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Patterned Magnetic Fluids with Magnetic Colloidal Polymers

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Self-assembly in magnetic fluids is known to affect their properties and is therefore a crucial component to control when designing magnetic fluids for specific applications. By introducing crosslinks to fix naturally occurring self-assembled motifs, thereby moving from classical to patterned magnetic fluids, one can achieve finer control over material properties and develop next-generation stimuli-responsive materials. Here, we focus on magnetic colloidal polymers (MCPs) as the pattern of interest—polymer-like mesostructures formed by crosslinked magnetic nanoparticles (NPs)—which exhibit enhanced optical, thermal, mechanical, rheological, and surface-adsorption properties compared with conventional magnetic fluids[1]. The interplay between magnetic interactions and solvophilic/solvophobic forces gives rise to complex self-assembly behaviour, which can be controlled using magnetic fields.

In our previous work, we investigated isolated MCPs and showed how solvophobicity can lead to compact, magnetically frustrated conformations, with structural features depending on the type of crosslinking and the magnetic nature of the nanoparticles [2]. These distinctions also have a strong impact on MCP dynamics under shear flow and external magnetic fields [3].

Building on this foundation, in this contribution we study in silico the self-assembly of solvophobic MCP-based magnetic fluids. We explicitly simulate the magnetodynamics of magnetic nanoparticles with finite magnetic anisotropy[4], considering magnetically soft, hard, and isotropic particles. Using a sophisticated computational methodology, we capture internal magnetization dynamics over long timescales and for system sizes large enough to probe bulk behaviour. We discuss the distinct and varied structural, magnetic, and dynamical features driven by both solvophobicity and the intrinsic magnetic properties of the constituent nanoparticles, and relate them to the MCP architecture.

References

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