**ACTIVE NEMATICS**

**Turbulent beginnings**

An inspired experimental approach sheds light on the formation of active turbulence in a system of microtubules and molecular motors. The emergent scaling behaviour takes us a step closer to understanding how activity begets turbulence.

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A comparison between passive and active liquid crystals reveals dramatic differences. A uniformly aligned passive nematic is in its equilibrium state and will remain aligned unless acted upon by an external force. In contrast, a uniformly aligned active nematic is intrinsically unstable; its director spontaneously bends and the fluid begins to flow, driven solely by the consumption of chemical energy. Writing in *Nature Physics*, Berta Martínez-Prat and co-workers have captured the initial instability in a two-dimensional nematic consisting of bundles of microtubules and their associated kinesin motors deposited on an oil–water interface.

The experimental challenge was aligning the active nematic at the beginning of the experiment. In previous studies of this system, the instability, which occurs rapidly, would happen out of sight while the experimenters were loading the samples onto the microscope. To overcome this, the team inserted a straw into the centre of the sample at the oil–water interface, thereby drawing in material and creating radial flows that aligned the microtubules.

The initial state immediately after withdrawing the straw resembled a bicycle wheel with the spokes radiating outward from the hub (Fig. 1a). What followed next was dramatic. First, the aligned microtubule fibres began to undulate as they extended and periodically buckled, leading to a collective instability that resulted in alternating rings of ±½ topological defects in the liquid crystal (Fig. 1b). The ±½ defects acted as active quasiparticles that generated flow by propelling themselves forward and reoriented the microtubules into alternating bands of circumferentially aligned regions (Fig. 1c). Next, these aligned bands themselves became unstable and buckled, re-establishing the radial alignment (Fig. 1d). After another cycle or two of this striking sequential folding, the active nematic became fully turbulent (Fig. 1e).

As the field of active matter matures, there is an increasing need to quantitatively compare theory and experiment. The testing of scaling laws, as done by Martínez-Prat and colleagues, is a first step. But even this step is challenging. In their data analysis, the team assumed the activity was proportional to the logarithm of the concentration of ATP. A recent paper suggests another expression for the activity based on the fact that the speed of single kinesin motors follows Michaelis–Menten kinetics.

**Fig. 1 | Transition to turbulence.** Microtubules mapping the nematic director in black, defects in grey with flow direction marked in red. a, In the experiment by Martínez-Prat and colleagues, microtubules initially radiated outward. b, A collective instability then produced alternating rings of ±½ topological defects. c, The defects reoriented the microtubules into alternating bands of circumferentially aligned regions. d, A second instability generated radially aligned bands of defects and reoriented the microtubules. e, Finally, the active nematic became fully turbulent.
to be reliable, so beyond the issue of whether or not the relationship of activity to ATP concentration is correct, is the problem that the data for the scaling law cover less than an order of magnitude in ATP concentration. To make progress beyond scaling laws, researchers are now quantitatively comparing detailed dynamics between numerical models and experiment — revealing ways in which theory and experiment agree, and more importantly for pushing the field forward, disagree5–7.

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References