Glass stability changes the nature of the yielding transition under oscillatory shear

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Amorphous solids, such as concrete, colloidal glasses, and metallic glasses, have been proposed as novel material for industrial and commercial applications nowadays thanks to their excellent mechanical strength and lack of "defect" of the systems. However, their applications are largely limited due to their brittleness and low plasticity after large deformation. Understanding the way of controlling brittleness, or equivalently the yielding behavior, is thus important for guiding material design. Recent simulations studies have revealed that the yielding behaviors of glassy systems depend sensitively on the extent of both mechanical and thermal processing. In particular, thermal annealing generally involves quenching the system from different equilibrium temperature, and mechanical processing involves the cyclically shearing or compressing the system. It is interesting to understand the difference and limitations of those two annealing processes. We carry out molecular dynamics simulation to study glass-formers under athermal quasi-static oscillatory shear. By changing the initial thermal annealing degree of the system, we are able to comprehensively understand the interplay of mechanical and thermal processings on the systems. Our results suggest that the extent of mechanical processing on the system depends crucially on the initial degree of thermal annealing. In particular, there exists a critical degree of thermal annealing so that the effect of mechanical processing on the system can be separated into two regimes. For initially poorly annealed system, oscillatory shear is able to stabilize the systems into more stable configuration. In other words, the initial memory of the system is gradually wiped out due to mechanical processing. On the other hand, for initially well annealed system, it is found that mechanical processing ceases to function anymore, meaning that system's initial memory is maintained. Our analysis also reveals that the separation of two regimes could be originated from the fundamental properties of potential energy landscape of the model of glass-former. Some predictions from this aspect are proposed and tested in this work.