Abstract Submitted
for the DFD15 Meeting of
The American Physical Society

The importance of flow history in mixed shear and extensional flows CAROLINE WAGNER, GARETH MCKINLEY, Massachusetts Institute of Technology — Many complex fluid flows of experimental and academic interest exhibit mixed kinematics with regions of shear and elongation. Examples include flows through planar hyperbolic contractions in microfluidic devices and through porous media or geometric arrays. Through the introduction of a "flow-type parameter" α which varies between 0 in pure shear and 1 in pure elongation, the local velocity fields of all such mixed flows can be concisely characterized. It is tempting to then consider the local stress field and interpret the local state of stress in a complex fluid in terms of shearing or extensional material functions. However, the material response of such fluids exhibit a fading memory of the entire deformation history. We consider a dilute solution of Hookean dumbbells and solve the Oldroyd-B model to obtain analytic expressions for the entire stress field in any arbitrary mixed flow of constant strain rate and flow-type parameter α. We then consider a more complex flow for which the shear rate is constant but the flow-type parameter α varies periodically in time (reminiscent of flow through a periodic array or through repeated contractions and expansions). We show that the flow history and kinematic sequencing (in terms of whether the flow was initialized as shearing or extensional) is extremely important in determining the ensuing stress field and rate of dissipated energy in the flow, and can only be ignored in the limit of infinitely slow flow variations.

Caroline Wagner
Massachusetts Institute of Technology

Date submitted: 30 Jul 2015 Electronic form version 1.4