Energy Stored in Deformation Fields: Opportunities for Directed Assembly in Soft Matter

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When particles interact with soft matter, energy can be stored in distortions owing to their presence. This energy can be harnessed to direct particle assembly. These spontaneous interactions can complement- or even replace- external applied fields to orient, assemble and steer colloidal materials into well-defined structures at given locations.

We have been working on three example systems in which spontaneous interactions occur owing to microparticle-induced distortions. In the first example, we study capillary interactions which occur between anisotropic particles at fluid interfaces, or between particles trapped at cured interfaces. The microparticles distort the fluid interface to satisfy their wetting boundary conditions or owing to kinetic trapping of the contact line, altering the area and hence the energy of the interface. The product of this area and surface tension is an energy field, which we exploit to direct particles to migrate, orient and assemble. We focus on the role of particle shape in determining pair interactions on planar and curved interfaces. In the second example, we exploit elastic energies and defect fields that arise in confined liquid crystals. In these systems, elastic energy is stored in a distortion of the director field, either owing to the particle surface or to confinement. Examples of nematic liquid crystals confined on topographically complex surfaces to store elastic energy and to direct particle assembly along defect lines, or in geometries dictated by defect lines. Related examples for particle migration in smectic films, with either free surfaces or on topographically complex surfaces are discussed. In the final example, initial work on understanding interactions owing to bending energies and tension in tense fluid membranes is presented.