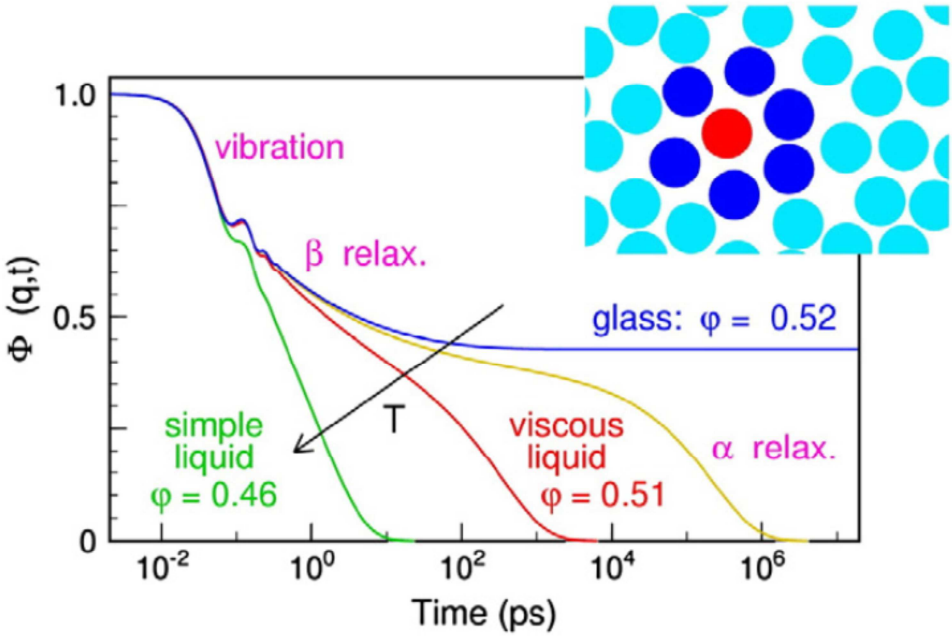
What is a glass transition? Intuitive explanation

1) The liquid-glass transition affects the mechanical and thermal properties of a system, without exhibiting a significant structural change. It is thus a dynamic transition, since only the dynamic properties show a step-like behavior: The properties of a "silly putty ball" vary from a brittle glass to a viscous liquid, depending on the speed of external perturbation.
2) The main structural relaxation restores the ergodicity of the liquid, which is a prerequisite of defining equilibrium properties. The GT thus represents the physical change from ergodic to non-ergodic behavior. It occurs at the cross-over of structural relaxation- and observation time. Thus a fundamental change in the system properties occurs at T_g, falling out of thermal equilibrium. Whether a amorphous material behaves as a glass or a liquid depends on the time scale of observation. The Challenger catastrophe happened, because the slow structural relaxation of a rubber ring could not adjust to the fast oscillatory stress imposed by the rockets.
3) Walter Kauzmann wrote in 1948[1]: *"It is widely agreed that this "glass transformation" is caused by a relaxation effect, through which some process in the amorphous material occurs too slowly at low temperatures to permit thermodynamic equilibrium to be established in all degrees of freedom. It is shown that the molecular movements involved in the relaxation process must resemble closely the movements in viscous flow and dielectric relaxation. Movements of this type permit the liquid structure to change following temperature and pressure changes…The glass transformation temperature T_g could then be "defined" in a very general way as the temperature below which the relaxation time for structural degrees of freedom are long compared with the duration of the experiment."*

4) The glass transition of hydrated proteins is a well-established concept of food science. It was shown by Morozov[2] et al., that the Young modulus of hydrated lysozyme crystals exhibits a step-like increase near 170 K, which varies with the probe frequency. The neutron scattering experiment probes the glassy relaxation of the protein-water system on a ps - to ns time scale, thus T_{on}(ns) >> T_g (s) and T_{on}(100 s) ≈ T_g. The protein dynamical transition (PDT) is thus a glass transition of the protein water system observed on a short time scale[3]. The relaxation time of a super-cooled liquid changes from ps to s within a narrow temperature interval according to a super-Arrhenius law. The relaxation time varies over 14 decades, a time span longer than the age of the universe. This fact may justify the notion of a “dynamical transition”.



Density correlation function of a simple liquid across the glass transition leading to nonergodic behavior: fast local in cage motion (β) and slow arresting structural (α) relaxation.

(1) W. Kauzmann, Chem.Rev. 1948, 43(2), 219.
(2) V.N. Morozov, S.G. Gevorkian, Biopol. 1985, 24, 1785.
(3) W. Doster, BBA (2010) 1804, 3: The protein-solvent glass transition