A global stability approach to the onset of oscillation for freely falling objects

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ABSTRACT

The study of the motion of falling or rising bodies, relevant in various fields as meteorology, chemical engineering, aerospace to say few, has known a great interest in the last decade [1]. The dynamics of such systems is complex and the dependance with the parameters is not yet well understood.

The purpose of this work is to investigate the first transition from steady, vertical path to unsteady, periodic path. For this we develop a global stability approach which consists of linearizing the coupled system formed by the Navier-Stokes equation governing the flow of fluid in the frame of the body, and the Newton equations governing the body's trajectory. The computations are done using the finite element methods software FreeFEM++ and the eigenvalue solver SLEPC.

We mostly consider two-dimensionnal objects such as plates, cylinders, rods of rectangular section. In the limit of very heavy objects, the eigenmodes separate into two families. The first family are identical to the ones existing in the wake of a fixed object, and comprise, for two-dimensional objects, the well-known Von-Karman shedding mode. The other family consists of 'slow modes' with weak eigenvalues, which can be predicted using a quasi-static model [2]. For thin plates, these slow modes are always weakly damped, but for other geometries such as a cylindrical rod of square section they can become unstable. For bodies with lower masses, the two families of modes interact in a complex way [3]. However, in most cases the eigenmode appearing at the first transition remains similar to the one existing in the wake of a fixed objects.

The extension of this work to three-dimensional objects with axial symmetry (spheres, ellipsods, disks) is in progress and first results will be presented.

REFERENCES

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