Time and glass

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Abstract

Time plays an essential role in the physics of glass. It comes into play first during the quenching process, the optimum time for which depends on the chemical composition of the material. Then, once the glass has set, it continues to evolve through the multiple relaxation phenomena. The global system and its subsystems seek to minimise the characteristic energies of their state and this leads to the definition of a characteristic time for the phenomena that occur. The production of entropy makes it possible to define the attractor state towards which the glass irreversibly evolves.
The relaxation phenomena are as numerous as the atomic environments, different for each atom in a disordered system such as glass. Thus, if a glass is often characterised by a discrete number of relaxation times, the most adequate view is undoubtedly that of one or more relaxation time distributions, similar to the descriptions and models proposed for biological systems (see for example K. Kneller, Phys. Chem. Phys., 2005, 7, 2641-2655).

Simulations of quenching based on assumptions about the interactions between atoms or molecules allow to define a structure towards which the glass tends. Experimental results generally confirm these structures as plausible. However, it can be seen that the quenching times, or more precisely the quenching durations, in the simulations are generally much shorter than those of the real quenching. Simulations of molecular dynamics in oxide glasses give quenching rates of the order of 1012 K/sec to 1014 K/sec (see for example Nuclear Instruments and Methods in Physics Research B 326 (2014) 256-259 and Computational Materials Science 43 (2008) 1123-1129) whereas the quenching rates for real glasses are of the order of a few tens of K/sec. These differences between the dynamics described by the simulations and those of reality lead us to question the role of the time factor. Is it an actor of reality in these phenomena?
The difficulty encountered in giving an unambiguous account of the macroscopic reality, that characterises the glassy state, from the microscopic approach, i.e. the reality of what is at the atomic level, lies in the characterisation of the middle range order. This problem exists in other fields of physics, very different, but which also raise the question of the construction of the macroscopic from the microscopic. So the question is : is there a possibility of a common questioning?

Keywords: time, relaxation, quenching, intermediate range order

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