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Continuum and Meso-scopic Models for the Nonlinear Relaxation Behavior of Glassy Polymers

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We will describe recent work on developing a physically based constitutive equation for amorphous polymers and present a novel, meso-scale model that begin to bridge the gap between molecular simulations and continuum models. A nonlinear thermoviscoelastic constitutive model has been developed that is thermodynamically consistent, uses generalized strain measures, and where relaxation is controlled by the configurational internal energy. Using this model, we have been able to describe nonlinear stress relaxation, yield, post-yield deformation, physical aging, enthalpy relaxation, and solidification dynamics in the glass transition region. A fluctuation model has been developed that explicitly acknowledges the effect of temporal fluctuations in the thermodynamic variables on the relaxation behavior. The fluctuation model naturally predicts the shape of the relaxation spectra, which is a consequence of the distribution of environments that a small material element experiences.