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Exploring flocking via quantum many-body physics techniques

ANTON SOUSLOV, BENJAMIN LOEWE, PAUL M. GOLDBART, Georgia Institute of Technology — Flocking refers to the spontaneous breaking of spatial isotropy and time-reversal symmetries in collections of bodies such as birds, fish, locusts, bacteria, and artificial active systems. The transport of matter along biopolymers using molecular motors also involves the breaking of these symmetries, which in some cases are known to be broken explicitly. We study these classical nonequilibrium symmetry-breaking phenomena by means of models of many strongly interacting particles that hop on a periodic lattice. We employ a mapping between the classical and quantum dynamics of many-body systems, combined with tools from many-body theory. In particular, we examine the formation and properties of nematic and polar order in low-dimensional, strongly-interacting active systems using techniques familiar from fermionic systems, such as self-consistent field theory and bosonization. Thus, we find that classical active systems can exhibit analogs of quantum phenomena such as spin-orbit coupling, magnetism, and superconductivity. The models we study connect the physics of asymmetric exclusion processes to the spontaneous emergence of transport and flow, and also provide a soluble cousin of Vicsek's model system of self-propelled particles.

Anton Souslov
Georgia Institute of Technology

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