Transport and deformation of an elastic filament in a cellular flow

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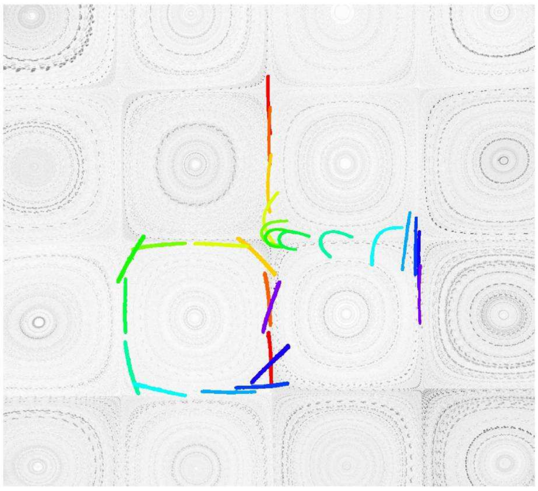
ABSTRACT

The interaction of a deformable body with a viscous flow is found in a wide range of situations, ranking from biology to polymer science. Numerous studies both experimental and theoretical have been devoted to this field, but a large number of questions remains to be answered. The experimental study of simple model systems, such as homogeneous elastic fibers, evolving in a controlled flow geometry, could help understanding the complex interactions that govern the dynamics.

Here we address the fundamental question of the modification of the transport of an object induced by its deformation in a viscous flow as studied by Young and Shelley [1]. In this context, we experimentally study the deformation and transport of an isolated elastic fiber in a viscous cellular flow at low Reynolds number (see figure 1), namely a lattice of counter-rotative vortices. We show that the fiber can buckle when approaching a stagnation point. By tuning either the flow or the fiber properties, we measure the onset of this buckling instability. The buckling threshold is determined by the relative intensity of viscous and elastic forces, the elasto-viscous number Sp. We directly compare our experimental results to theoretical predictions by Young[1] et al. Moreover we show that flexible fibers escape faster from a vortex (formed by closed streamlines) compared to rigid ones. As a consequence, the deformation of the fiber changes its transport properties in the cellular flow.



Successive shapes of a rigid fiber (bottom left) and a flexible (top right) experiencing the same flow field in two different experiments ($\Delta t = 0.4s$). The background flow is visualized independently.

REFERENCES

[1] Yuan-Nan Young and Mike Shelley. *Stretch-Coil Transition and Transport of Fibers in Cellular Flows*, Physical Review Letters **99**, 058303, 2007.

[2] Elie Wandersman, Nawal Quennouz, Marc Fermigier, Anke Lindner and Olivia du Roure *Buckled in translation*, Soft Matter **6**, 57155719, 2010.