Weekly CEAFM Seminar: Fall 2017

JOHNS HOPKINS
Center for Environmental
& Applied Fluid Mechanics

Date: **Friday, October 27, 2017**

Time: 11:00 AM

Location: Hodson Hall # 210

Speaker: **Prof. Amy Shen** (Okinawa Institute of Technology)

Title: *"Viscoelastic and Inertial Instabilities in Microfluidic Flows"*

Abstract

Microfluidics has emerged in recent years as a versatile platform of manipulating fluids at small length-scales, offering a large range of deformation rates and direct visualization of resulting flow fields, providing unique opportunities for capturing the flow instabilities of viscoelastic fluids in real time. Two simple microfluidic platforms are used to highlight the intricate balance between viscoelastic and inertial instabilities of complex fluids.

(1) Micro-cross-slot devices: studies of flow instabilities in stagnation point flow geometries have focused mostly on either Newtonian fluids, in which the instabilities are driven entirely by inertia, or on highly elastic fluids where inertia plays a negligible role. However, weak fluid elasticity can modify the flow response remarkably, giving rise to important effects such as turbulent drag reduction in macroscale pipe flows. Here we examine fluid flow through micro-cross-slot devices with various aspect ratios, and investigate how weakly elastic fluids can influence an inertially-driven flow instability. Our experimental configuration allows direct examination of a single steady vortex, shedding new insight into the competing effects of inertial and elastic instabilities on vortex formation and dynamics at small length scales.

(2) Confined microfluidic cylinders: Wormlike micellar (WLM) solutions are frequently used as fracture and proppant-carrying fluids in enhanced oil and gas recovery applications in porous rock beds where complex microscopic geometries result in mixed flow kinematics with strong shear and extensional components. To gain understanding of WLM fluids flowing through porous media, we examine the flow of WLM fluids around a single micro-scale cylinder aligned on the flow axis. The WLM solution is strongly viscoelastic and exhibit shear banding behaviour. Flow of WLM solutions around confined cylinders results in the onset of a sequence of low Re flow instabilities, which depend on both Wi (as high as 10^5) and the blockage ratio. Interestingly the flow instabilities first emerged upstream of the cylinder, which are associated with high stresses in fluid that accelerates into the narrow gap between the cylinder and the channel wall, while instabilities downstream of the cylinder are associated with stresses generated at the trailing stagnation point and the resulting flow modification in the wake, coupled with the onset of time-dependent flow upstream and the asymmetric division of flow around the cylinder.