MATERIALS SCIENCE

Anisotropic electrostatic screening of charged colloids in nematic solvents

Jeffrey C. Everts[1,2]*, Bohdan Senyuk[3]*, Haridas Mundoor[3], Miha Ravnik[1,4]†, Ivan I. Smalyukh[3,5,6]†

The physical behavior of anisotropic charged colloids is determined by their material dielectric anisotropy, affecting colloidal self-assembly, biological function, and even out-of-equilibrium behavior. However, little is known about anisotropic electrostatic screening, which underlies all electrostatic effective interactions in such soft or biological materials. In this work, we demonstrate anisotropic electrostatic screening for charged colloidal particles in a nematic electrolyte. We show that material anisotropy behaves markedly different from particle anisotropy. The electrostatic potential and pair interactions decay with an anisotropic Debye screening length, contrasting the constant screening length for isotropic electrolytes. Charged dumpling-shaped near-spherical colloidal particles in a nematic medium are used as an experimental model system to explore the effects of anisotropic screening, demonstrating competing anisotropic elastic and electrostatic effective pair interactions for colloidal surface charges tunable from neutral to high, yielding particle-separated metastable states. Generally, our work contributes to the understanding of electrostatic screening in nematic anisotropic media.

INTRODUCTION

[illegible] (1, 2) [illegible] (3) [illegible] (4 7) [illegible] (8) [illegible] (9 11) [illegible] (12, 13) [illegible] (14, 15) [illegible] (16 18) [illegible] (19 21) [illegible] (22) [illegible] (23) [illegible] (24, 25) [illegible] (26) [illegible]

[illegible] (27 29)

$$\phi(\mathbf{r}) \quad \mathcal{A}(\;,\;\lambda_D^I) \frac{(\;\lambda_D^I)}{\;} \qquad (1)$$

[illegible] λ_D^I [illegible] $\mathcal{A}(\;,\;\lambda_D^I)$ [illegible] $\phi($ [illegible]

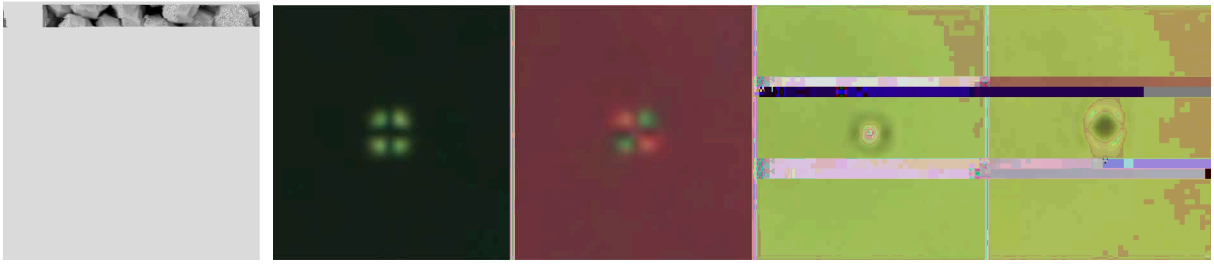
[illegible] (32 36) [illegible] (37 39) [illegible] (40) [illegible] (41, 42). [illegible]

[illegible]

RESULTS

Charged colloidal dumpling particles dispersed in a nematic electrolyte as model system

[illegible] 2 [illegible] 1 μ [illegible] (1000 [illegible]) [illegible] 1 ([illegible]), [illegible] n(r) [illegible] 1 [illegible] (43, 44). [illegible] 1) [illegible] n_0 [illegible] D /D [illegible] 1. [illegible] 1. [illegible] 1), [illegible]



[illegible]

[illegible]

$$\frac{\lambda_D(\theta)}{\lambda_D^I} \quad \frac{\epsilon \quad \epsilon}{\epsilon(\epsilon \quad \Delta\epsilon \quad {}^2\theta)} \tag{10}$$

[illegible] $\Delta\epsilon$ 0 ($\Delta\epsilon$ 0), [illegible]

[illegible]

[illegible]

$$\Phi(\;,\;)\quad \Phi_E(\;,\;) + \Phi\;(\;) + \Phi$$

[illegible]

$$\frac{\Phi_{E}(\ ,\ )}{\ _{B} T} \quad \alpha^{2}\gamma\ \ ^{2}\lambda_{B}(\ )\frac{\ /\lambda_{D}(\ )}{\ } \qquad (1\ )$$

[illegible] (. 2).

[illegible]

[illegible]

[illegible]

[illegible] (51), [illegible] (42, 52 54). [illegible] (55). [illegible] (56).

MATERIALS AND METHODS

Synthesis and characterization of charged colloidal dumplings

[illegible] (57). [illegible]

$\phi(\mathbf{r})/$

$/\phi(\mathbf{r})$ $/$ 1

$$^2\phi(\mathbf{r})\quad 0, \qquad\qquad (1\ )$$

$$(\epsilon\ /\bar{\epsilon})\qquad \kappa^2$$

[illegible] (2). [illegible] .2 [illegible] (5

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