Elastic Turbulence with Particles

The viscoelastic properties of polymer solutions can profoundly influence shear flows, transforming a stable flow into a combination of a steady primary flow and a dynamic secondary flow, even when the inertia effect is negligible. This transformation is characterized by the development of secondary flows that exhibit hierarchical flow structures, which generally follow a power-law distribution in terms of frequency. In this study, we report on the intriguing effects of incorporating particle suspensions into viscoelastic polymer solutions. The inclusion of particles modulates the secondary flow and also disrupts the established power-law distribution by inducing an unexpected rotational motion, concurrently damping the presence of other flow structures.

To delve deeper into this phenomenon, we employed direct visualization techniques to analyze both the velocity field and the formation of particle structures within the flow geometry. This investigation revealed that the observed regulatory effect stems from the shear-induced crystallization of the particles into layered sheets. Remarkably, this crystallization occurs even when the particle volume fraction remains significantly below the typical threshold required for such structural organization. Furthermore, we demonstrate a method to restore the original power-law distribution of flow structures by using polydispersed particles to hinder the crystallization process.

Our findings underscore the complex interactions between particle suspensions and viscoelastic fluid flows and challenge the conventional perspective that treats particle suspensions as a homogenous phase. This study expands our understanding of flow behavior in complex fluids and provides new insights into the control mechanisms applicable to such systems.