

Colloidal particles at a nematic-isotropic interface: Effects of confinement

J.L. West¹, K. Zhang¹, A. Glushchenko², D. Andrienko^{3,1}, M. Tasinkevych^{4,5,a}, and Y. Reznikov⁶

¹ Liquid Crystal Institute, Kent State University, Kent, OH 44242, USA

² University of Colorado at Colorado Springs, Colorado Springs, CO 80933, USA

³ Max-Planck Institute for Polymer Research, Ackermannweg 10, Mainz 55128, Germany

⁴ Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, Stuttgart 70569, Germany

⁵ Institut für Theoretische und Angewandte Physik, Universität Stuttgart, Pfaffenwaldring 57, Stuttgart 70569, Germany

⁶ Institute of Physics, Prospect Nauky 46, Kyiv 03039, Ukraine

Received 9 January 2006 and Received in final form 5 May 2006 /

Published online: 22 June 2006 – © EDP Sciences / Società Italiana di Fisica / Springer-Verlag 2006

Abstract. When captured by a flat nematic-isotropic interface, colloidal particles can be dragged by it. As a result spatially periodic structures may appear, with the period depending on particle mass, size, and interface velocity (J.L. West, A. Glushchenko, G.X. Liao, Y. Reznikov, D. Andrienko, M.P. Allen, *Phys. Rev. E* **66**, 012702 (2002)). If liquid crystal is sandwiched between two substrates, the interface takes a wedge-like shape, accommodating the interface-substrate contact angle and minimizing the director distortions on its nematic side. Correspondingly, particles move along complex trajectories: they are first captured by the interface and then “glide” towards its vertex point. Our experiments quantify this scenario, and numerical minimization of the Landau-de Gennes free energy allows for a qualitative description of the interfacial structure and the drag force.

PACS. 61.30.Jf Defects in liquid crystals – 64.70.Md Transitions in liquid crystals – 82.70.-y Disperse systems; complex fluids

1 Introduction

Precise manipulation of tiny particles in liquids is a rapidly developing direction of modern technology. Manufacturing of *e*-papers and electrophoretic displays [1,2], separation of bacterial species and living cells [3–5], trapping of DNA and polymer particles [6–8], growth of photonic crystals [9, 10], are only a few examples revealing its scientific and technological importance.

In order to move, organize, or separate colloidal particles several techniques have been suggested, among them the drag of the micro-particles by a moving nematic-isotropic interface [11]. Briefly, due to the interfacial and surface tensions as well as long-range distortions of the director field, particles can be captured and subsequently dragged by the moving interface. Matching the speed of the interface, particle size, and elastic properties of the liquid crystal, one can move particles of specified radius and control their spatial distribution in the cell.

In our previous work [11] we consider the situation when the interface between the nematic and isotropic phases is flat. In a slab geometry, however, the interface

bends accommodating the contact angle between the nematic phase, the isotropic phase, and the substrates, and minimizing the director distortions on the nematic side of the interface [12,13]. As a result, the meniscus of the isotropic phase extends into the nematic phase; this, of course, influences particle trajectories in the interfacial region. In this paper we study the behavior of colloidal particles captured by a wedge-shaped interface. We first examine the shape of the interface and the director distribution in its vicinity. Then we analyze how these factors influence the trajectory of a particle in the interfacial region. We conclude that there is an additional force on a particle acting towards the vertex of the interface. Finally, we compare our experimental results to the estimates based on the minimization of the Landau-de Gennes free energy.

2 Experiment

Spherical polystyrene particles of diameter $d = 16 \mu\text{m}$ are dispersed in the isotropic phase of the liquid crystal 5CB using an ultrasonic shaker. The density of the particles, 1.04 g/cm^3 , is slightly higher than the density of pure 5CB, 1.007 g/cm^3 [14]. The surface of the particles provides planar alignment of the liquid-crystal director. Forty

^a e-mail: miko@fluids.mpi-stuttgart.mpg.de