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On the question of subaging in slow non-equilibrium dynamics

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The history of glass formation strongly affects the relaxation dynamics of glassy materials. These dynamics are found to become slower with the "age"of the system, that means with the time t_w expired since the material was brought into the glassy state. Such aging phenomena have been identified in many systems and various dynamical probes.
Relaxation or correlation functions $C(t_w+t,t_w)$ in aging experiment are measured as a function of t after the waiting time t_w has passed. For large t and t_w, they commonly follow a scaling according to $C(t_w+t,t_w) \sim F(t/\tau(t_w))$, where $\tau(t_w)$ increases with t_w as a power law, $\tau(t_w) \sim t_w^\mu$ with $\mu > 0$. In experiments best fits to measured data often yield a subaging behavior with $\mu < 1$, while most theoretical treatments suggest a normal aging with $\mu = 1$ in the asymptotic large time limit. The question hence arises, whether subaging is a transient phenomenon. Indeed, this was suggested in a recent molecular dynamics study of a binary Lennard-Jones glass [1].
Here we reinvestigate subaging in the quenched trap model [2] with respect to the question, whether it can appear as a true scaling behavior. In this model, dynamics of glassy systems are described on a coarse-grained level by thermally activated transitions between traps (inherent states) of a potential energy landscape. The probability $\Pi(t_w+t,t_w)$ of remaining in the same trap in the time interval $[t_w,t_w+t]$ was shown to exhibit a subaging behavior, see Fig. 1.

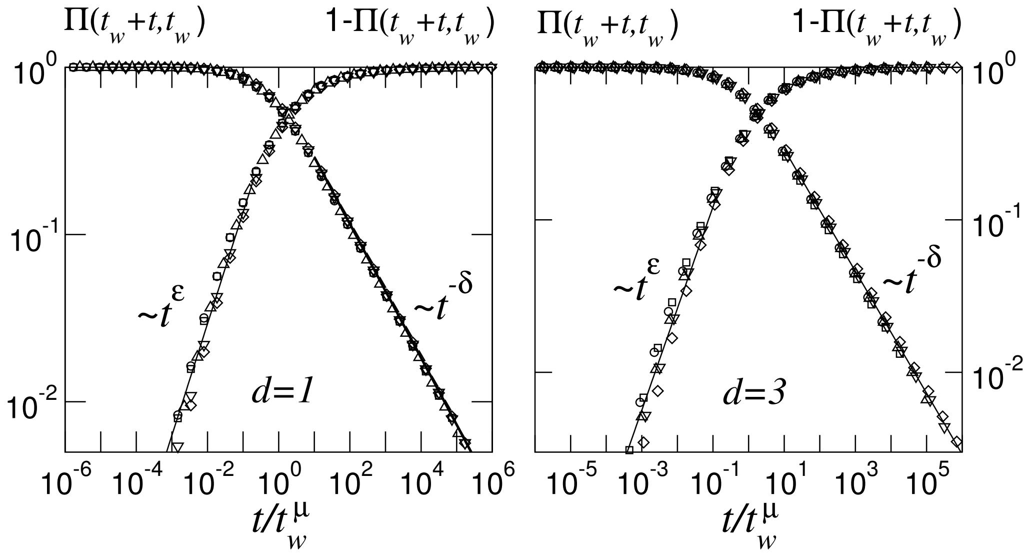

Figure 1: Double-logarithmic plots of $\Pi(t_w+t,t_w)$ and $[1-\Pi(t_w+t,t_w)]$ as functions of $t\ /\ t_w^\mu$ in dimensions $d=1$ and $d=3$. For this example, $\mu=1/2$ ($d=1$) and $\mu=5/8$ ($d=3$). Different symbols correspond to various waiting times t_w in the range 10^5-10^{10}. The solid lines have slope $\varepsilon=6/5$ (small t behavior) and slope $-\delta=-2/5$ (large t behavior).

$\Pi(t_w+t,t_w)$, however, is not fully capturing the correlation dynamics. One should better consider the probability $C(t_w+t,t_w)$ that the system is at time t_w+t in the same trap as reached after t_w, irrespective of whether it has left this trap in the time interval $[t_w,t_w+t]$. By performing Monte Carlo simulations we study if $\Pi(t_w+t,t_w) \sim C(t_w+t,t_w)$ for times $t \lesssim t_x$, and if t_x increases with t_w. This would imply that subaging is valid also for $C(t_w+t,t_w)$ for large t,t_w with t/t_w^μ fixed.

References

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