a critical value U_c depending on the plate dimensions.

Figs. 2 and 3 show superimposed views of the side edge of the plates during one flutter period, captured just at the threshold U_c for both plates. Such figures allow to visualize the envelope of the futter motion. Images are captured with an high speed camera parallel to the Z-axis (see Fig. 1.), the air flow is from left to right. These visualizations reveal that different flutter modes can take place at the threshold as the plate dimensions are varied. For the material considered here, the two figures show a change of the mode shape from a single-neck (Fig. 2) to a double-neck (Fig. 3) envelope when the length is increased from 8 to 21 cm. It should be pointed out that these two flutter modes differ not only by the envelope shape but also by the flapping frequency: the measured flutter frequency for the mode shown in Fig. 2 is of 29 Hz, and of 5.6 Hz for the longest plate (Fig. 3).