Weekly CEAFM Seminar: Fall 2014

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Date: **Friday, October 31, 2014**

Time: 11:00 AM

Location: Gilman Hall # 132

Speaker: **Prof. Michael Graham** (University of Wisconsin-Madison)

Title: ***"Drag Reduction and the Dynamics of Turbulence in Simple and Complex Fluids"***

Abstract

Addition of a small amount of very large polymer molecules or micelle-forming surfactants to a liquid can dramatically reduce the energy dissipation it exhibits in the turbulent flow regime. This rheological drag reduction phenomenon is widely used, for example in the Alaska pipeline, but it is not well-understood, and no comparable technology exists to reduce turbulent energy consumption in flows of gases, in which polymers or surfactants cannot be dissolved. The most striking feature of this phenomenon is the existence of a so-called maximum drag reduction (MDR) asymptote: for a given geometry and driving force, there is a maximum level of drag reduction that can be achieved through addition of polymers. Changing the concentration, molecular weight or even the chemical structure of the additives has no effect on this asymptotic value. This universality is the major puzzle of drag reduction.

We describe direct numerical simulations of turbulent channel flow of Newtonian fluids and viscoelastic polymer solutions. Even in the absence of polymers, we show that there are intervals of "hibernating" turbulence that display very low drag as well as many other features of the MDR asymptote observed in polymer solutions. As viscoelasticity increases, the frequency of these intervals also increases, leading to flows that increasingly resemble MDR. A simple theory captures key features of the intermittent dynamics observed in the simulations. Additionally, simulations of "edge states", dynamical trajectories that lie on the boundary between turbulent and laminar flow, display characteristics that are similar to those of hibernating turbulence and thus to the MDR asymptote, again even in the absence of polymer additives. Furthermore, a family of nonlinear traveling solutions in channel is found whose mean velocity closely resembles MDR. Based on these observations, we propose a tentative unified description of rheological drag reduction. The existence of "MDR-like" intervals even in the absence of additives sheds light on the observed universality of MDR and may ultimately lead to new flow control approaches for improving energy efficiency in a wide range of processes.