Abstract for an Invited Paper
for the MAR08 Meeting of
The American Physical Society

The Coil-Stretch Transition after more than 30 years

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From the seminal paper of DeGennes (1974), there has been a long debate over the nature of polymer dynamics surrounding the "critical point" in flow strength where local fluid line extension rates (and the resulting drag created on a linear polymer) dominate over the entropic restoring force – the so-called coil-stretch transition. This debate has now essentially ended as a result of recent single molecule experiments and large scale molecular simulations which demonstrate that, for steady extensional flow, the basic tenets DeGennes put forth were correct, albeit with certain details which DeGennes did not foresee. However, for flows which are either not steady or which contain significant vorticity, there are qualitatively different features which have now been suggested and remain essential to understand. For example, molecular simulations of planar mixed flows demonstrate that conformational fluctuations play a key role in the coil-stretch transition especially for flows that are "near shear". Finally, the application of the DeGennes' ideas to turbulent drag reduction are far from clear, and new large scale molecular simulations have shed some light on polymer dynamics in this important application.