Abstract Submitted
for the DFD08 Meeting of
The American Physical Society

Instabilities, pattern formation and mixing in active suspensions

DAVID SAINTILLAN, Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign, MICHAEL SHELLEY, Courant Institute, New York University — Suspensions of self-propelled particles are known to undergo complex dynamics as a result of hydrodynamic interactions. To elucidate these dynamics, a kinetic theory is developed and applied to study the linear stability and the non-linear pattern formation in these systems. The evolution of a suspension of self-propelled particles is modeled using a conservation equation for the particle configurations, coupled to a mean-field description of the flow arising from the stress exerted by the particles on the fluid. Based on this model, the stability of isotropic suspensions of particles is first investigated. We demonstrate the existence of an instability in which shear stresses are eigenmodes and grow exponentially at long scales, and propose an interpretation in terms of the system entropy. Non-linear effects are also studied using numerical simulations in two dimensions. These simulations confirm the results of the stability analysis, and the long- time non-linear behavior is shown to be characterized by the formation of strong density fluctuations, which merge and break up in time in a quasi-periodic fashion. These complex motions result in very efficient fluid mixing, which we quantify by means of a multiscale mixing norm.

David Saintillan
Department of Mechanical Science and Engineering,
University of Illinois at Urbana-Champaign

Date submitted: 02 Aug 2008 Electronic form version 1.4