Numerical simulation of falling leaves using a pseudo–spectral method with volume penalization

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The study of falling leaves dates back to the nineteenth century [3]. Recent experimental and numerical studies of 2d fall of strips through viscous fluids have been performed by Wang (cf. [5] and the references therein). They point out a connection of the vortex dynamics between the free-fall of a leaf and insect locomotion.

The aim of the present work is to present an efficient numerical method to perform numerical simulations of falling leaves in viscous incompressible fluids and to study the role of viscosity on the transition between fluttering and tumbling. The 2d Navier–Stokes equations, written in the vorticity-streamfunction formulation, are discretized using a Fourier pseudo-spectral scheme with adaptive time-stepping [4]. Solid obstacles of arbitrary shape can be taken into account using the volume penalization method [1]. Time-dependent penalization is implemented, making the method capable of solving problems where the obstacle follows an arbitrary motion [2].

Different numerical simulations of falling leaves are performed, using the above model supplemented by the discretized ODEs describing the motion of a solid body subjected to external forces and moments. Various regimes of the free fall are explored, depending on the physical parameters and initial conditions. The influence of the Reynolds number on the transition between fluttering and tumbling will be investigated, showing the stabilizing effect

of viscosity. Figure 1 shows four vorticity snapshots of a falling leaf which illustrates the complex vortex dynamics of the problem.

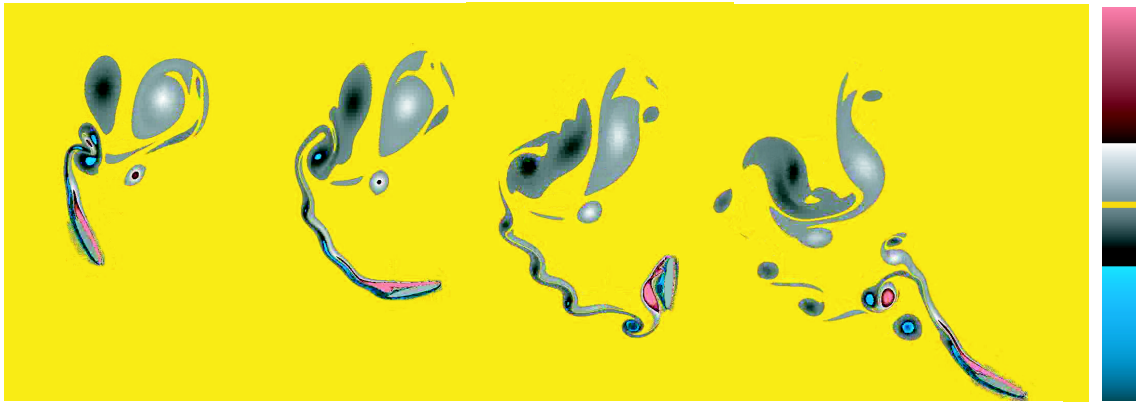

Figure 1: Tumbling falling leaf: snapshots of vorticity at 4 subsequent time instants.

References

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