Polar state reversal in active fluids

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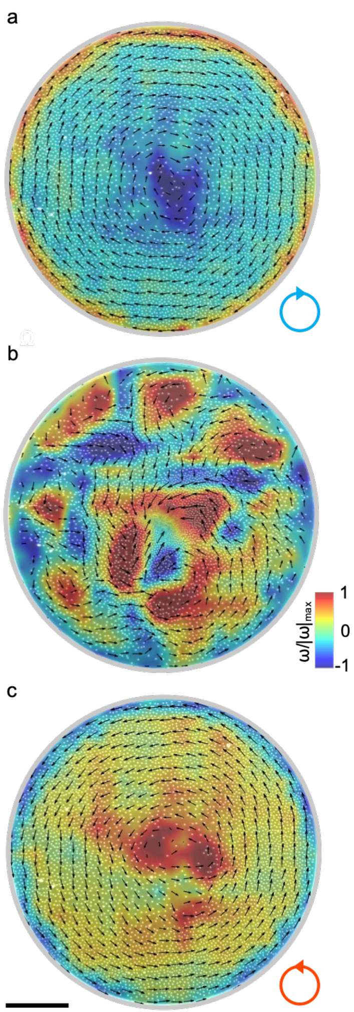

Figure. Snapshots of superimposed velocity (arrows) and vorticity (background color) fields of the rollers during a vortex reversal under a temporal modulation of the activity. (a) A stable initial roller vortex with a clockwise rotation. (b) Intermittent flocking after re-activation of the system. Rollers initially move mostly towards the center of the cell. (c) A stable vortex with a counter-clockwise rotation evolved from the state shown in (b). The blue and red circles with an arrow illustrate the chirality of the states. The scale bar is 0.2 mm. The field strength E = 2.7 V μm^{-1}, the particle area fraction $\phi = 0.12$.

Scientific Achievement

We discover that a global vortex formed by colloidal rollers exhibits polar state reversal, and a subsequent formation of the collective states upon re-energizing the system is not random.

Significance and Impact

Seemly disordered dynamics of active particles tend to develop local structural asymmetries in response to competing repulsive and aligning interactions, which could be exploited to systematically control self-organized emergent states with the aid of temporal modulation of activity.

Research Details

We combine experiments and simulations to elucidate how a combination of hydrodynamic and electrostatic interactions leads to hidden asymmetries in the local particle positional order, reflecting the chiral state of the system. We isolate the role of hydrodynamics as a driving force in the development of the local particle positional asymmetries and reveal the crucial role of electrostatic repulsive interactions as a key mechanism making the spatial distribution of particles relevant in the formation of the subsequent chiral states of the ensemble upon reactivation.

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CBES Center for Bio-Inspired Energy Science