Catastrophes, avalanches, and the basic mechanisms of plastic deformation in amorphous materials

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The elementary mechanisms of plastic deformation in amorphous materials have long remained elusive, due to the lack of clearly identifiable defects such as crystalline dislocations. Significant progress has come in the last years from numerical simulations, which first have established that, as initially proposed by Ali Argon, macroscopic plastic deformation is the net result of an accumulation of elementary events which are local rearrangements ("shear transformations" or "flips") of small clusters ("zones") of atoms, molecules, or particles. But simulations have also revealed several surprising facts : shear transformations occur via saddle-node bifurcations, when weak zones driven by macroscopic strain reach their local instability thresholds ; each flip creates elastic distortions (à la Eshelby) in the surrounding medium, hence may induce secondary events ; this mechanism gives rise avalanche behavior. We will review the numerical evidence and show how it helps us understand the macroscopic response and especially the rheology of amorphous materials.