On the nature of the plate flutter bifurcation

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ABSTRACT

The flutter of a flexible plate immersed in a parallel flow is the result of the competition between the destabilizing flow pressure force and the stabilizing plate rigidity. This simple system has been considered for a long time as a canonical example of flutter instability of a flexible body interacting with a fluid flow because it allows to perform well controlled experiments as well as to conduct analytical study. It has enjoyed a renewal of interest since the beginning of the 21st century and has been object of a recent review [1].

But in spite of the large number of studies, the nature of the plate flutter bifurcation is still a controversial subject as mentioned is the Outlook section of the review [1]. Indeed in all experiments a large hysteresis is reported (e.g. [2]) that could be indicative of a subcritical bifurcation while two-dimensional simulations exhibit either a supercritical bifurcation or a much smaller hysteretic cycle.

In the present study we show that the hysteresis measured in the experiments is mainly due to defects inherent in experimental works. For example a planarity defect δ associated with a curvature in the flow direction would result in a drastic increase of the plate flexural rigidity that scales like $D[1 + (\delta/e)^2]$ where D is the rigidity of the perfectly plane plate and e the plate thickness. This effect is evidenced performing experiments with plates initially curved along their chord. In this case, the thresholds observed as the flow velocity is increased, strongly increase with the plate curvature while the thresholds, for a decreasing flow velocity, do not depend on the curvature and are well-predicted by linear stability analyzes. Thus the size of the hysteretic cycles depends on the initial plate deflection. In addition, whatever the plate, the flutter modes appear one dimensional and do not depend on the initial curvature. For these reasons, the bifurcation seems to be supercritical and the hysteretic cycles experimentally observed could be due to plate imperfections. This conclusion is supported by a weakly non-linear development of the plate governing equation at the threshold.

REFERENCES

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