Probing Glass Formers with X-rays

Scientific Achievement

Determined ability of glass-forming glycerol to support propagation of high-frequency acoustic waves by comparing X-ray scattering spectra measured at different pressures with ultrasound absorption data

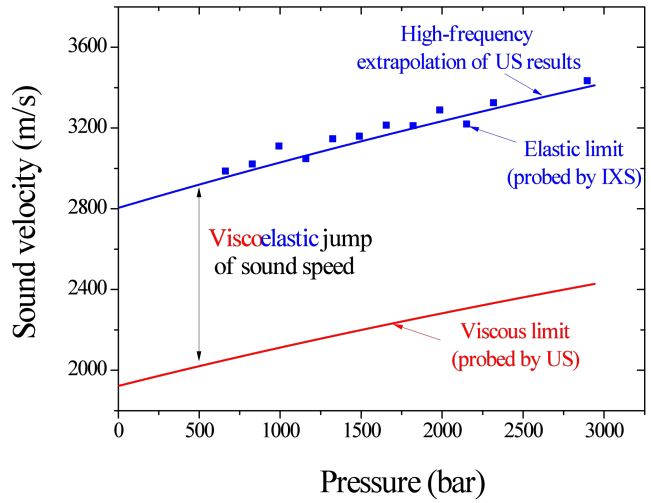
Significance and Impact

A novel result because it proposes a quantitative understanding of the measured sound dispersion using recently developed theory, potentially solving a long-standing debate about the dynamics of glass formers

Research Details

- Presence of two distinct relaxation processes inferred: slow triggers increase of frequency-dependent sound velocity, fast induces no visible dispersive effects on sound propagation
- These apparently opposite behaviors are likely to coexist in all glass formers near temperatures at which they melt into liquids

A Cunsolo, *Journal of Physics: Condensed Matter* **24** 375104 (2012)



The viscoelasticity of glycerol can be seen by comparing the low-frequency limit of sound speed measured at different pressures by ultrasound (US) techniques (dashed line), the high-frequency limit measured by IXS (solid squares), and the high-frequency extrapolation of US results (solid line). When the molecules relax, the sound velocity depends on the frequency of the sound wave. For low acoustic frequencies (long periods), the fluid reacts very rapidly to the sound wave perturbation. This is called a **viscous**, or liquid-like, response. Conversely, in the opposite, **elastic,** regime the system appears frozen like a solid (no molecular rearrangements). At intermediate frequencies, the response of the system is **viscoelastic**, that is, it conjugates liquid-like and solid-like features.

Work was performed at Argonne National Laboratory