PHYSICAL MATHEMATICS SEMINAR

LIFE AND DEATH OF A WEAKLY VISCOELASTIC JET: FROM FLUID MECHANICS TO RHEOMETRY

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ABSTRACT:

Dilute polymer solutions are used extensively in the formulations for inks, water-borne paints, food, nasal sprays, cosmetics, insecticides, fertilizers and bio-assays to control the rheology and processing behavior of multi-component dispersions. These complex dispersions are processed and used over a broad range of shear rates ($1 - 10^6$ s^{-1}) and extensional rates ($> 10^3$ s^{-1}). Since the polymer solutions typically have low viscosity (~10 mPa s) and short relaxation times (< 1 ms), their non-Newtonian behavior is not apparent in a conventional rheometer. Both filament stretching and capillary break-up extensional rheometers face challenges with weakly viscoelastic fluids. However, the presence of even a dilute concentration of polymer alters the character of instability growth and pinch-off dynamics during jetting. I experimentally study the influence of both elasticity and extensibility on the capillary break-up of weakly viscoelastic fluids. The delicate interplay of capillary, inertial, elastic and viscous effects typically leads to complex dynamics in a necking fluid thread formed during dripping, self-thinning of a liquid bridge and jetting. I show that by carefully controlling the excitation frequency and amplitude of harmonically perturbed jets, it is possible to drive the capillary break-up in a particularly simple and symmetric mode. The image analysis of self-thinning dynamics of the necking fluid thread forms the basis of a jetting-based rheometer called Rayleigh Ohnesorge Jet Extensional Rheometer (ROJER) developed as a part of my research. In this presentation, I will describe the measurement of relaxation times (< 1ms) and elongation viscosity for highly dilute polymer solutions (outside the range of typical conventional techniques) using ROJER. Since the flows at high extension rates encountered in inkjet printing, jetting and spraying are all surface-tension driven, imaging-based jetting rheometry is the ideal technique for characterizing rheology and processing behavior – sprayability, jettability, printability, spinnability, stringiness – of weakly viscoelastic complex fluids.

TUESDAY, MARCH 1, 2011
2:30 PM
Building 2, Room 105

Refreshments at 3:30 PM in Building 2, Room 290

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