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Formation of Complex Spherical Packing Phases in Hard Spheres with SALR Interactions

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Complex spherical packing phases, namely the Frank-Kasper (FK) phases, have been discovered in various soft matter systems such as block copolymers and surfactant solutions. A generic and simple model for the formation of spherical packing phases in these systems comprises hard spheres with short-range attraction and long-range repulsion (SALR). In the SALR systems, the attractive head promotes the colloids to form clusters, while the repulsive tail prevents the clusters from growing infinitely. The resultant finite-sized clusters could pack onto a crystal lattice forming a cluster crystal. It is anticipated that the ability of the clusters to change their volume and shape could enable the formation of stable complex spherical packing phases. In the current work, the formation of the FK σ and A15 phases in a system of hard spheres with SALR interactions is studied using density functional theory. A set of phase diagrams with different SALR potentials are constructed showing that the stability of σ and A15 phases is highly sensitive to the potential. The key factor stabilizing the FK phases is also discussed. Our results provide a first step in understanding the universality of the existence of the complex spherical packing phases in a broader range of soft matter systems.

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