Chirality and Odd Mechanics in Active Liquid Crystals

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Living matter continually converts chemical energy into work, driving it out of equilibrium. Active matter is a general framework for describing such driven systems through additional stresses that break time-reversal symmetry at the microscopic level. It has been used to describe the novel dynamics, mechanics, and statistics of bacterial swarms, biofilms, developing tissues, self-propelled colloids, and a plethora of broken-symmetry phases [1]. A fundamental theme is the breaking of symmetries, or reciprocities, that hold in thermal equilibrium and an example of current high interest is the "odd elasticity" of two-dimensional chiral active solids [2, 3]. Chiral materials are distinguishable from their mirror images and are ubiquitous in biology, where left-right symmetry breaking is normal. Recently, we have identified minimal realisations of odd elasticity in three-dimensional chiral active liquid crystals [4, 5], predicting sustained vortical fluid flows and oscillatory dynamics without mechanical inertia, which should be seen *in vitro* in biofilament-motor complexes and are likely to arise in living columnar structures such as axons and muscle.

This project will develop the theory of chiral mechanics in three-dimensional active liquid crystals and solids. It will identify the key signatures of odd elasticity, including active instabilities and oscillatory dynamics, and the minimal ingredients needed to control the odd mechanical responses. A focus will be on the role of topological defects, including those associated specifically with chirality, and on mechanical responses that are sensitive to the handedness of the material structure in addition to the chirality of active stresses.

References

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