

Colloidal self-assembly : From effective interactions to new structures

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Colloidal suspensions are complex fluids that consist of mesoscopic particles moving around in a solvent, often with other components such as salt ions or added polymers. As colloids display the same phase behaviour as atoms or molecules, colloidal suspensions are widely used to study basic fundamental processes such as melting, freezing and glass transitions. Another attractive feature is that the effective interactions between colloids can be tuned.

In this talk, I will show how one can exploit this picture of colloids as extremely tunable "superatoms or building blocks" to obtain new phases and new structures which may lead to "advanced functional materials", e.g., e-ink displays, photonic bandgap structures, and electrorheological fluids. More specifically, I will show that binary hard-sphere mixtures can either give rise to a broad fluid-solid transition or can organize spontaneously into superlattice structures depending on the precise size ratio of the two species. In addition, mixtures of oppositely charged colloids display a remarkably rich variety of crystal structures as the crystal structure is not dictated by the charge neutrality condition as in the case of ionic crystals.

The resulting phase diagram of oppositely charged colloids displays colloidal analogs of simple-salt structures, colloidal counterparts of the doped fullerene structures, but also novel structures. Finally, I will show that many new phases can be manipulated by external fields, e.g., an electric field stabilizes the hexagonal-close-packed, body-centered-orthorhombic, and body-centered-tetragonal phase, while triangular, square, buckling, and prism phases are found in confined hard spheres.