The Formation of Complex Structure in Confined Colloid Systems.

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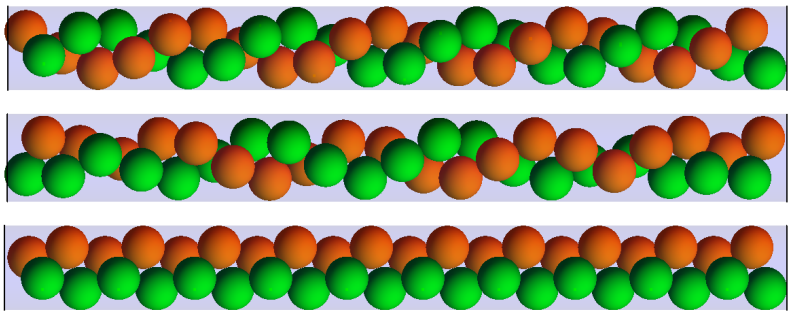
When spherical colloidal particles are geometrically confined they form an array of complex structures that are unstable in the bulk. For example, when confined to narrow, quasi-one-dimensional channels, the particles form a series of helical packings, including single, double and triple staggered helices, depending on the diameter of the channel. If confined between parallel plates in a quasi-two-dimensional geometry, the colloids exhibit multiple crystalline phases that vary in relative stability depending on the separation of the plates. We use a combination of theory and simulation to study the mechanisms of structure formation in these confined geometries. In the case of the quasi-one-dimensional channels, we show that topological defects play an important role in the winding and unwinding of the helical structure. We also find that packing constraints within sections of the helix lead to a long range entropically driven attraction between defects that may have interesting implications for the phase behaviour of these systems. In the quasi-two-dimensional system, we study the nature of the solid-solid transition between a crystal with square symmetry and one with triangular symmetry. In the bulk, solid-solid transitions usually involve a Martensitic transformation. However, in this confined system, the transition occurs through a non-classical nucleation mechanism, mediated by the formation of precritical liquid clusters.



Colloids confined to a narrow cylindrical channel. The least dense packing of spheres in the channel consists of two zig-zag chains (bottom). Removing pairs of defects leads to a winding of the structure to form a perfect helix (top).