Abstract Submitted
for the MAR12 Meeting of
The American Physical Society

Nonlinear effective medium theory of disordered spring networks

M. SHEINMAN, VU University, C.P. BROEDERSZ, Princeton University, F.C. MACKINTOSH, VU University — Disordered soft materials, such as fibrous networks in biological contexts exhibit a nonlinear elastic response. We study such nonlinear behavior with a minimal model for networks of simple Hookian elements with disordered spring constant. We develop a mean-field approach to calculate the differential elastic bulk modulus for the macroscopic network response of such networks under large isotropic deformations. We find that the nonlinear mechanics depends only weakly on the lattice geometry and is governed by the average network connectivity. In particular, the nonlinear response is controlled by the isostatic connectivity, which depends strongly on the applied strain. Our predictions for the strain dependence of the isostatic point as well as the strain-dependent differential bulk modulus agree well with numerical results in both two and three dimensions. In addition, by using a mapping between the disordered network and a regular network with random forces, we calculate the non-affine fluctuations of the deformation field and compare it to the numerical results. Finally, we discuss the limitations and implications of the developed theory.

Fred MacKintosh
VU University

Date submitted: 14 Dec 2011

Electronic form version 1.4