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Reversible Avalanches and Criticality in Amorphous Solids

CHARLES REICHHARDT, Los Alamos National Laboratory

Despite its importance for basic science and industry, the physical process that causes a solid to change its shape permanently under external deformation is still not well understood. In this paper we use molecular dynamics simulations of amorphous solids under oscillatory shear to study this phenomenon, and show that at a critical strain amplitude, the size of the cooperative atomic motion that allows for a permanent deformation diverges. We compare this non-equilibrium critical behavior to that of a "front depinning" transition. This viewpoint, based on fluctuations and statistics, is complementary to the dynamical "transition to chaos" which was previously identified at the same strain amplitude. Below this irreversibile-depinning transition, we observe large avalanches which are completely repetitive with each shear strain cycle. This suggests that while avalanches on their own do not cause irreversible deformation, it is likely that the irreversibility transition and the "depinning-like" transition are two aspects of the same phenomena. One implication is that the transition could be detected before the onset of irreversible flow by an analysis of the power spectra of avalanches.

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