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Shifts:	**Local contact**: Alain Mermet	*Received at ESRF:*

Names and affiliations of applicants **(* indicates experimentalists):**

M. Soltwisch, Inst. f. Experimentalphysik, Freie Univ. Berlin, D-14195 Berlin, Germany

C. Masciovecchio, ESRF, BP-220 F-38042 Grenoble, Cedex France

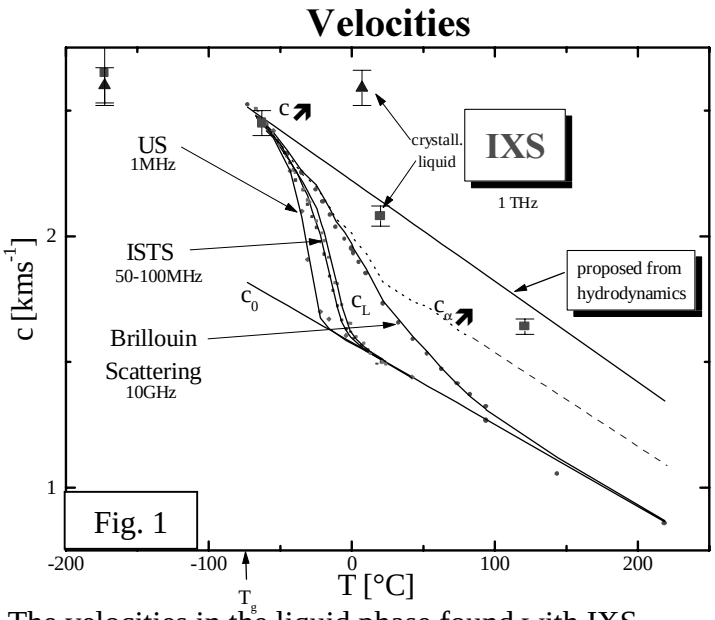
G. Ruocco, Universita di L'Aquila, I-67100 L'Aquila, Italy

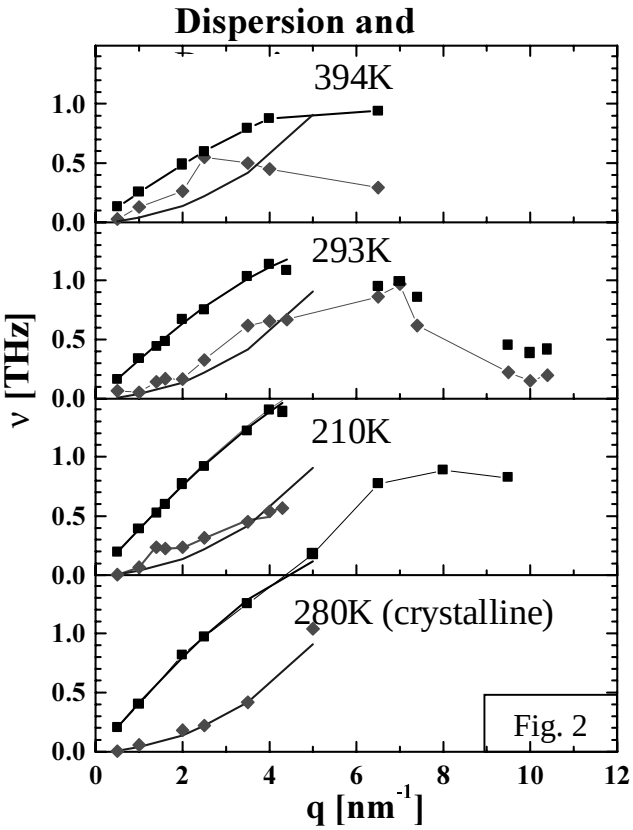
G. Monaco, Universita di L'Aquila, I-67100 L'Aquila, Italy

Report:

Inelastic high resolution (ΔE=1.5meV) x-ray measurements (IXS) have been performed on the fragile liquid glassformer meta-tricresylphosphate (mTCP). Main effort was given to a precise description of propagating sound waves below the first sharp diffraction peak (q=1nm^{-1} to < 8nm^{-1}). mTCP is a molecular van der Waals liquid and its glass forming ability is mainly due to ist complicated molecular structure. Measurements were performed in the glassy phase below T_g, at T_g=-68^{0}C and in the liquid phase up to 220^{0}C. Additionally we could measure the inelastic spectra of a powdered crystalline sample (melting point T_m≈20^{0}C).

The energy dependent inelastic spectra consist of a central component and of two Brillouin components. The central component could well be described by a delta function. The existing broadening due to translational and orientational diffusion is orders of magnitudes smaller than the energy resolution as it is known from NMR and light scattering measurements (see /1/ and references therein). To describe the phonon spectra we used a damped harmonic oscillator shape (DHO). Allowing for a q-dependent dispersion of the sound velocity as it is known from crystals, global fits in the range q=1 to 4.4nm^{-1} gave the hydrodynamic limiting values c(q=0,T). They are reported in Fig. 1, where they can also be compared with different sets of measurements performed at low frequencies, i.e. in the true hydrodynamic range /1/.





The velocities in the liquid phase found with IXS confirm the proposed infinite frequency sound velocity for mTCP from hydrodynamics. This proposal was made because we had to introduce there a high frequency β-process beside the normal structural α-process. The frequency width of this fast density relaxation process was found in the range of 0.03..0.10THz. Only IXS was able to prove the system at phonon frequencies much higher than this widths and thus to find the true $c_\infty(T)$.

Fig. 2 shows the module frequencies $\Omega(q)$ (squares) and the line widths $\Gamma(q)$ (HWHM, rhombs). The latter were determined numerically as the distance from a detected peak to its high energy half intensity. Especially at higher q's the DHO fits produce overdamped spectra and the meaning of a DHO-damping parameter may be a misleading quantity.

The lowest part in Fig. 2 shows the results for the crystalline powder sample. Here we found an astonishing strong damping which develops proportional to q^2 (thin line global fit with $\Gamma(q) \propto q^2$, rhombs local fits). The global line is repeated for the data of the liquid phase and appears there as a lower bound. The origin of this finding is at the moment a matter of speculation and the experiment should be repeated (under better controlled conditions and also for a similar system like oTP).

Use of the DHO in the fitting procedure is an effective parameterization of the spectra, but it is no explanation of its origin. The widths are much larger than expected from an extrapolation of the hydrodynamic region to these q values. We now start to describe the spectra by a distribution of force constants, which are due to the static disorder in the system /2/. This way is appealing, because there is no pronounced T-dependence in the damping parameters, only the mean force constants change (see Figs. 1 and 2).

/1/ M. Soltwisch, G. Ruocco, V. Mazzacurati, B. Balschun, J. Bosse, and D. Quitmann,
Phys.Rev. **E 57** (1998) 720

/2/ W. Schirmacher, G. Diezemann and C. Ganter, Phys. Rev. Lett. **81**, 136 (1998)