DESCRIBING AND PREDICTING HOW MATERIALS BEHAVE

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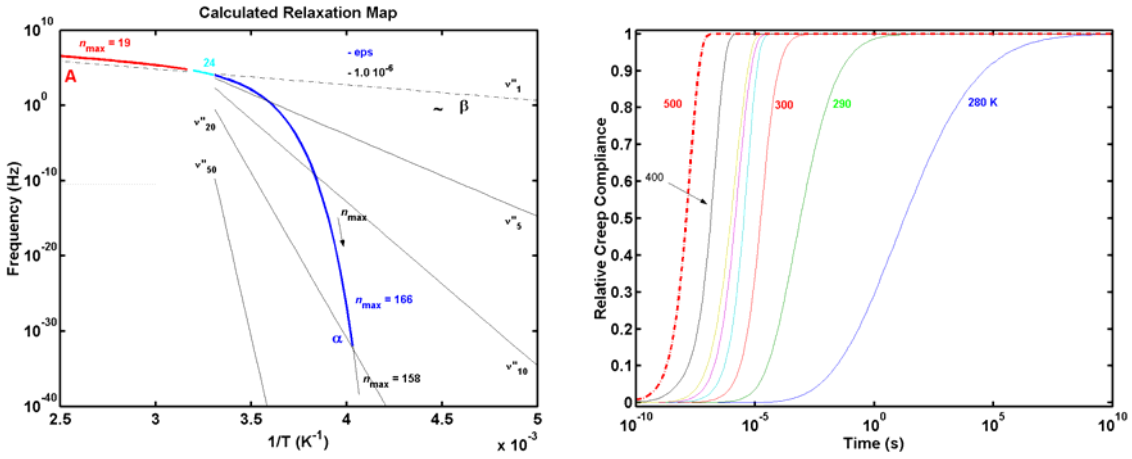
The most advanced research in the general field of materials requires a combination of phenomenological approaches, of experimental measurements using a very wide range of complementary techniques, and of physical and mathematical modeling. It is increasingly being recognized that, in the field of amorphous condensed matter, the physical behaviour is formally similar (surprisingly similar) between materials of widely different origin (inorganic and organic, polymers, biological, such as proteins, etc.), which recommends integrated approaches for their physical and mathematical modeling [1,2] and the utilization of the widest possible range of experimental analysis and measurement techniques (from quantitative thermal analyses, especially differential scanning calorimetry, to the mechanical and dielectrical spectroscopies, extending to NMR and light and neutron scattering) to experimentally study the materials' responses to every possible type of thermal and forced excitations, in widely different time-scales, from $<10^{-3}$ Hz to the GHz and THz. The ultimate and most challenging scientific objective of cutting-edge research in condensed matter physics is the development and experimental validation of physically sound predictive models for the dynamic behaviour (with special emphasis on amorphous materials) [1], applicable in every situation and relevant applications, out of equilibrium and at equilibrium.

It is not difficult to understand and visualize the general dynamic (compliance and/or relaxation) behaviour of any type of material, under the widest range of situations and time-scales, as resulting from a range of motions/transitions at the molecular scale – whole molecule (or atom) in non-macromolecular materials, and gauche-trans conformational transitions or other motions (e.g. crankshaft) in macromolecular ones – whose dynamics may be modelled such as to accurately portray the behaviour under a variety of static or dynamic excitations. The ubiquitous, but still mysterious [1], crossover and super-Arrhenius behaviour are here predicted and finally explained, together with any overall physical (mechanical, thermal or other) response of the material (cf. Figures).



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