Abstract Submitted
for the MAR06 Meeting of
The American Physical Society

Elastic Fluctuations and Rubber Elasticity XIANGJUN XING, Syracuse University, PAUL GOLDBART, University of Illinois, LEO RRADZIHOVSKY, University of Colorado — A coarse-grained phenomenological model is constructed to describe both phonon fluctuations and elastic heterogeneities in rubbery materials. It is a nonlocal, spatially heterogeneous generalization of the classical model of rubber elasticity, and with a tunable repulsion interaction. This model can also be derived from the Vulcanization theory. The residual stress and the non-affine deformation field, as well as their correlations, are calculated perturbatively, to the leading order of quenched randomness. It is explicitly shown that the interplay between the repulsive interaction and quenched randomness induces non- affine deformation. The spatial correlations of the non- affine deformation field and residual stress exhibit power-law scaling, with no characteristic length scale. We also calculate the contributions to the elastic free energy from both thermal and quenched fluctuations for arbitrary deformation. We find that they naturally explain the universal features in the Mooney-Rivlin plot of the stress-strain curve for rubbery materials. The (disorder averaged) thermal fluctuation of monomers is shown to depend on deformation, and becomes anisotropic upon shear deformation, as long as the repulsive interaction is finite.

Xiangjun Xing
Syracuse University

Date submitted: 30 Nov 2005 Electronic form version 1.4