# Sujet Stage M2

## Fluid/structure interaction in turbulent flows at low Reynolds number

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### Summary

Complex fluids often show viscoelastic properties, i.e. a mix of solid- and liquid-like behavior. These materials are structured on a mesoscopic scale in contrast to the atomic structure of simple liquids. While being processed or used, they undergo moderate or strong flows which can easily affect their mesostructure. In turn, structural modifications feed back on the flow itself, often triggering instabilities. Those instabilities occur at flow rates where inertial effects are usually negligible, *i.e.* when the Reynolds number which compares inertial and viscous effects is low. They are driven by elastic forces and give rise to disordered flows and complex spatio-temporal behavior sometimes reminiscent of inertial turbulence (Fig. 1).

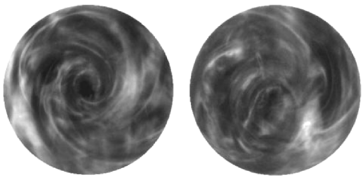

FIGURE 1 – Snapshots illustrating the disordered flow state called elastic turbulence in a viscoelastic polymer solution flowing between two parallel disks (von Karman swirling flow).

The flow of viscoelastic fluids is widespread in many industrial applications and the development of instabilities in these flows are of huge importance. Indeed elastic instabilities and turbulence are one of the main production-limiting factors, as for instance in extrusion of polymer solutions or melts, a major element of polymer processing in industry. Elastic instabilities have also often to be avoided at smaller scale, such as lab-on-a-chip diagnostics or jetting applications. On the other hand, advantage can be taken from the complex dynamics resulting from these phenomena for potential applications in mixing at low Reynolds number. Elastic turbulence can be used to create effective mixing and heat transport even at small scales, as in microfluidic applications, where inertia is absent.

The goal of the internship is to develop an innovative strategy of flow control based on the specific fluid/structure interaction. It consists in tuning the boundary conditions limiting the flow domain in order to suppress or enhance the flow instabilities that develop in complex fluids exhibiting viscoelasticity.

We will determine how the onset of elastically-induced instabilities and turbulence and the subsequent flow patterns are modified by the stiffness and roughness of the walls. The structure of the flow will be explored by combining direct visualizations (distribution of anisotropic reflective particles) and quantitative velocimetry measurements [particle image velocimetry (PIV) and laser anemometry (LDV)]. The global response of the system in terms of shear stress will be monitored simultaneously. We will also take advantage of a smart photonic PAA hydrogel to gain crucial insights into the underlying mechanisms behind the flow control.