Dynamics of Colloidal Particles in Nematic Liquid Crystals

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Abstract

With the development of new technologies and demands, the study of dynamics of colloidal particles has caught the attention of many researchers over the last years[1]. Despite the long history of the general phenomenon, colloidal suspensions in complex fluids such as a liquid crystal, is a relatively recent topic, scientific advances in which can bring new practical applications. Colloidal interactions in liquid crystals demonstrate new features caused by the long-range nature of elastic distortions associated with the orientational order of the liquid crystal and the so-called surface anchoring of molecular orientation at the interfaces, including the surface of the dispersed particles. Although the statics of liquid crystal colloids has been actively explored[2,3], little is known about the dynamics of colloidal particles in a liquid crystal host which is influenced by effects such as "backflow" associated with the molecular reorientation[4]. In this work we report on the dynamical properties of the micron-size spherical particles in the nematic liquid crystal. The dynamics is caused by application of AC electric field perpendicular to the overall director $\hat{\mathbf{n}}(\mathbf{r})$ that specifies the average molecular orientation of LC. The dielectric anisotropy of the material is negative so that the initial orientation of $\hat{\mathbf{n}}(\mathbf{r})$ parallel to the plates of the cell is reinforced by the field. We observed an unexpected directional motion of the particles along $\hat{\mathbf{n}}$ (perpendicular to the field); the motion can reverse its direction as a function of the field frequency. These results cannot be explained through the classic mechanisms such as the model of linear electrophoresis of charged particles in an isotropic fluid (which predicts a zero velocity in an AC field) and have to be attributed to the intrinsic properties of the LC colloids such as director distortions around the particles. We show that the velocity vs. electric field amplitude dependency is strongly nonlinear with an important contribution that is proportional to the square of the electric field that explains the very ability of the electrophoresis in an AC field.

References

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