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ע״ש וולפסון
The Wolfson Department of Chemical Engineering

Wolfson Department of Chemical Engineering Seminar

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Room #6

Dynamics of flat superparamagnetic micropropellers driven by a rotating magnetic field

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MSc seminar

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In the past decade synthetic micro and nanomotors capable of propulsion in various biological fluids attracted considerable attention, as they can be used in various biomedical applications. Magnetic actuation is of particular interest as it offers engine-less and fuel-free propulsion. In comparison to traditional techniques, where strong static *gradient* fields are applied (of about 0.1 Tesla/cm) to steer magnetic nano-particles, it was found that efficient propulsion can be achieved under a much weaker *rotating* magnetic field (milli-Tesla range). Significant progress has been recently made in experimental and theoretical research of three-dimensional chiral (e.g., helical) micro/nanostructures; however, their fabrication requires sophisticated techniques as opposed to two-dimensional (2D) structures, which can be manufactured by standard photolithography methods. Here we demonstrate that actuation by a rotating magnetic field can yield propulsion of flat V-shaped superparamagnetic (i.e., susceptive to magnetization) structures. Superparamagnetic propellers do not possess remanent magnetization, but get instantly magnetized in the presence of an applied magnetic field. The lack of the remanent magnetic moment prevents the spontaneous agglomeration in a suspension in the absence of the actuating field, as opposed to the ferromagnetic micro/nanostructures.

We found that net propulsion is feasible for V-shaped polarizable structures, although the direction of the easy-axis of magnetic anisotropy has a significant influence on the frequency range at which propulsion is achieved. We focus particularly on two cases of (i) in-plane and (ii) off-plane orientation of the magnetic anisotropy easy-axis. It was found that asymmetric V-shaped structures (with unequal arm lengths) are superior “swimmers” in comparison to the symmetric propellers, as they offer optimal combination of the magnetic anisotropy, and large wobbling angles, as required for efficient propulsion of V-shaped structures.