TECHNISCHE UNIVERSITÄT
IN DER KULTURHAUPTSTADT EUROPAS
CHEMNITZ

Institut für Physik
Physikalisches Kolloquium



Donnerstag, 03.12.2026, 15:30 Uhr

Ort: Reichenhainer Str. 90;
Zentrales Hörsaal- und Seminargebäude, Raum C10.013

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Sculpting with Dipoles: Non-Equilibrium Dynamics and Self-Assembly in Magnetic Colloids

Magnetic colloidal suspensions - fluids of nanoscale particles carrying permanent magnetic moments - sit at the cross-roads of non-equilibrium statistical mechanics, soft matter, and functional materials design. Using large-scale molecular dynamics (MD) simulations of the Stockmayer (SM) model, which pairs isotropic Lennard-Jones (LJ) interactions with directional dipole-dipole couplings, we explore how dipolar anisotropy reshapes phase separation, magnetic ordering, and self-assembly across length and time scales. Furukawa predicted that late-time domain growth in binary fluids is governed by fluid inertia, following the asymptotic scaling law $l_s(t) \sim t^{2/3}$ [Phys. Rev. A 31, 1103 (1985)]. Capturing this inertial regime in MD simulations, however, has remained elusive. In our simulations of the coarsening SM fluid, we observe unambiguous evidence of this $l_s(t) \sim t^{2/3}$ scaling. Intriguingly, fluid inertia dominates from the onset of phase separation, suppressing the early diffusive $[l_s(t) \sim t^{1/3}]$ and intermediate viscous $[l_s(t) \sim t]$ crossover regimes characteristic of conventional LJ fluids.

At later stages and across varying densities, dipolar interactions sculpt rich, density-dependent equilibrium morphologies with distinct magnetic signatures. By tailoring thermal and cooling protocols, we show how to guide these building blocks into defect-free colloidal magnetic crystals or trap them into arrested glassy states following deep quenches. Beyond resolving long-standing questions in non-equilibrium coarsening, these mechanisms offer practical design principles for catalysis, targeted drug delivery, magnetic memory devices, and tunable magnetic photonic crystals.

1. Glassiness and dynamic arrest in magnetic and non-magnetic colloids.
   Anuj Kumar Singh, Lambert Münster, Varsha Banerjee and Martin Weigel.
   https://doi.org/10.48550/arXiv.2609.14599
2. Self Assembly of Dipolar Crystals from Magnetic Colloids.
   Anuj Kumar Singh, Sanjay Puri and Varsha Banerjee.
   Physical Review E 112, 015420 (2025).
3. Phase Separation in a Magnetic Fluid: Asymptotic States and Non-Equilibrium Kinetics.
   Anuj Kumar Singh and Varsha Banerjee.
   Physical Review E 108, 064604 (2023).
4. Accelerated Inertial Growth in the Spinodal Decomposition of Magnetic Fluids.
   Anuj Kumar Singh and Varsha Banerjee.
   Soft Matter 19, 2370 (2023).

Alle Zuhörer sind ab 15:15 Uhr zum Kaffee in den Seminarräumen C60.033/032 eingeladen.