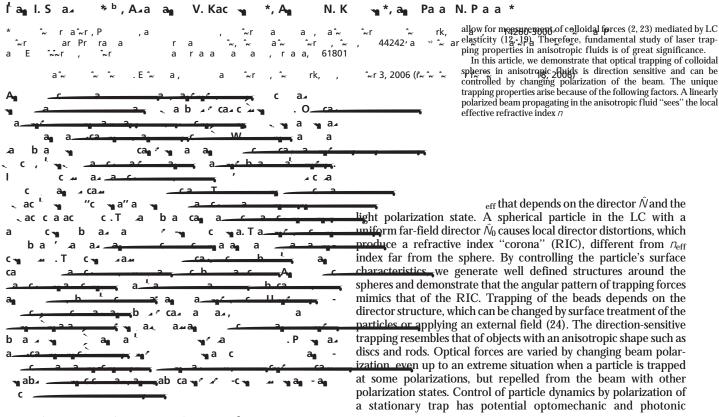
## Laser trapping in anisotropic fluids and polarization-controlled particle dynamics

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n ~rf(a 4)a/v (4)aewhach is an optar axis in the most common anisotropic fluids, the uniaxial liquid crystals (LCs). LCs are widely known for their applications in displays, telecommunications, and electro-optic devices (1). However, membranes, cytoskeleton proteins, amino acids, viruses, and lipids can form LC phases not only in vitro but even in vivo, ranging from self-organized structures of collagen in cornea (5) to nematiclike actin and myosin organization in muscle fibers (4), and to ordered structures in human spermatozoa (6, 7). Anisotropic

(11). Anisotropic suspensions (12, 13) and phases of bent-core molecules (14) have attracted a great deal of attention because of their unique properties and potential applications. Anisotropic self-organization in a living cell's interior may play a vital biological function and is readily observed by means of birefringence imaging (15, 16). Recently, there has been a growing interest in optical trapping in anisotropic media (17–22). Laser tweezers can control dynamics of nano- and micro-objects and

bead (Fig. 1 E and I). The only defects are two surface point defects (called "boojums") at the poles of a particle along  $\hat{N}_0$ . The colloidal beads that align  $\hat{N}$  perpendicular to their surfaces can produce dipolar (Fig. 1B) or quadrupolar (Fig. 1C) director structures and RICs; the structure type is controlled by the particle confinement into chambers of different thickness h (13). A dipole-type structure is formed in thick chambers of h 30  $\mu$ m much larger than the particle radius  $R = 1 \mu m$  (Fig. 1B); the bead is accompanied by a point defect in  $\hat{N}$ , the hyperbolic hedgehog. A quadrupolar "Saturnring" configuration is observed in an h 6 μm cell and contains a line defect (the disclination of a half-integer strength) encircling the particle in the equatorial plane perpendicular to  $\hat{\mathcal{N}}_0$  (Fig. 1 C, G, and K). Finally, when surface anchoring forces are weak compared with bulk elastic forces, the uniform director structure is barely perturbed by the beads and  $\hat{N}$  strongly deviates from the tangential (Fig. 1 D and L) or perpendicular (Fig. 1 H) orientations at their surfaces.

All director structures in Fig. 1 have a rotational symmetry axis crossing the particle's center parallel to the far-field director  $\hat{\mathcal{N}}_0$ . The respective RICs have a mirror symmetry plane orthogonal to the substrates and crossing the particle's center parallel to  $\hat{\mathcal{N}}_0$ . In the case o (dev)-3paredan-15.73291.4(1)]15.736 1 Tf17.6147 056 T0 Tc(N)Tj0.1 1 Tf0.6381 0 TD58 $\mathcal{N}$ 

that would be mirror images of those shown in Fig. 2  $\,{\cal C}$  and  $\,{\cal E}$ 

the far-field director  $\hat{N}_0$  than perpendicular to it (Fig. 4 A and B), consistent with the theory (13, 27) and recent experiments (28). We determine diffusion coefficients  $D_{\parallel/\perp}$   $^2_{\parallel/\perp}/2\tau$  and find the ratio  $D_{\parallel}/ea60.00573$  [{he}73[{006226.[{1Tf6.5006105.68}/9g}24.8{he})

shows that the studied anisotropic trapping properties are unique for anisotropic fluids.

T B F . In addition to thermotropic LCs, we also studied trapping in biological anisotropic fluids: aqueous solutions of  $\lambda$  phage DNA with optical anisotropy n  $n_{\rm e}$   $n_{\rm o}$  0 and FD virus with n 0. In both cases, |n| 0.01 is small and the average LC index  $\bar{n}_{\rm LC}$   $[(2n_{\rm o}^2$   $n_{\rm e}^2)/3]^{1/2}$  is close to that of water  $n_{\rm w}$  1.33. The anisotropy of trapping forces  $F_{\rm t}$  in these systems is observed ( 10%) when trapping silica beads with  $n_{\rm p}$  1.45. However, optical trapping is strong but direction insensitive for MR particles with  $n_{\rm p}$  1.69. Moreover,  $F_{\rm t}$ 

(19, 21). This behavior is in contrast to that in isotropic fluids, where calibration for only one direction in the lateral plane is sufficient (2). Moreover, Fig. 5B demonstrates that quantitative studies can be performed only for relatively low power. The measurements are easier in materials with low  $\ensuremath{n}$  for which the