Shear Banding in Wormlike Micellar Solutions

Aichi Gakusen Univ. Tatsuhiro Imaeda
Institute of Industrial Science, Univ. of Tokyo Akira Furukawa
Dept. of Physics, Kyoto Univ. Akira Onuki

wormlike micellar solutionの shear banded状態における時空間構造について、Gizburg-Landau スキームにもとづいたモデルを数値的に解いて議論する。(1) shear stressが一定である条件下での shear rateの空間平均の時間的挙動、(2) shear rateが一定である条件下での shear stressの空間平均の時間的挙動、(3) それらの違いと空間的構造との関係、について報告する。stress-diffusion couplingが重要な役割を果たすことを強調したい。

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 Ginzuburg-Landau model[1].In Fig.1, we display a stress-strain curve in homogeneous states. The region $\partial\sigma_{xy}/\partial\dot{\gamma} < 0$ is unstable and shear bands appear.

3 Results

In Fig.2, we show the erratic temporal fluctuations of $\langle\dot{\gamma}\rangle(t)$ and some snapshots of $\Phi(\mathbf{r}, t)$ (composition) and $\dot{\gamma}(\mathbf{r}, t)$(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

1) A. Furukawa and A. Onuki, Physica D **205**(2005), 195.

2) H. Azzouzi, J.P.Decruppe, S.Lerouge,and O.Greffier, Eur.Phys.J.E **17**(2005), 507.

3) R. Ganapathy and A. K. Sood, Phys. Rev. Lett. **96** (2006), 108301.

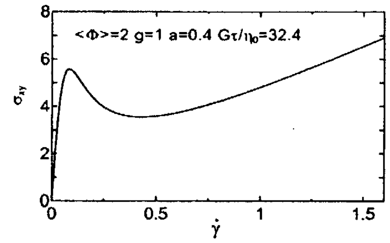

Figure 1: Stress-strain relation for wormlike micellar solutions in homogeneous states.

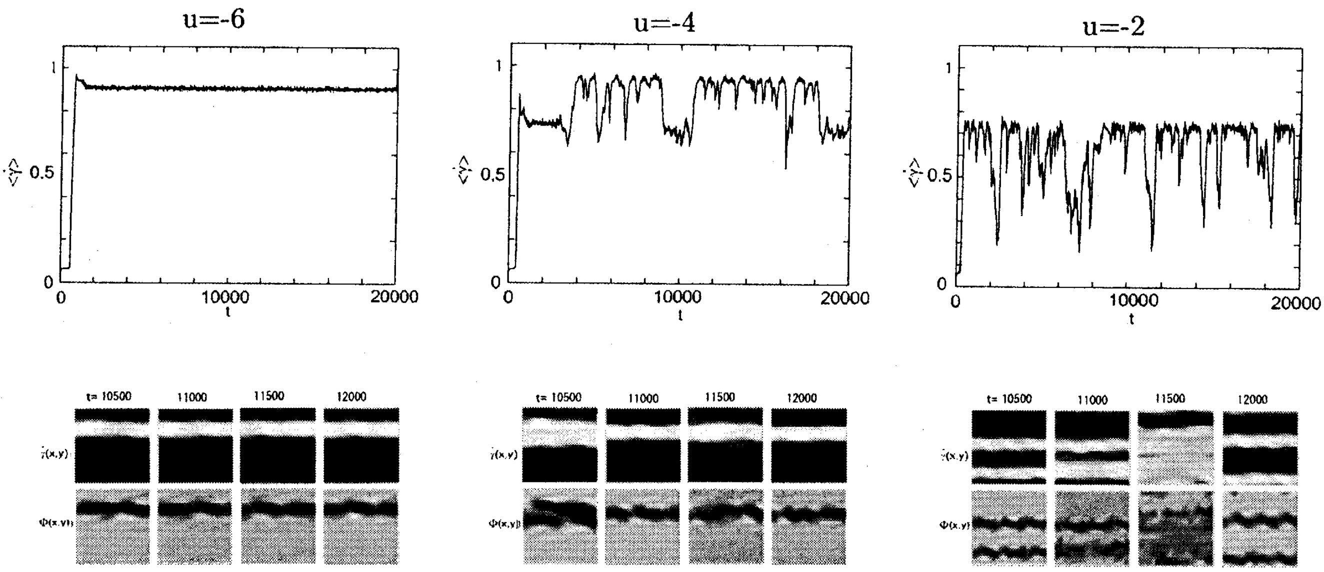

Figure 2: Time evolution of the average shear rate $\langle\dot{\gamma}\rangle(t)$ and snapshots of $\dot{\gamma}(\mathbf{r},t)$ and $\Phi(\mathbf{r},t)$ for $\langle\sigma_{xy}\rangle = 5.4$. From left to right, $u = -6, -4, -2$,respectively. $u = N^{1/2}(2\chi - 1)$,χ the interaction parameter.

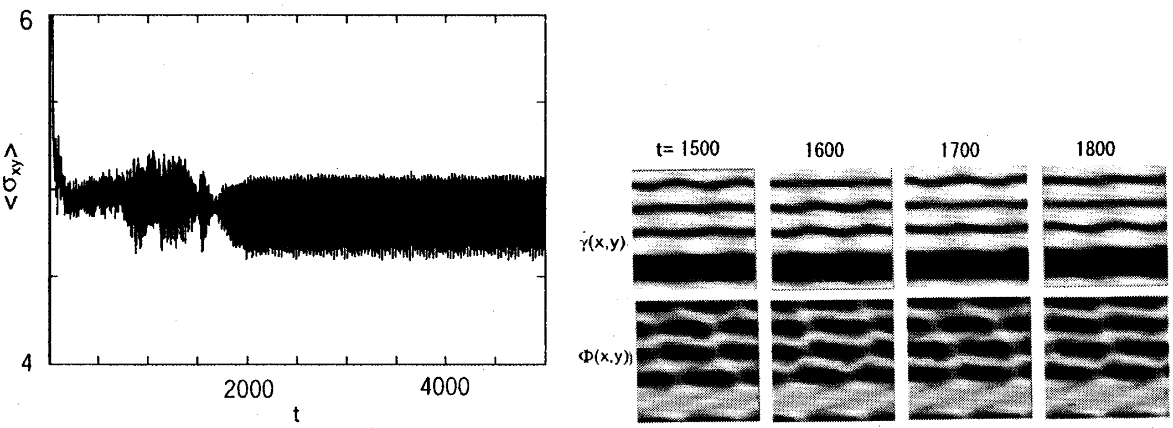

Figure 3: Time evolution of the average shear stress $\langle\sigma_{xy}\rangle(t)$ and snapshots of $\dot{\gamma}(\mathbf{r},t)$ and $\Phi(\mathbf{r},t)$ for $\langle\dot{\gamma}\rangle = 0.4$. $u = -6$.