Measurment of interparticle force between colloidal particles in nematic liquid crystal by optical tweezers

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異方的な流体である液晶中でのコロイド粒子間相互作用を光ピンセットを用いて測定することに成功した。この力は、等方的な媒質の場合と異なり、液晶の配向弾性力に起因した特徴的な力である。得られた粒子間力は、粒子-欠陥対の種類により大きく異なることが明らかとなった。

1 Introduction

Interaction between colloidal particles in isotropic fluid is mainly governed by *van der Waals* and electrostatic interactions. On the other hand, when the particles are dispersed in nematic liquid crystal (LC), the interaction is mediated by elastic deformation of LC. In this case, the alignment of LC is deformed by the anchoring force at the particle surfaces, although the alignment far from the particles (far-field director) is homogeneous. Especially in case of normal boundary condition at the particle surfaces, particle itself becomes a topological defect (radial hedgehog) and another defect (hyperbolic hedgehog) emerges beside the particle (Fig. 1). Interaction between particles with such defects are theoretically predicted by electrostatic analogy (dipolar type interaction) [1]. In this study, we measured the interparticle force F directly by using dual beam optical tweezers.

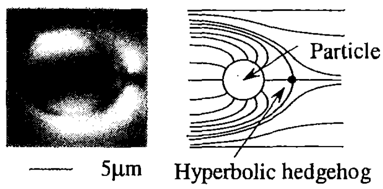

Figure 1: Dipolar-type particle-defect pair

2 Experiment

We prepared the particle-defect pairs by dispersing polystyrene latex particles whose radii a are 2.55±0.1 μm into low refractive nematic LC. The particles were covered with DMAOP to promote normal anchoring at their surfaces. In force measurement, we used dual-beam optical tweezers system. A particle trapped by the tweezers is in potential of the tweezers which we can approximately regard as harmonic one. Therefore, we can obtain F by measuring displacement

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of the particles from bottom of the potential. Furthermore, by changing the position of the laser focus, we change interparticle distance R along the line parallel to the far-field director.

3 Results and Discussions

We first show the dependence of F on R in parallel configuration which is shown in the inset (Fig. 2). The long range attractive force is explained by analogy to electrostatic $F \propto R^{-4}$. Furthermore, repulsive force is found at small R. According to recent numerical research [2] and careful observation under cross-Nicoles [3], this repulsion is originated from deformation of the hyperbolic hedgehog between the particles. We also found another type of configuration in the normal boundary condition. After making hyperbolic hedgehog face each other and the particles come very close, we could make the situation where two particles are connected with a defect like chewing-gum known as bubble-gum defect [4] (inset in Fig. 3). In this case, F increases with increasing R. In both cases, F reaches to long distance compared to that in isotropic medium. From these results, we found force curve depends on type of the accompanied defects.

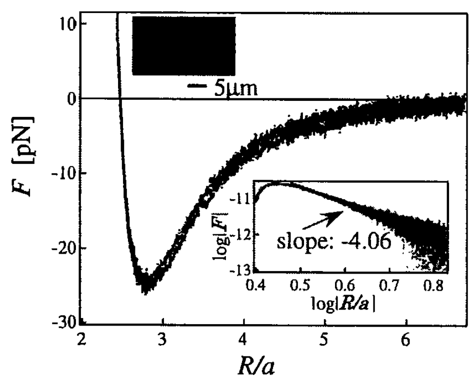

Figure 2: Dependence of F on R in paralle configuration as shown in the inset picture.

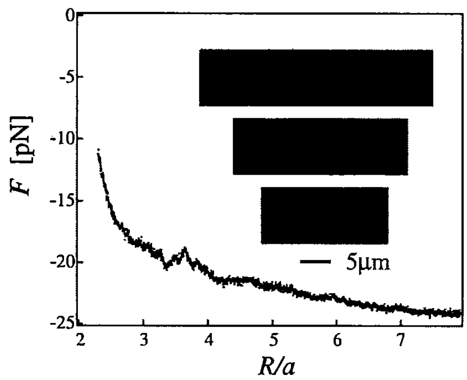

Figure 3: Dependence of F on R in a bubble-bum defect as shown in the inset picture.

References

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