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Plasticity in amorphous solids

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Yielding and the slow plastic flow of amorphous solids exhibit striking heterogeneities: swift localised particle rearrangements take place in the midst of a more or less homogeneously deforming medium. At low temperatures, failure events become increasingly correlated and develop self-similar properties that resemble critical phenomena. Moreover, plastically deforming regions organize into macrocroscopic shear bands that limit the lifetime to failure. This talk will discuss two questions that must form essential ingredients in a statistical theory of amorphous plasticity: where to localized plastic events occur, and how do correlations arise from their interactions? With molecular dynamics simulations of model athermal solids driven by shear at constant strain rate, we first show that the loci and directions of local shear transformations can be predicted from a superposition of soft modes in the low energy vibrational spectrum [1]. The so-defined "soft spots" are long-lived structural features and remain correlated with plastic activity even in the supercooled fluid regime. We then compute spatiotemporal correlations of the plastic events and compare them to a mesoscale elastoplastic model that coarse-grains the atomistic dynamics into a lattice model that preserves only the essential features of the localized plastic events. Upon local yielding, energy is redistributed throughout the lattice with an elastic Green's function that displays quadrupolar symmetry and algebraic decay. We test several assumptions in the mesoscopic theory directly against the behaviour on the molecular level [2,3]. Recent successes as well as avenues for further improvement of these class of models will be discussed.

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