Are rigidity and directed percolations the precursors of colloidal gelation?

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One major goal in condensed matter is identifying the physical mechanisms that lead to arrested states of matter, especially gels and glasses. The complex nature and microscopic details of each particular system are relevant. However, from both scientific and technological viewpoints, a general, consistent and unified definition is of paramount importance. Through Monte Carlo computer simulations of states identified in experiments, we demonstrate that dynamical arrest in adhesive hard-sphere (AHS) dispersions is the result of rigidity percolation with coordination number, $\langle n_b \rangle = 2.4$. This corresponds to an established mechanism leading to mechanical transitions in network-forming materials. Thus, our findings connect the concept of critical gel formation in colloidal suspensions with short-range attractive interactions to the universal concept of rigidity percolation. Furthermore, with states recently explored in confocal microscopy experiments of colloid-polymer mixtures at intermediate colloidal volume fractions and in computer simulations, we corroborate that directed percolation can be identified as the equilibrium pretransition towards the formation of gels in colloidal dispersions with competing interactions.

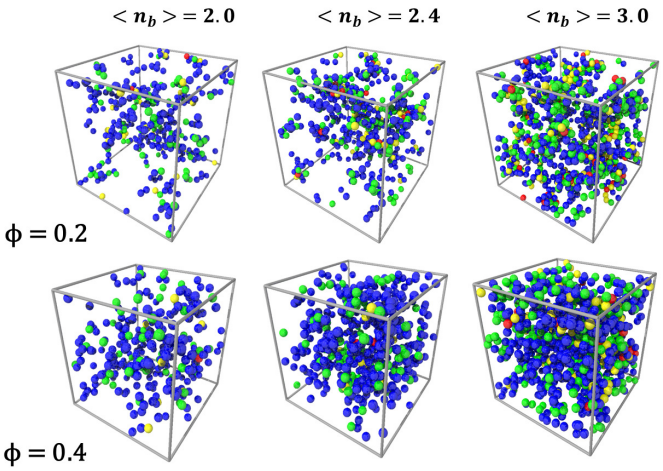

FIG. 1. Snapshots of the AHS system at two different volume fractions for three different iso-coordination number curves: $\langle n_b \rangle = 2$ (left), $\langle n_b \rangle = 2.4$ (middle) and $\langle n_b \rangle = 3$ (right). Particles with 4 (blue), 5 (green), 6 (yellow) and 7 or more (red) bonds are only displayed, which would correspond to rigid regions.

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