Record dynamics as the origin of aging

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We provide a unified description of "aging", the increasingly sluggish dynamics widely observed in the jammed state of disordered materials, in terms of record dynamics. Structural evolution in aging materials requires ever larger, record-sized rearrangements in an uncorrelated sequence of intermittent events (avalanches or quakes). According to record statistics, these (irreversible!) rearrangements occur at a rate $\approx 1/t$. Hence, in this log-Poisson statistics, the number of events between a waiting time t_w and any later time t integrates to $\approx \ln(t/t_w)$, such that any observable inherits the t/t_w-dependence that is the hallmark of pure aging. Based on this description, we can explain the relaxation dynamics observed in a broad range of materials, such as in simulations of low-temperature spin glasses and in experiments on high-density colloids and granular piles [1]. We have proposed a phenomenological model of record dynamics that reproduces salient aspects of the experiments, for example, persistence, intermittency, and dynamic heterogeneity [2]. Here, we compare the predictions of the model with the data available from experiments by Yunker, et al. [3]. These experiments provide the first opportunity to confront both the central assumption of record dynamics on quake statistics and one of its predictions, namely the emergence of growing mesoscopic real-space structures. The data shows that they concur with the fundamental assumptions as well as with the predictions of the theory. For the first time, direct experimental evidence for record dynamics as a coarse-grained description of dense colloids in particular, and of a broad class of aging materials in general, is provided. We complement the analysis of the data with a simple, coarse-grained lattice model of an aging colloid that matches the experimental results in great detail and allows predictions regarding observables to measure dynamic heterogeneity and the growth of length scales in the system. A mean-field rate equation even allows analytic predictions about the growth of domains with system age.

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