Elastic turbulence in von Karman swirling flow of wormlike micelles

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Wormlike micelles are now well-known to exhibit elastic flow instabilities and turbulence in flows with curved streamlines, with a global phenomenology reminiscent of the one reported in regular polymer solutions over the past thirty years. Depending on the surfactant concentration, elastically-dominated turbulence and purely elastic turbulence have been observed in Taylor-Couette flows. The purely elastic case was reported for semi-dilute and concentrated systems undergoing a shear banding transition beforehand.

Purely elastic turbulence in polymer soutions was first and mainly characterized in von Karman swirling flow where the sample is held in a stationary cylindrical cup with a flat bottom (lower plate) and is sheared with a co-axial rotating upper plate touching the surface of the fluid[1,2]. The main features of this disordered flow state are a large increase of the flow resistance with a strong hysteretic character and excitation of a broad range of spatial and temporal scales leading to power law decay in the power spectra of the velocity fluctuations. Furthermore, the transition to elastic turbulence in this flow geometry is supposed to be mediated by the existence of a large toroidal vortex having the vessel size.

In this work, we propose to examine the transition towards purely elastic turbulence of shear banding worm-like micelles in von Karman swirling flow. Together with the rheological response, the flow structure is investigated using flow visualizations in different planes and velocimetry measurements. We show that a stationary and stable shear banding structure can develop in von Karman swirling flow but is quickly destabilized by the base flow, leading to a strongly disordered flow, which exhibits highly localized extensional components. The statistical properties of the fully turbulent state are also compared with the case of regular polymer solutions.

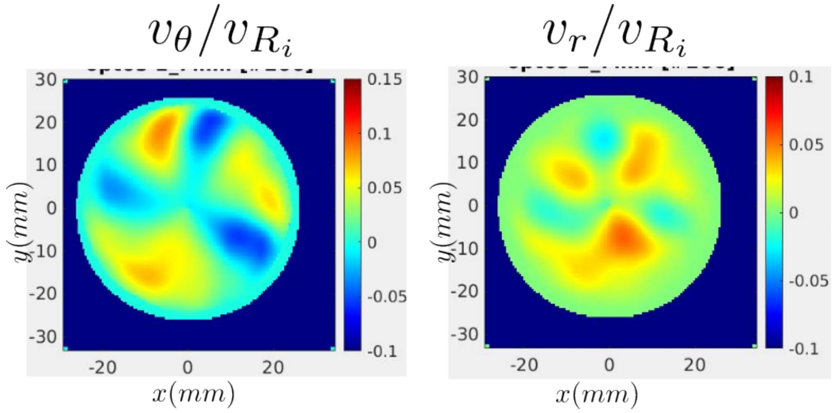

Figure 1: Instantaneous spatial distribution of the orthoradial (left) and radial (right) velocity components in the turbulent regime.

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[1] A. Groisman and V. Steinberg, *New J. Phys.* **6**, 29 (2004).

[2] T. Burhelea et al., *Phys. of Fluids* **19**, 053104 (2007).