Title: Shear Banding in Wormlike Micellar Solutions

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Citation: 物性研究 (2006), 87(1): 112-113

Issue Date: 2006-10-20

URL: http://hdl.handle.net/2433/110623

Type: Departmental Bulletin Paper
Shear Banding in Wormlike Micellar Solutions

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1 Introduction

Complex materials, such as wormlike micellar solutions, often exhibit remarkable rheological behavior in shear flow. Shear banding is one of such phenomena whose spatio-temporal structures have been attracted much attention in recent years.

2 Model

We numerically investigate the spatio-temporal behavior in wormlike micellar solutions under shear using a time-dependent Ginzburg-Landau model[1]. In Fig.1, we display a stress-strain curve in homogeneous states. The region $\partial \sigma_{xy}/\partial \gamma < 0$ is unstable and shear bands appear.

3 Results

In Fig.2, we show the erratic temporal fluctuations of $\langle \gamma \rangle(t)$ and some snapshots of $\Phi(r,t)$ (composition) and $\gamma(r,t)$ (shear rate) at fixed shear stress. The large-amplitude fluctuations and highly unstable interfaces between bands are more pronounced closer to the coexistence curve in one phase region. In Fig.3, we present the temporal fluctuations of $\langle \sigma_{xy} \rangle(t)$ at fixed shear rate. Appearance of irregular "beats" is in accord with recent experiments[2,3].

References

Figure 1: Stress-strain relation for wormlike micellar solutions in homogeneous states.

Figure 2: Time evolution of the average shear rate $\langle \dot{\gamma} \rangle(t)$ and snapshots of $\dot{\gamma}(r,t)$ and $\Phi(r,t)$ for $\langle \sigma_{xy} \rangle = 5.4$. From left to right, $u = -6, -4, -2$, respectively. $u = N^{1/2}(2\chi - 1)$, $\chi$ the interaction parameter.

Figure 3: Time evolution of the average shear stress $\langle \sigma_{xy} \rangle(t)$ and snapshots of $\dot{\gamma}(r,t)$ and $\Phi(r,t)$ for $\langle \dot{\gamma} \rangle = 0.4$. $u = -6$. 

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