Biased rearrangement pathways drive densification in a colloidal glass under local perturbations

Chandan Kumar[1]

[1]IIT Gandhinagar, Gandhinagar, India

Glasses can be prepared in highly stable amorphous states using specialized protocols such as vapor deposition or non-local dynamical schemes, raising the question of whether such stability requires fundamentally altered dynamics or can emerge from more generic processes. Here we show experimentally that repeated, local stochastic perturbations drive a gradual densification of a colloidal glass without modifying interactions or inducing global relaxation. Individual perturbations generate strongly heterogeneous responses, ranging from localized rearrangements to spatially extended cascades, while the system remains structurally arrested. By resolving the structural impact of individual events, we find that rearrangements are intrinsically asymmetric in their outcomes: a majority produce an increase in packing at larger distances, leading to net compaction. These events are associated with rearrangements that propagate over extended, tortuous pathways through the disordered structure. The resulting evolution can therefore be understood as a biased stochastic process over rearrangement pathways, in which repeated local activation selectively samples configurations that improve packing. These results identify a minimal mechanism by which glasses can evolve toward denser amorphous states without global driving or engineered dynamics, and suggest a unifying perspective on different routes to glass stabilization.