Time evolution of elementary structural events in amorphous materials

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Unlike fluids, where structural relaxation is sufficiently fast to be accessible to experiments, relaxation processes in a glassy material are sluggish and beyond the experimentally available time window. While for a system at equilibrium time translation invariance holds, for a system in a glassy state, on the other hand, one expects that the evolution of the system towards an (unreachable) equilibrium state should reflect itself in an age dependence of both dynamical [1] and mechanical [2] properties. Here, age, t_{a}, is the time spent between the quench (from a liquid to a glassy state) and the beginning of the measurement. A way to characterize properties of an aging system is to study the effect of age on the probability distribution of elementary relaxational events, i.e., the first passage time, p_1 (the time for the occurrence of the very first event), and the persistence time, p (the time passed between two successive events). Intuitively, one expects that both p_1 and p should depend on the age of the system as both these quantities closely depend on the evolving structure of the system. On this intuitive view, the dependence upon aging reflects the evolution towards equilibrium and is expected to hold for ever if the relaxation time is infinite. It is important to realize, however, that, since the distance to equilibrium decreases upon aging, its effects are expected to become progressively weaker and thus more difficult to detect with increasing age, t_{a}. As a consequence, a proper definition of the age is essential for a correct interpretation of aging effects. Another issue –of high importance for a correct determination of the persistence time distribution– is a proper detection of the second jumps. This work focuses on these and other related technical issues. In particular, it is shown that aging effects are indeed present both in the first passage time and persistence time distribution functions. In the light of these results, possible reasons are discussed for the absence of aging in the persistence time distribution reported in [3]. Furthermore, more insight is gained into the problem by a comparison of aging in the continuous time random walk model (CTRW) [5-7], which has an stationary persistence time distribution, to the aging in BLJM, which has an age dependent persistence time distribution.

References

[1] W. Kob, J.-L. Barrat, Phys. Rev. Lett. 78, 4581 (1997).
[2] F. Varnik, L. Bocquet, J.-L. Barrat, J. Chem. Phys. 120, 2788 (2004).
[3] M. Warren, J. Rottler, EPL 88, 58005 (2009).
[4] N. Hamidi-Siboni, D. Raabe, F. Varnik (in preparation).
[5] C. Monthus and J.-P. Bouchaud, J. Phys. A 29, 3847 (1996).
[6] J. P. Bouchaud, J. Phys. I France 2, 1705 (1992).

[7] E. Barkai and Y.-C. Cheng, J. Chem. Phys. 118, 6167 (2003).