The Physics of Soft and Biological Matter

Colloidal aggregation and dynamics in anisotropic fluids

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The formulation of colloidal particles/liquid crystals (LC) composites is a well-identified route towards the design of smart responsive materials with tunable optical or mechanical properties. However, the particles aggregate because they distort the intrinsic order of LC phases, which costs elastic energy. For micron-sized inclusions, the resulting elastic forces dominate the coarsening of the system. In this study, we find a new regime where elastic interactions no longer prevail when the particles are downsized to the nanometer scale. Instead, the system evolution is governed by an anisotropic Brownian diffusion coupled to attractive depletion interactions. This finding opens up new possibilities to better control the clustering of colloids in such media.

In our work, we present experiments and numerical simulations to investigate the collective behavior of sub-micrometer-sized particles immersed in a nematic micellar solution. We use latex spheres with diameters ranging from 190 nm to 780 nm and study their aggregation properties due to the interplay of the various colloidal forces at work in the system. We found that the morphology of aggregates strongly depends on the particle size with an evidence for two distinct regimes: the biggest inclusions clump together within minutes into either compact clusters or “V-like” structures that are completely consistent with attractive elastic interactions. On the contrary, the smallest particles form chains elongated along the nematic axis, within comparable time scales. In this regime, Monte Carlo simulations, based on a modified diffusion-limited cluster aggregation model, strongly suggest that the anisotropic rotational brownian motion of the clusters combined with short-range depletion interactions dominate the system coarsening; elastic interactions no longer prevail. The simulations reproduce the sharp transition between the two regimes upon increasing the particle size. We provide reasonable estimates to interpret our data and propose a likely scenario for colloidal aggregation. These results emphasize the growing importance of the diffusion of species at sub-optical-wavelength scales and raise a number of fundamental issues.