Master 2 Internship/Thesis

Turbulence at low Reynolds number

Laboratory :

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Summary

In contrast to simple fluids, complex fluid (polymer solutions, emulsions, foams...) are all characterized by a mesoscopic structure, with characteristic length scales ranging from molecular sizes to the sample size. As a consequence, complex fluids exhibit viscoelastic properties, in the sense that their response to an external deformation combines an elastic (solid-like) part and a viscous (liquid-like) part. While being processed or used, complex fluids undergo moderate or strong flows which can easily affect their microstructure, which in turn feeds back on the flow itself, often leading to instabilities. Those instabilities occur at flow rates where inertial effects are negligible and are driven by elastic forces, leading to complex spatio-temporal behaviors sometimes reminiscent of inertial turbulence. They are involved in many industrial processes using extrusion of polymer solutions or melts. The mechanism of purely elastic turbulence is still an open question illustrating that fundamental research is required to find solutions to either suppress or control such instabilities. The control of elastic turbulence would be a promising solution to enhance mixing at small scale. Additionally, it can provide a route for heat transport into and from the sample which is also very challenging in microfabrication of new materials, and in particular in the control and productivity of chemical reactions.

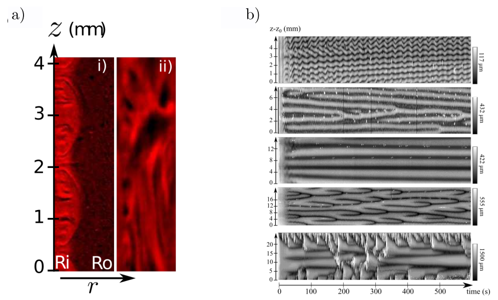

FIGURE 1 – *(a) Development of coherent structures and turbulence in the Taylor-Couette flow of wormlike micelles. (b) Different flow patterns as a function of the applied shear rate.*

In this project, we want to focus on elastic instabilities and turbulence that develop in giant micelles systems, whose flow behavior can easily be tuned by varying the surfactant concentration. The challenges are to characterize the flow and temperature fields under various flow conditions and to determine quantitatively the elastic driving forces. In particular, we want to explore the inertio-elastic and purely elastic regimes in benchmark macro-flows (von Karman and counter-rotating Taylor-Couette flows) to understand the interaction between elastic, inertial and thermal effects. Ultimately, we plan to control (enhance or inhibit depending on the required application) the instabilities by tuning in a systematic fashion the properties of the flow boundaries, namely their surface roughness, surface chemistry as well as their deformability.