Introduction to statistical field theories for active matter

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Statistical field theories are a standard theoretical toolkit for describing the spatiotemporal patterns of phases in continuous systems. For an equilibrium system, its symmetries and conservation laws fix the form of the field theory, with fluxes given by the gradients of thermodynamic potentials. But what kinds of field theories can we use to describe the patterns formed by living systems? In this lecture, I will review how statistical field theories have been extended to active matter, a class of nonequilibrium systems consisting of agents that propel themselves. First, we will examine derivations field theories for scalar, polar, and nematic active matter, highlighting how they model nonequilibrium fluxes. Then we will discuss how each model provides intuition into the collective patterns of living systems, especially with regards to clustering, flocking, and topological properties.