133

Orientational bistability and field-controlled switching of a superparamagnetic dimer

Author: James Tett[1]

Co-authors: Alice Thorneywork [1]; Brennan Sprinkle [2]; Finlay Johnston [1]

[1] *University of Oxford*

[2] *Colorado School of Mines*

Superparamagnetic colloids are widely used as field-responsive building blocks in magnetic actuation and biosensing assays and provide a versatile soft matter model to explore interacting systems. While the interactions of superparamagnetic colloids are often described in terms of induced magnetic moments aligned with an applied field, this picture cannot fully account for the torque-generating response exploited in many experiments.

Here, we study the orientational dynamics of rigid superparamagnetic colloidal dimers using bright-field microscopy in static and square-wave magnetic fields. In static fields, permanently bonded magnetic dimers fluctuate between two preferred in-plane orientations, giving a bimodal steady-state distribution. Under periodic field reversal, the same dimers show a sharp field-controlled crossover in their relaxation response: from full π-reorientations to small hops. We show that a minimal model for magnetic response that combines a strong induced magnetic moment with a weaker body-fixed component rationalises both behaviours, through movement across a multistable orientational energy landscape. By combining the field-dependence of the preferred orientations, the crossover field and short-time orientational variance, we infer the magnitude and orientation of the effective permanent dipole of individual dimers directly from microscopy. More broadly, these results show how weak internal magnetic asymmetries in nominally superparamagnetic particles leave dynamical fingerprints at the level of a single colloidal assembly 1.

References

1) Tett et al. Orientational bistability and field-controlled switching of a superparamagnetic dimer, 2026. arXiv:2604.15212

Type:

Oral