Sujet Stage M2

Elastic turbulence in von Karman swirling flow

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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).

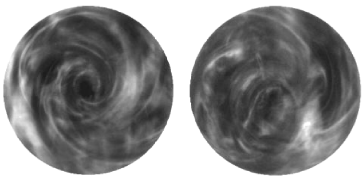

FIGURE 1 – Snapshots illustrating the disordered flow state called elastic turbulence in a viscoelastic polymer solution flowing between two parallel disks (von Karman swirling flow).

Recently, we revisited the transition to purely elastic turbulence in von Karman swirling flow of the benchmark polymer solution used in the literature over the past twenty years. We discovered that the base state was not the one speculated so far, namely a single toroïdal vortex at the scale of the whole setup. Instead, we observed the coexistence of two toroïdal vortices, one purely inertial in the central part of the flow and one purely elastic in the peripheral region. This observation entirely challenges the underlying mechanisms proposed up to now to explain the transition to purely elastic turbulence. The route to turbulence also remains an open question, as well as the universality of the scalings of the statistical properties in the fully turbulent state.

The goal of the internship is to tackle these various open questions and to provide a better understanding of the mechanisms responsible for the transition to elastic turbulence. Using experimental tools such as velocimetry techniques [particle image velocimetry (PIV) and laser anemometry (LDV)] and flow visualisations, and simultaneously monitoring the global response of the system in terms of shear stress, we will fully characterize the flow field and its dynamics for various viscoelastic systems ranging from the inertio-elastic domain to the purely elastic domain. We will also systematically examine the statistical properties of the fully turbulent state in these different domains, possibly providing insights into robust and universal characteristics as in the purely inertial counterpart.