Self-replication with magnetic dipolar colloids

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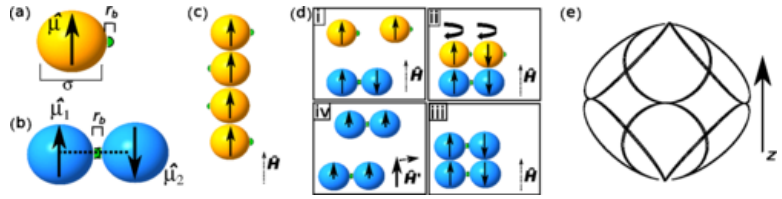
Colloidal self-replication represents an exciting research frontier in soft matter physics. In this paper, we introduce a scheme using ferromagnetic dipolar colloids and preprogrammed external magnetic fields to create an autonomous self-replication system. Interparticle dipole-dipole forces and periodically varying weak-strong magnetic fields cooperate to drive colloid monomers from the solute onto templates, bind them into replicas, and dissolve template complexes. We show via statistical models and computer simulations that our system exhibits nonlinear growth of templates and produces nearly exponential growth (low error rate) upon adding an optimized competing electrostatic potential.



The simple dipole replication scheme. (a) Detailed sketch of the dipole model used for self-replication (b) A dimer template which will be replicated. If the external field strength H is weak compared to k, then the two magnetic moments in the dimer antialign. (c) If no colloids are bound, then the preferred configuration for low dipole concentrations in a weak field is a line. Binding sites are never close enough to form a new dimer. (d) The four-step replication cycle. In steps (i)–(iii) (the replication phase), a template replicates. In step (iv) (the mixing phase), a strong external field is reoriented continuously to dissolve clusters. (e) A sample of the direction of the mixing field indicated by the path it traces on the unit sphere.

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