Shape-directed Microspinners Powered By Ultrasound

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ACS Nano **12**, 2939–2947 (2018)

The propulsion of micro- and nanoparticles using ultrasound is an attractive strategy for the remote manipulation of colloidal matter using biocompatible energy inputs. However, the physical mechanisms underlying acoustic propulsion are poorly understood, and our ability to transduce acoustic energy into different types of particle motions remains limited. Here, we show that the three-dimensional shape of a colloidal particle can be rationally engineered to direct desired particle motions powered by ultrasound. We investigate the dynamics of gold microplates with twisted star shape (C_{nh} symmetry) moving within the nodal plane of a uniform acoustic field at megahertz frequencies. By systematically perturbing the parametric shape of these "spinners", we quantify the relationship between the particle shape and its rotational motion. The experimental observations are reproduced and explained by hydrodynamic simulations that describe the steady streaming flows and particle motions induced by ultrasonic actuation. Our results suggest how particle shape can be used to design colloids capable of increasingly complex motions powered by ultrasound.

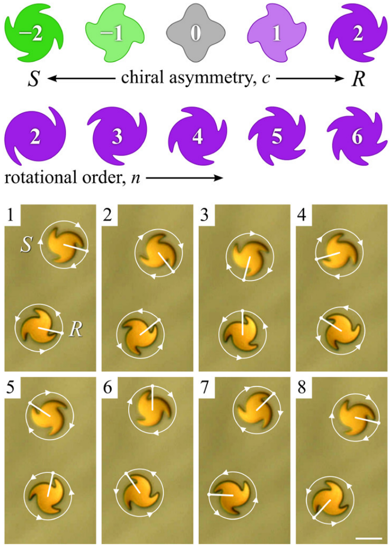

Figure: (top) Particle shapes defined by eq 1 for different values of the chiral asymmetry c (top, with n = 4) and the rotational order n (bottom, with c = 2). (bottom) Image sequence showing a pair of counter-rotating spinners with a = 5.8 μm, c = ±2, and n = 3 (see also Supporting Movie 1). Here, the R spinner rotates CCW, and the S spinner rotates CW. The time interval between successive frames is 1.17 s; the scale bar is 10 μm.

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Funding: Work by the Olvera group was funded by the Center for Bio-Inspired Energy Science, an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Basic Energy Sciences under Award DE-SC0000989.