Propulsion and Controlled Steering of Nanohelices

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The development of artificial micro and nanomotors that can be externally controlled accurately and precisely in spatial and temporal time scales has attracted increasing interest for applications in biosensing, targetted delivery and environmental remediation. Recent experiments have demonstrated that fuel-free propulsion can be achieved through the application of external magnetic fields on magnetically shaped structures. The magnetic interaction between the helices and the rotating field induces a torque that rotates and propels the helix because of the coupled rotational and translational motion. Experiments show that controlled motion remains a challenge at the nanoscale due to Brownian motion that interferes with the deterministic motion and makes it difficult to achieve controlled steering [1]. Here we employ quantitatively accurate simulation methodology to design a setup for which magnetic nanohelices of 30 nm in radius, with and without an attached cargo, can be accurately propelled and steered in the presence of thermal fluctuations. We also demonstrate fast transport of such nanomotors and devise protocols in manipulating external fields to achieve controlled steering at biologically relevant conditions.

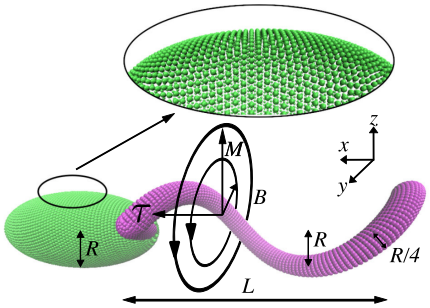

Figure 1. Node representation of the nanohelix that is driven with a rotating external magnetic field. The magnetic moment of the helix is fixed perpendicular to its long axis such that the resulting torque from the interaction with the magnetic field is along the long axis of propulsion.

[1] Schamel, D. *et al.* Nanopropellers and their actuation in complex viscoelastic media. *ACS Nano* **8**, 8794-8801 (2014)