Design and control of a magneto-elastic micro-swimmer inspired by the motility of sperm cells

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Abstract

We formulate and solve the equations governing the dynamics of a microscopic artificial swimmer composed of a head and a magnetic tail, inspired by the geometry of sperm cells, and actuated by an oscillating magnetic field. Using values for the geometric and material parameters which are realistic for a magnetic multi-layer, we show that the model swimmer can reach swimming speeds of the order of one body-length per second, under reasonable values of the driving magnetic field. This provides a proof of principle for the viability of the concept. In addition, we discuss the possibility to steer the system along curved paths. Finally, we compare the propulsion mechanism of our swimmer with that of sperm cells. The main difference between the two is that, contrary to its biological template, our artificial system does not rely on the propagation of bending waves along the tail, at least for the range of material and geometric parameters explored in this paper.

Keywords: low Reynolds number swimmers, soft robotics, bio-inspired robots, artificial flagella and cilia, magnetic multi-layers.

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