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Magnetic Anisotropy Effects in Nanoscale Polymer Chains

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Magnetic nanoparticles are conventionally modelled using a static dipole approximation, equivalent to assuming infinite magnetic anisotropy, which is a reasonable assumption for particles above 100 nanometres. For smaller particles, thermal energy becomes significant, allowing the magnetic dipole to fluctuate away from the easy-axis, making finite anisotropy effects important. We employ a thermal Stoner-Wohlfarth model to compare infinite and finite magneticanisotropy scenarios[1].

Self-assembled nanopolymers exhibit diverse structures including rings, chains, zigzags, and hairpins, with certain structures appearing exclusively in one model. We quantify filament stiffness using a novel measure based on the principal component of the radius of gyration tensor, evaluated as a function of position along the chain and fit to theoretical expressions. Unexpectedly, finite anisotropy chains exhibit greater stiffness and show larger end-to-centre stiffness variation when compared to their infinite anisotropy counterparts. At all field strengths examined, differences between the two models are significant, demonstrating that magnetic anisotropy effects cannot be neglected when modelling magnetic nanomaterials of size 10–100 nanometres.

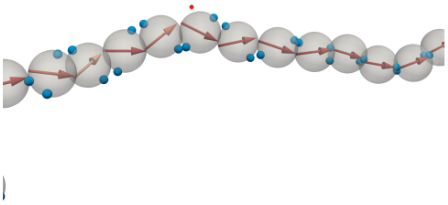

Figure 1: Snapshot of a magnetic nanopolymer simulated using the thermal Stoner-Wohlfarth model showing a 'zigzag'conformation. Note the dipoles are not aligned with the easy-axis, denoted by the blue spheres on each particle.

References

[1] Deniz Mostarac; Andrey A. Kuznetsov; Santiago Helbig; Claas Abert; Pedro A. S´anchez;Dieter Suess; Sofia S. Kantorovich Phys. Rev. B 2025, 111, 014438.

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