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Antipolar ordering of topological charges in active liquid crystals

JORN DUNKEL, MIT, ANAND OZA, Courant Institute — Recent experiments demonstrated that ATP-driven microtubule-kinesin bundles can self-assemble into two-dimensional active liquid crystals that exhibit a rich creation and annihilation dynamics of topological defects, reminiscent of particle-pair production processes in quantum systems. This remarkable discovery has sparked considerable theoretical and experimental interest. Here, we present and validate a minimal continuum theory for this new class of active matter systems by merging universality ideas with the classical Landau-de Gennes theory. The resulting model agrees quantitatively with recently published data and, in particular, predicts a previously unexplained regime of antipolar order. Our analysis implies that active liquid crystals are governed by the same generic ordering principles that determine the non-equilibrium dynamics of dense bacterial suspensions and elastic bilayer materials. Moreover, the theory manifests a profound energetic analogy with strongly interacting quantum gases. Generally, our results suggest that complex nonequilibrium pattern-formation phenomena might be predictable from a few fundamental symmetric-breaking and scale-selection principles.

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