Weekly Seminar: Spring 2009

Date: Friday February 27

Time: 11:00 AM

Location: Maryland Hall 110

Speaker: Jeffrey F. Morris, City College of New York

Title:*"Suspension Mechanics with Inertia: Particle-Scale and Bulk Phenomena"*

Abstract

Suspension flows of rigid particles in Newtonian fluids are perhaps the simplest of dispersed multiphase flows. In the limit of vanishing inertia at the particle scale, where the Reynolds number Re (based on the particle size and shear rate) can be taken as zero, these are well-studied materials. This seminar will consider current understanding of the influence of inertia, i.e. finite Re, in the behavior of suspensions of rigid particles and describe recent work showing inertial effects at both particle and bulk scale. Following an overview of Stokes flow (Re = 0) suspensions to provide background, the following topics showing the influence of inertia in suspensions will be discussed:

i. At the particle scale, inertia alters the topology of streamlines and particle trajectories. The flow around a single particle and the trajectories of a pair in simple shear flow will be discussed. These show spiraling and reversing regions absent at vanishing inertia.

ii. In pressure-driven flows, inertia drives a very well-known but still poorly described cross-stream migration phenomenon initially described by Segré & Silberberg (J. Fluid Mech. v. 14; 1962). Our experiments at large pipe Reynolds number have shown that the lateral force associated with Recent theory combined with numerical simulation show clearly that the influence of finite size is a major player in this behavior; we consider the implications for observed migrations and hence the distribution of particles in conduit flows. This is observed to have major impact in microfluidic flows. In addition, the particles may induce instability, including an early onset of turbulence.

iii. At the bulk scale, even small inertia in a particle-laden flow introduces the Reynolds stress mechanism for momentum transfer. This mechanism is based on velocity fluctuations. Based on stress determined from wall-bounded simple shear of suspensions from 5-30% solids, computed by lattice-Boltzmann simulation, the constitutive behavior for the suspension stress at finite Rep in simple shear is explored, and a simple form – amenable to use in computational fluid dynamics – is proposed to capture key features.