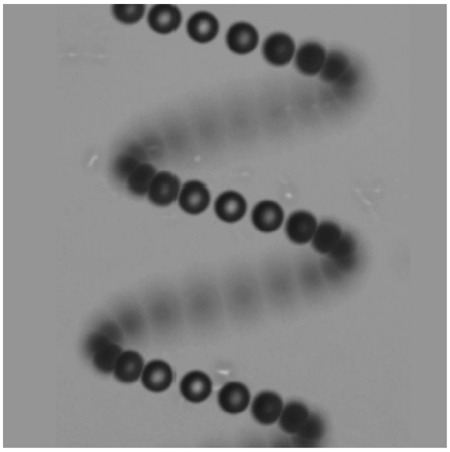
ACTIVE MATTER

Swirling swimmer

Nat. Commun. **10**, 2575 (2019)



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The development of functional micro- and nanoscale robotics calls for new strategies to design locomotion that facilitates navigation through crowded environments. However, this task has proved challenging due to the significant gravitational and thermal forces that are operational at reduced scales, which tend to confine the motion of self-propelled particles to two dimensions. Now, Lee and colleagues show how to realize and program helical motion using patchy microspheres powered by an electric field in solution.

Polystyrene microspheres are coated with triangular metal patches characterized by a single plane of mirror symmetry. On application of an a.c. field, an asymmetric fluidic flow is generated around each particle due to the induced-charge electrophoresis effect, driving the particle to perform steady helical motions. The speed and radius of the trajectories are programmable by controlling the geometry of the metal patches and the strength of the a.c. field. The particles following helical trajectories are shown to have an enhanced transport efficiency through a crosslinked cellulose membrane with porous structure, compared with those moving along linear trajectories. This approach can help design future micro- and nanorobots capable of moving in three-dimensional complex environments in an efficient and controllable way. *CH*

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ROTAXANES

The catalyst and the machine

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Rotaxanes are molecules made up of two components: a ring and an axle. The ring threads the axle and cannot escape due to the presence of stopper groups. The axle can be made to contain two recognition groups, or stations, so that the ring shuttles between them in response to a chemical signal. Biagini and colleagues now show a rotaxane molecular machine in which one of the two stations is a catalyst and where catalytic activity is switched on and off as a result of a transient change in pH, induced by the addition of a fuel.

The researchers install a thiourea and an amine station along the axle. Under acidic conditions, the amine gets protonated and the axle prefers to bind to the ammonium group. Under basic conditions, interaction with the thiourea is preferred instead. When the axle vacates the thiourea station, the catalytic function of the rotaxane is switched on. More precisely, thiourea catalyses the reduction of a nitrostyrene by a Hantzsch ester. To induce acidic conditions, the researchers add trichloroacetic acid — a compound that decomposes over time into chloroform and carbon dioxide. The trichloroacetic acid is akin to a fuel: the machine only operates when it is available. The researchers show that the system is robust to a handful of consecutive additions of the fuel. *AM*

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MAGNETO-OPTICS

Light with momentum

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Circularly polarized light — that is, light with a spin angular momentum — can probe the magnetism of condensed-matter systems through an effect called circular dichroism. Light that carries an orbital angular momentum in addition to a spin angular momentum forms so-called vortex beams. Sirenko and colleagues now use such vortex beams at terahertz frequencies to detect magnetic excitations in a ferrimagnetic rare-earth iron garnet and observe an orbital-momentum-dependent dichroism in addition to the expected circular dichroism.

The researchers shine vortex beams of opposite orbital angular momentum onto the transparent crystal and measure the transmittance. They observe collective excitations of ligand field modes, which are linked to the precession of the rare earth and iron spins, and detect a dependence of the signal intensity on the orbital angular momentum of the vortex beams. Interestingly, the vortex beam dichroism is more pronounced than the circular dichroism also measured by the researchers. These experiments show the potential of vortex beams for the exploration of complex magnetic materials and for the distinction between spin and orbital contributions to the magnetic texture. *BH*

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2D MATERIALS

Understanding the twist

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Interlayer rotation — that is, the degree to which two monolayers are twisted against each other — is commonly observed in the layered structures of 2D materials, resulting in the formation of moiré patterns. Interestingly, even slight rotation variations may have a profound impact on the electronic properties of the resulting material system. However, it is still unclear what governs the formation of different twist angles and whether this process can be controlled to tailor material properties. Now, Zhu and colleagues, using bilayer MoS_2 and graphene as model systems, propose a general moiré-driven mechanism to explain the interlayer rotation in 2D layers.

To predict the rotation behaviour, the researchers employ an interface lattice model and molecular dynamics simulations. An interface lattice model — based on the assumption that the relative layer rotation is dominated by interactions of the two atomic layers at the interface — takes into account the relationship between interfacial energy and rotation angle, as well as the effect of the flake size. The analysis shows that the interlayer rotation is driven by the interface lattice moiré, which is universal for any 2D material, regardless of size. Generally, if moiré patterns are formed between two layers with a hexagonal lattice, a triangular array will emerge from the domains with high energy stacking, while a hexagonal array will be formed by the low-energy domains. In both cases, within a finite-sized region, the resulting rotation minimizes the total energy of the domains. *OB*

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Olga Bubnova, Benjamin Heinrich, Congcong Huang and Alberto Moscatelli