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DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING
COLLEGE OF EARTH AND MINERAL SCIENCES

~~Special Polymer Physics Seminar ~~

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301 Steidle Bldg.

Building a phenomenological and conceptual foundation for nonlinear rheology of entangled polymeric liquids

In this talk, I will first review the emerging phenomenology concerning polymer dynamics, especially of entangled systems to suggest that a new picture has arrived to replace that offered by the tube model. Here the new insights were afforded by the recent particle-tracking velocimetric observations, of which two dozens of home-video style recording of the time-dependent deformations have been captured and made available at http://www3.uakron.edu/rheology/. We assert that much of the leading nonlinear rheological phenomena including the stress overshoot and macroscopic motions after large step strain are a result of the mechanical failure of the entanglement network, involving mutual chain sliding past one another upon reaching the point of force imbalance between the intra-chain retraction forces and inter-chain gripping forces.[1]

I will then point out that the tube model for nonlinear dynamics of polymers bypassed the difficulty confronted by its predecessor, i.e., the transient network model, and skipped the profound physics required to explain why and how the entanglement network must break down during large deformations. It considered an artificial situation of a loading bearing chain confined to an affinely deformed tube where only the chain segment orientation, instead of chain stretching, produces stress. As a consequence, it could show non-monotonic relations between the shear stress and imposed strain for startup shear and step strain without having to develop a molecular mechanism for the collapse of the entanglement network. In the tube model, the nature of the overshoot is not yielding (transition from elastic deformation to irreversible flow), but an elastic instability.

[1]S. Q. Wang *et al.* J. Chem. Phys. **127**, 064903 (2007); Y. Y. Wang and S. Q. Wang, J. Rheol. **53**, 1389 (2009).