skin friction led to power savings ranging from 30% to 55% after accounting for the power required for generating the forcing.

The new methodology proposed does have its limitations, of course. For instance, even though the laminar state persists some distance downstream of the forcing location, the flow eventually transitions back to a turbulent state. This means that rotors or jet injectors used to make the mean profile more uniform have to be installed at regular intervals. Moreover, the transition to turbulence in pipe flow — a process that is still not fully understood[5–7] — becomes increasingly sensitive to small disturbances (such as vibrations or surface imperfections) as the Reynolds number increases. While disturbances can be minimized in laboratory conditions, this is normally not possible in practical applications. Larger ambient disturbances in real-world systems would result in a quicker transition back to a turbulent state, limiting the energetic savings possible.

Active turbulence control for pipe flows is not a new idea. Yet few of the turbulence-control techniques proposed previously have moved beyond proof-of-concept laboratory experiments and simulations, and for good reasons. Many proposed techniques require control elements distributed along the entire pipe, either to suppress disturbances as they arise in laminar flows or to continuously tinker with energetic turbulent flow features. Such control systems are complex to engineer and expensive. The path suggested by Kühnen et al. — letting the flow transition to turbulence naturally and intermittently destabilizing this turbulent flow by changing the mean profile — is inherently simpler. Perhaps we will see something similar in a pipeline before long. ❐

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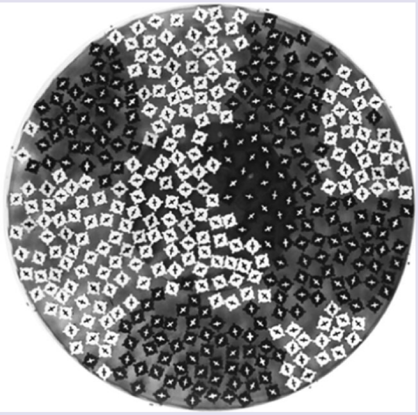
SOFT MATTER

# Cog in the machine

Active-matter systems are composed of elements that consume energy. Living things are the most obvious members of this category, but the definition is broad enough to include a number of artificial systems as well.

As is the case in many other fields of physics, the appeal of studying synthetic active-matter systems comes from the possibility of breaking down complex phenomena into their components, and investigating them in easily tunable environments. Testing hypotheses on an ensemble of bespoke robots sounds a lot simpler than messing around with a flock of birds.

A characteristic of many active-matter systems is their tendency to exhibit collective motion or self-organization, leading to non-equilibrium steady-state structures. But what exactly drives that tendency? In other words, what degrees of freedom need to be excited in order to elicit collective behaviour? As real systems are so complex, this sounds like the sort of question that a synthetic analogue might help us unravel.



Credit: Macmillan Publishers Ltd

This is precisely what drove Christian Scholz and co-workers to study the dynamics of rotors — 3D printed cog-shaped robots. Each rotor comprises a cross-shaped cap atop a cylinder that rests on seven tilted legs, angled at 18 degrees. Put in contact with a vibrating surface, the legs transform the vibration into a rotation, clockwise or counter-clockwise depending on their tilt.

What Scholz and colleagues have now shown (*Nat. Commun.* **9**, 931; 2018) is that an ensemble of 420 rotors — 210 rotating in one direction and 210 in the other — exhibit collective motion and phase separate into domains of co-rotating rotors (pictured, with black and white rotors spinning in opposite directions). This might sound counter-intuitive at first: two adjacent rotors spinning in the same direction tend to get in each other's way and can't freely rotate — so why would they clump together? In fact, the authors argue, it's precisely the long contact time generated by collisions that leads to the spontaneous separation of the ensemble.

The authors established a quantitative analogy between their ensemble of discrete and colliding rotors with real active-matter systems, typically driven by completely different forces, by showing that the dynamics they observed can be fitted to a system of coupled Langevin equations.

Although it's too early to say whether this system of synthetic active spinners may help us understand living systems, it's a welcome addition to our toolbox for studying active matter. ❐

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