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From interfacial slip to bulk flow: surprises in non-Newtonian flow of polymers? SHI-QING WANG, University of Akron — All types of flow involve interfacial contact between the confining solid boundary and the fluid. Thus, understanding the nature of the hydrodynamic boundary condition (HBC) is crucial to a realistic description of the fluid mechanics of both simple and structured liquids including polymeric liquids. Polymeric liquids are uniquely capable of violating no-slip HBC on large length scales because of a high level of chain entanglement and not because “the molecular scale over which slip might occur is large enough to result in macroscopic effects” [1]. This dynamic structure of chain entanglement appears to make polymeric liquids behave similarly to other yield-stress fluids such as foams, gels, dense suspensions and glassy colloids. In other words, the “structure” is breakable by external stress to display yield-like flow. This unanticipated feature of polymeric liquids has begun to produce several big surprises. In this presentation, we will describe these surprising results revealed by a combination of mechanical and optical measurements. Specifically, we show, using a newly developed particle tracking velocimetry, that not only the well-known protocol of controlled-rate seems problematic as a reliable way to delineate the nature of polymer flow, but also questionable is the popular apparatus of cone-plate shear cell in terms of its ability to generate uniform simple shear. Guided by these experimental results we are pursuing the fundamental questions of (a) how to revise the prevailing molecularly based theoretical understanding of entangled polymers, (b) whether the widely used cone-plate flow cell is suitable for exploring flow behavior of various non-Newtonian fluids, (c) what options and choices of experimental apparatus we should equip in any lab working on non-Newtonian flow.

[1] M.M. Denn, abstract of APS 2005 March Meeting.

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