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Emergence of Chiral Phases in Active Torque Dipole Systems

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The common description of active particles as active force dipoles fails to take into account that active processes in biological systems often exhibit chiral asymmetries, generating active chiral processes and torque dipoles. Examples of such systems include cytoskeleton filaments which interact with motor proteins and beating cilia and flagella. In particular, the generation of active torques by the actomyosin cytoskeleton has been linked to the break of chiral symmetry at a cellular level. This phenomenon could constitute the primary determinant for the break of left-right symmetry in many living organisms, e.g. the position of the human heart within the human body. In order to account for the effects of chirality, we consider active torque dipoles which generate a chiral active stress. We characterize quasi-1D and 2D systems of torque dipoles, using a combination of linear stability analysis and numerical simulations (Lattice Boltzmann). Our results show that activity drives a spontaneous breaking of chiral symmetry, leading to the self-assembly of a chiral phase, in the absence of any thermodynamic interactions favoring cholesteric ordering. At high values of activity, we also observe labyrinthine patterns where the activity-induced chiral ordering is highly frustrated.

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