Geometry as a field: Strategies for Directed Assembly

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We have been developing new strategies for directed assembly by defining energy landscapes in confined soft matter host by controlling the geometry and boundary conditions. Colloids placed in these hosts create deformations; those deformations often cost energy. Since the deformations decay over distances similar to the particles, there is an energy field around the particle. The energy field is dependent on the energy landscape in the host, which we use to direct assembly.

In one example particles trapped on fluid interfaces deform the interface, increasing the surface area and energy of the interface. Particles can interact and assemble in highly organized assemblies guided by the interface curvature. This phenomenon is remarkably rich; particles can experience curvature capillary attraction, repulsion, and find equilibrium states. A second example addresses particles in confined nematic liquid crystals (NLCs). The colloids distort the NLC host, and seed topological defects in the director field. By confining the NLC, a host director field can be defined. The colloid distorts the host field, and moves to minimize this distortion. Colloids move in well-defined paths to form structures guided by these fields. These phenomena are quite general, provided that three criteria are met. First, the soft matter host must have an energetic penalty to confinement. Second, the particle must distort the energy landscape. Third, the particle must not be in a trapped state, but must be able to move in the perturbed energy landscape. Applications and foci of current interest include structure formation in materials science to path planning in microrobotics.