Advanced Photon Source
XOR Sector 3

DYNAMICS OF LEVITATED HIGH TEMPERATURE LIQUIDS

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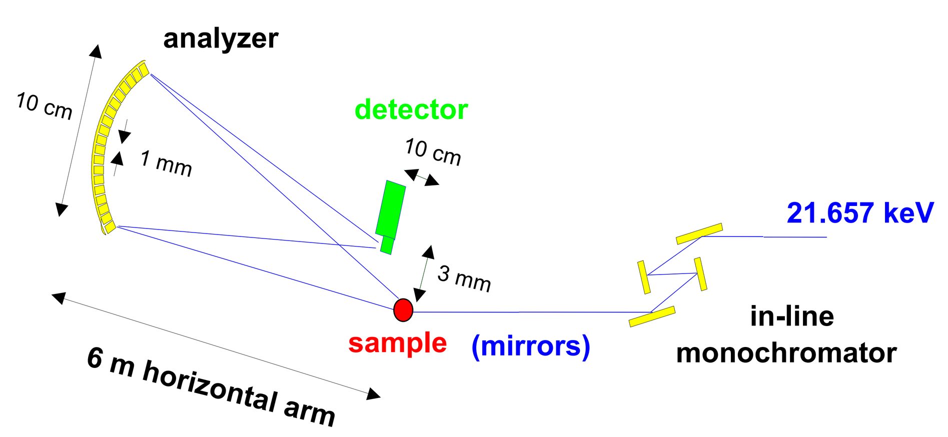
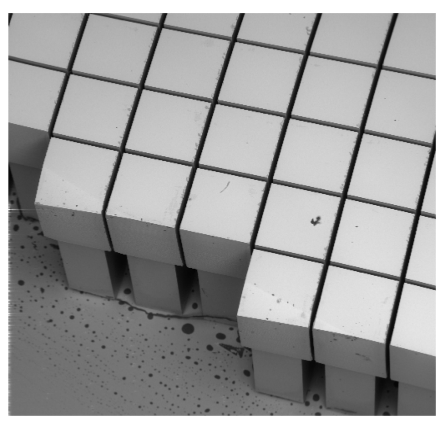
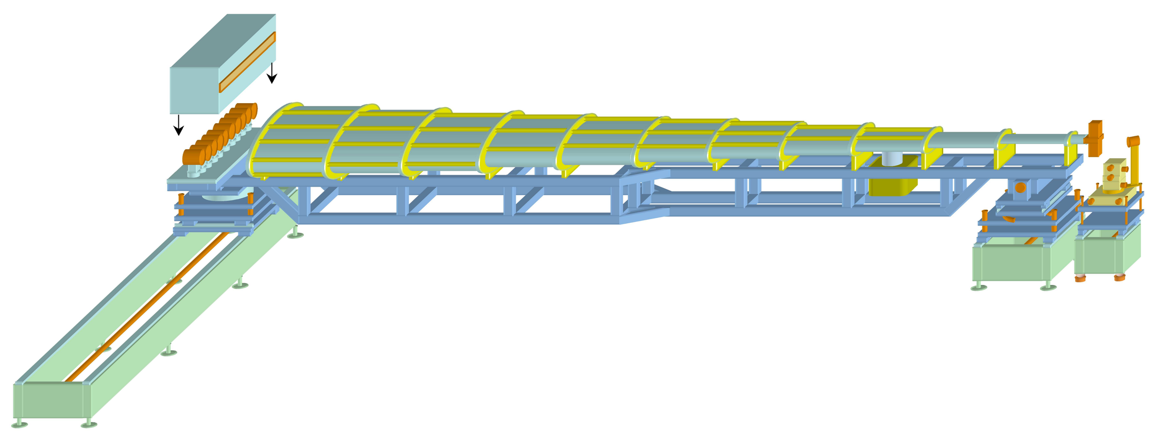
Inelastic X-ray Scattering

Inelastic X-ray Scattering (IXS) with a few meV energy resolution became an important tool in condensed matter spectroscopy in the last couple of years. The basic principle of the spectrometer is similar to a triple-axis neutron spectrometer, however, in order to reach the high relative energy resolution, monochromator and analyzer have to work in extreme backscattering geometry, requiring novel designs in synchrotron radiation instrumentation.

The main advantages compared to neutron scattering are the unlimited access to the energy momentum space, the insensitivity to isotopes and the small beam size of less than 0.2 mm. Recent reviews about experiments with inelastic X-ray scattering can be found e.g. in [1-3].







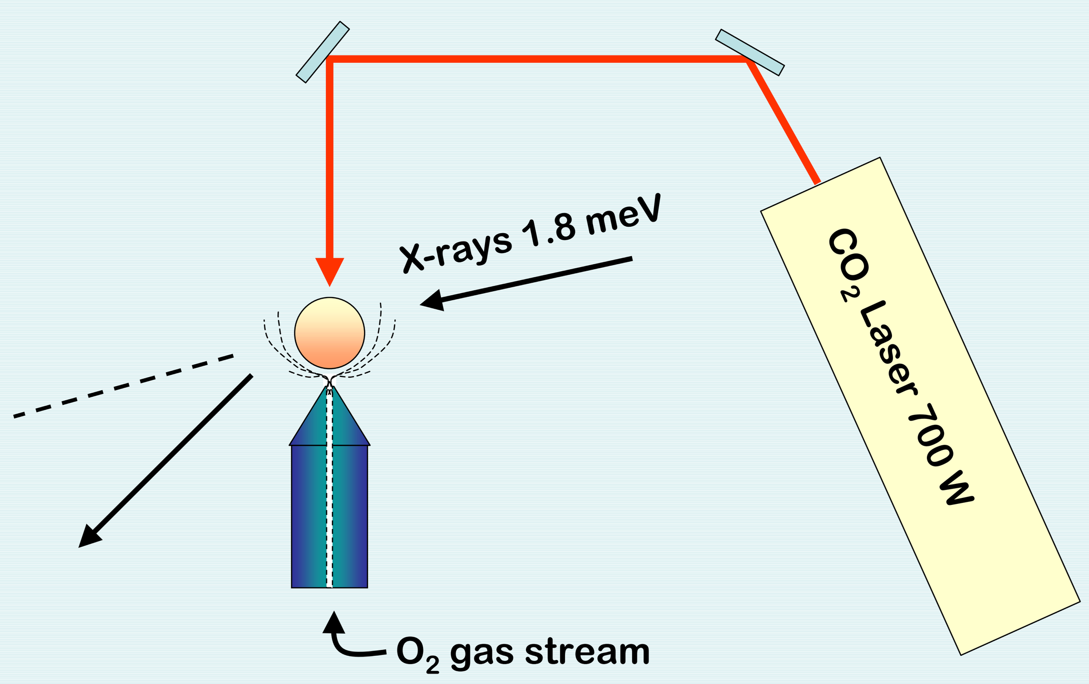
Left: *Schematic view of inelastic spectrometer at the APS, Sector 3 with an in-line monochromator.*
Middle: *Pixels of an analyzer crystal. The pixel dimensions are 1 x 1 mm and 4 mm heigh. The grooves on the surface are 80 microns wide.*
Right: *New spectrometer HERIX that will be built in 2005 on Sector 30, APS. It will operate 9 analyzers simultaneously with an energy resolution of 1 meV and better.*

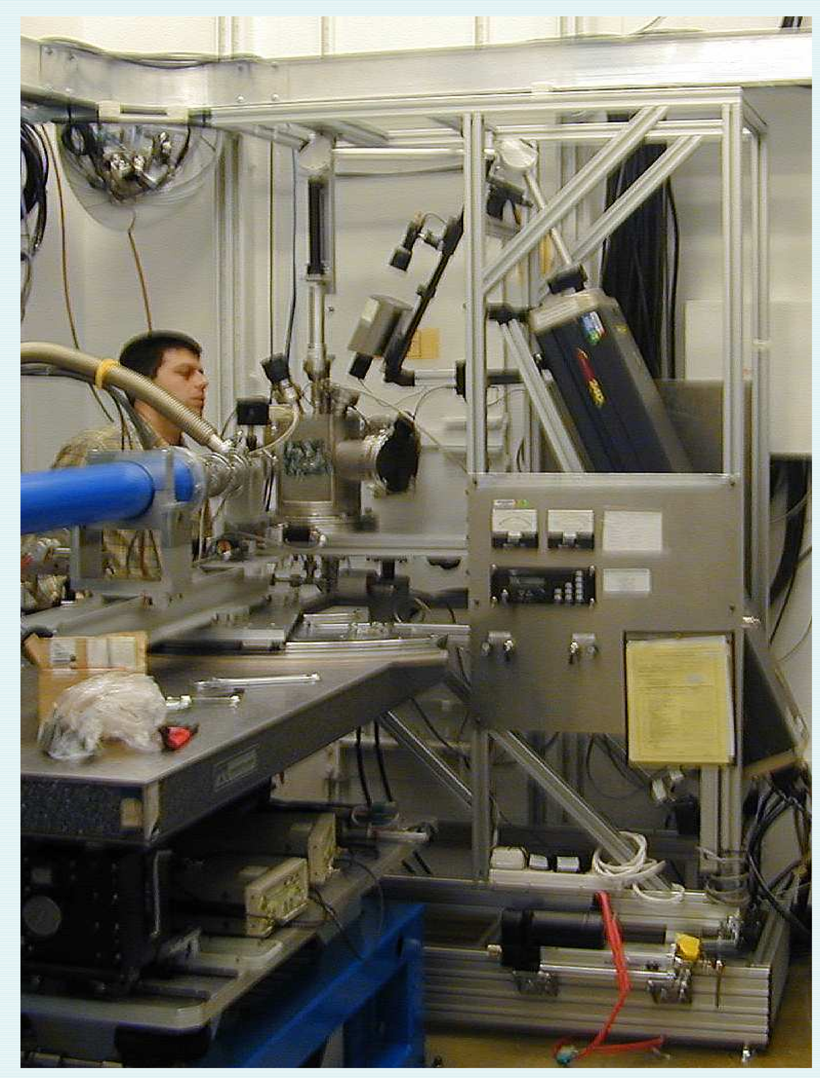
High Temperature Liquids

The transport properties in the liquid state of high melting substances are of fundamental interest for a number of applications like space technology or geo-science. However, due to their chemical reactivity, it is often impossible to keep them stable in any container and traditional methods like viscosimetry or sound velocity measurements fail.

We combined a levitation setup, where the sample is molten by a 270 Watts CO_2-laser (see Fig.1-3), with the inelastic X-ray spectrometer at the APS. The quantity that can be extracted from an inelastic scattering measurement in the dynamic structure factor $S(Q,\omega)$, shown for different Q-values in figure 4. From the position of the side peaks and widths one can extract the longitudinal sound velocity and damping (Fig. 5), which can be related to viscosity, relaxation times and diffusion processes (Fig. 6,7) [4]. Figure 8 shows a preliminary analysis of data on liquid boron. In contrast to the results in liquid alumina, an upward bend in the sound dispersion is observed, an indication of a high frequency viscoelastic transition.

References:
[1] F. Sette et al. PRL **75**, 850(1995)
[2] E. Burkel, Rep. Prog. Phys. **63**, 171 (2001)
[3] H. Sinn, J. Phys. Condens. Matter, **13**, 7525 (2001)
[4] H. Sinn et al, Science **299**, 2047 (2003)





Figures 1-3: ***Left****: Schematic view of levitation setup*
Middle: *Levitated alumina sphere at 2100°C. The diameter of the sample is about 3 mm.*
Right: *Integration of levitation setup at Sector 3, APS.*

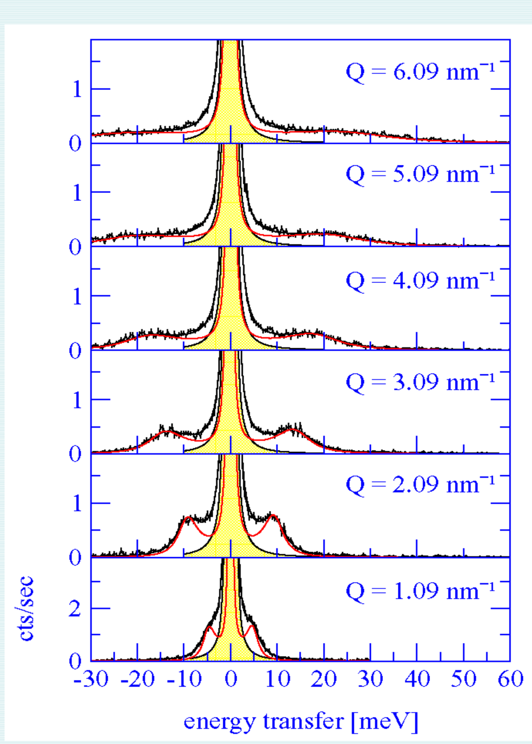


Fig.4: *Dynamic structure factor of liquid alumina at 2100°C*

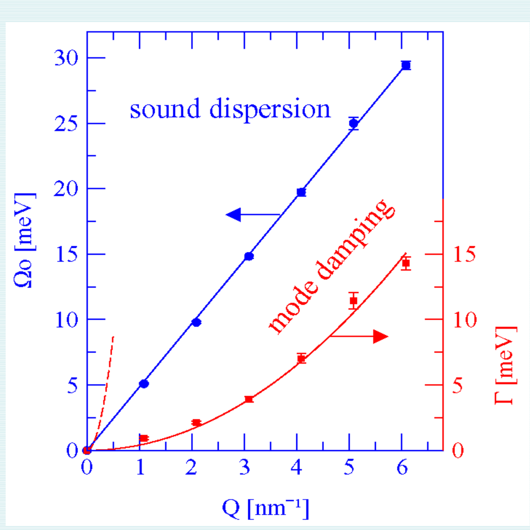


Fig.5: *Dispersion and damping of the sound modes*

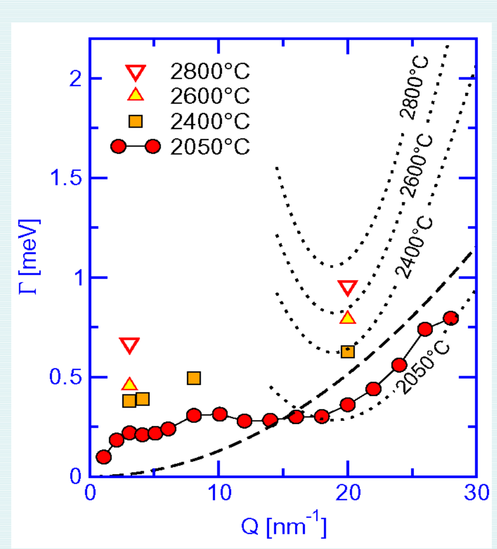


Fig. 6: *Width of the central line as a function of Q and T.*

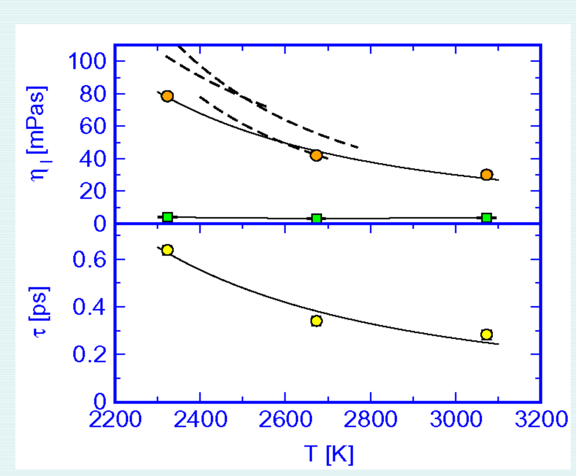


Fig. 7: *Relaxation times obtained by a viscoelastic fit to the alumina data.*

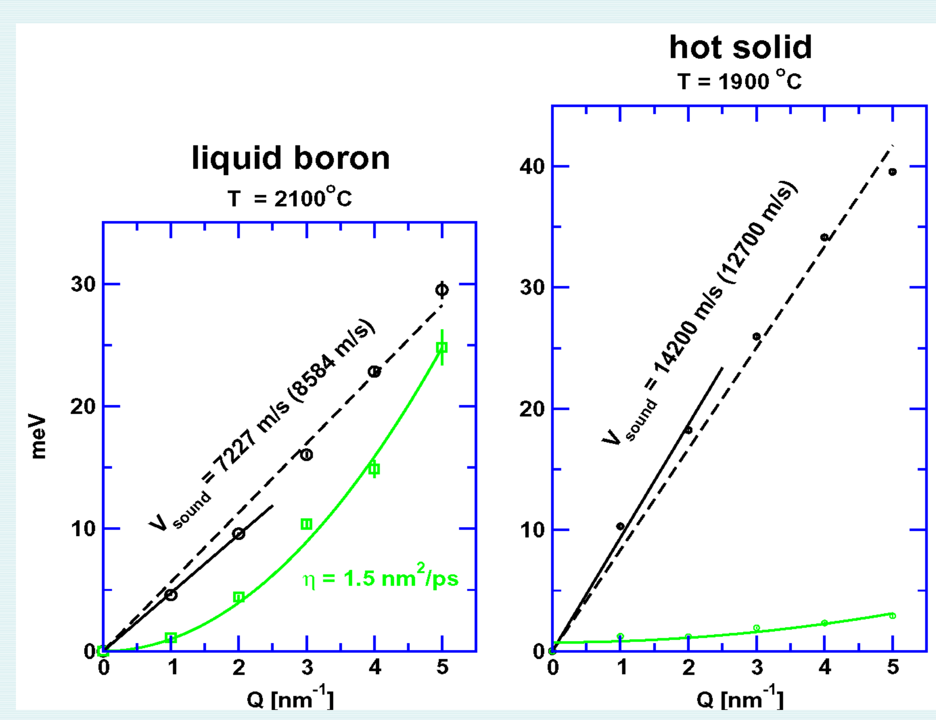


Fig.8: *Phonon dispersion in boron below and above the melting point*

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