

Curvature-driven fluxes of colloids

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There are important fields, intrinsic to soft matter, which we can exploit to direct colloidal assembly. The central idea is this: When a colloid is placed in a soft matter host, the colloid deforms the host, with some energetic consequence. If the host is a fluid interface, changes in interface area and particle wetting energies define the energetic consequence. If the host is a nematic liquid crystal, elastic energy costs owing to deformations of the director field play a role. If the host is a lipid bilayer membrane, costs associated with bending and tension emerge. In each of these examples, by molding the soft matter host within well-defined boundaries, we can define global energy fields that drive colloids along well defined paths to sites for preferred assembly. We demonstrate this concept at fluid interfaces by molding their curvatures. Particles align modes of their deformation fields along principle axes and move along paths defined by the local curvature gradients. We then demonstrate this concept using confined nematic liquid crystals. In this example, we form host director fields that are non-singular. Particles migrate within these fields to form structures guided by the host field, and nest in specific docking sites defined by gentle energy gradients in the vicinity of bounding walls. Finally, we discuss particles trapped on lipid bilayers, which interact with vesicle shape. In each of these examples, in the small deformation limit, there are important analogies to charge multipoles that guide our thinking. For example, for colloids at fluid interfaces, the leading order mode in the particle-sourced distortion is a quadrupolar mode; as such the colloidal distortion couples, via orthogonality, to the anti-symmetric part of the interface curvature. Colloids with homeotropic anchoring in nematic liquid crystals form dipolar or quadrupolar elastic defects, which couple to slopes or curvatures of the nematic director field. The value and limitations of these analogies are explored. Strategies are developed to drive colloids into complex structures.