Title: Simple models of complex active materials

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Abstract: Active matter describes far-from equilibrium systems, such as the internal components of a cell or a bacterial suspension, whose constituent particles consume energy to generate motion. I will describe computer simulations of two recently developed active matter systems, and some unexpected ways in which these systems exhibit order or disorder at large scales. (1) Self-propelled colloids with repulsive interactions and no aligning interactions are a minimal model active matter system. We and others have shown that, even when particles experience only repulsive interactions, this system undergoes a phase coexistence that mimics the equilibrium phase separation of attractive colloids. I will present a simple kinetic theory that describes the dynamics of phase separation, resulting in a framework analogous to equilibrium classical nucleation theory. (2) Active nematics are liquid crystals which are driven out of equilibrium by energy-dissipating active stresses. The ordered nematic state is unstable to the proliferation of topological defects, which undergo birth, streaming dynamics, and annihilation to yield a seemingly chaotic dynamical steady-state. I will describe a heretofore unknown broken-symmetry phase that we have discovered in 2D active nematics, in which the topological defects themselves undergo orientational ordering. Time permitting, I will then describe a preliminary understanding of instabilities that occur in the ordered state of a 3D active nematic.