THE GLASSY STATE: INTERMEDIATE-RANGE ATOMIC STRUCTURE MAGNETICALLY VIEWED FROM THE FROZEN END

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Most studies of the atomic structure of glasses, especially non-metallic ones, are conducted at high temperatures and - in terms of modeling - often from the supercooled phase of the melt. That comes because X-ray and neutron-scattering techniques cannot unambiguously resolve the intermediate- and long-range atomic structure of amorphous solids. For insulating glasses the continuously random network model of Zachariasen-Warren has dominated the field in the West since the 1930s, though in the Soviet Block the antagonist concept of crystallites and cellular superclusters has held fast to the post up to these days (see for example the polycluster concept of A.S.Bakai).

In this talks the case for an intermediate picture of the glassy structure will be advocated, looking at the glassy state from its frozen end (at low and very low temperatures) as one would do with a crystal. The new tool to watch with is proposed to be those remnant degrees of freedom in the otherwise frozen matrix of a glass that are still ergodic and are dynamical defects known as tunneling systems. These are normally modeled in terms of simple tunneling two-level systems, sitting in a medium with a flat distribution of their relevant parameters – a legacy from Zachariasen-Warren. However, the two-level systems picture – though partly successful - is not capable of describing many experiments at low temperatures in a consistent way, notably: experiments contradicting the standard tunneling model, and especially the magnetic and composition effects that are hard to explain with this simple picture. It will be shown that a demise of the Zachariasen-Warren dogma and a refined cellular-type structural model for the intermediate-range atomic structure can lead, when folded in the tunneling-systems concept, to a much improved explanation of most experiments with cold glasses[1] and to an improved picture of the atomic structure. Perhaps, also to the mechanism for the glass transition.

The new cellular picture for the intermediate atomic structure of a glass will be introduced and the implementation of the tunneling model, with two very distinct tunneling species on such structure will be shown to lead to a quantum-mechanical theory for the remnant effective degrees of freedom capable of explaining all experiments so far. Also, predictions for exotic new magnetic effects[2] will be made, so that the atomic structure of glasses will be accessible through new, tunneling, magnetic eyes.

In the first talk, the basic concepts of glassy atomic structure and of tunneling states (or systems) will be introduced, with an overview of the results – and puzzles – achieved by means of **the standard 1972 tunneling mode**l of Phillips and of Anderson, Halperin & Varma. The emphasis will be on concepts and the justification (yet non-existent) of the models, no details will be given.

In the second talk, the major puzzles opened by the low-temperature physics of glasses will be introduced and an overview of our resolution of these difficulties will be presented, with a sample of some of the most striking results obtained in Como in the last 10-15 years. The emphasis will again be on concepts and now on the mature and profound justification of **the extended tunneling model**, which rests upon a new picture of the intermediate-range glassy atomic structure, on a clear identification of the nature of the (two types of) tunneling states and the justification of the exotic magnetic effects in real glasses (silicates, but also a-Si, chalcogenides and organics, multi-component or contaminated single-component) at low but – and here is the novelty – all the way to room temperatures.

[1] G.Jug, M.Paliienko and S.Bonfanti, J.Non-Cryst.Solids 401 (2014) 66-72;

[2] S.Bonfanti and G.Jug, J.Low-Temp.Phys. (2015 in print) (arXiv: 1504.05722v1)