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Experiment title: Q-dependence of the broadening of high frequency acoustic phonons in densified silica glass		Experiment number: HS-1749
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Report:

At sufficiently low frequencies Ω, acoustic modes propagate in glasses as in any continuous medium. In the GHz region and at a sufficient T, the attenuation is dominated by the Akhiezer mechanism, $\Gamma_{\mathrm{hom}} \propto \Omega^2$. However, glasses show a pronounced ”plateau” in the T dependence of their thermal conductivity. This was explained, *e.g.* in [1], by postulating the existence of a rapid *crossover* of acoustic waves into a regime where they experience *strong scattering* for $\Omega > \Omega_{\mathrm{co}}$. Several models predict an inhomogeneous width of the phonons, Γ_{inh}, increasing with a high power of Ω, typically $\Gamma_{\mathrm{inh}} \propto \Omega^4$, leading to this rapid crossover. The origin of the high power remains debated, either Rayleigh scattering from structural defects or resonance with local modes. Rayleigh scattering seems too weak to account for the relatively low value of Ω_{co} derived from the position of the plateau [1,2]. Local modes are seen in the ”boson peak” and produce an excess over the Debye specific heat. On the basis of recent IXS results, some authors challenged the above picture by denying the existence of Ω_{co}, *e.g.* [3,4]. In our experiment, we find the region where the linewidth is dominated by the rapid increase of Γ_{inh}. For this purpose, we investigated densified silica glass, d-SiO_2, in which the crossover is at about 8 to 9 meV and at a wave vector q_{co} near 2 nm^{-1} [5], making the region before crossover accessible to IXS experiments.

Fig. 1 shows the spectra obtained with ID16 on d-SiO_2 at 565 K for scattering vectors Q ranging from 1.2 nm^{-1} to 2 nm^{-1}. In Fig. 1a, the full spectrum is shown for our smallest $Q = 1.17$ nm^{-1}. The dashed line in 1a follows the elastic peak. To extract information on the position Ω and half-width Γ of the Brillouin doublet, the spectra are adjusted to a damped harmonic oscillator (DHO) plus an elastic central peak,

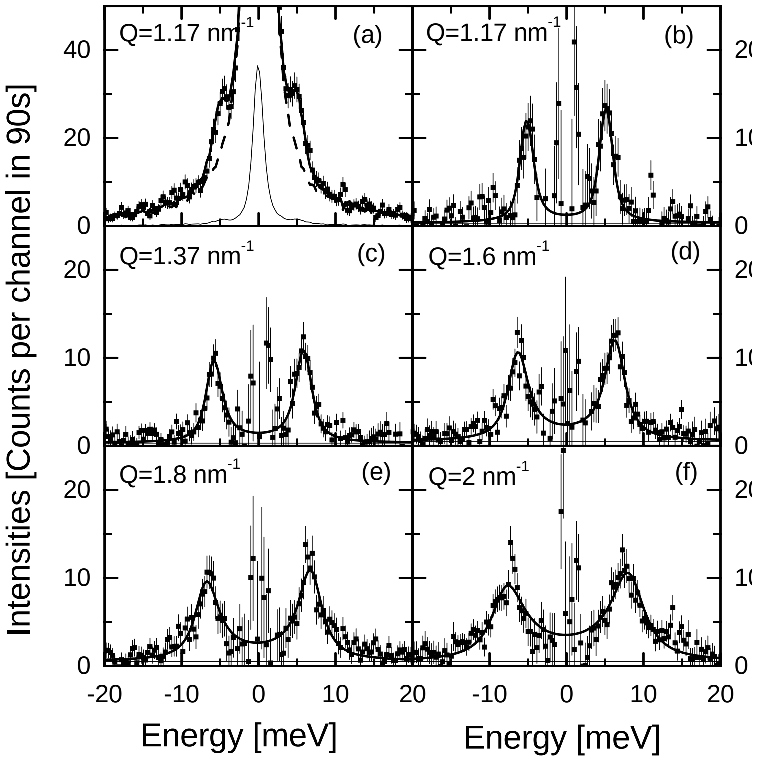

Figure 1

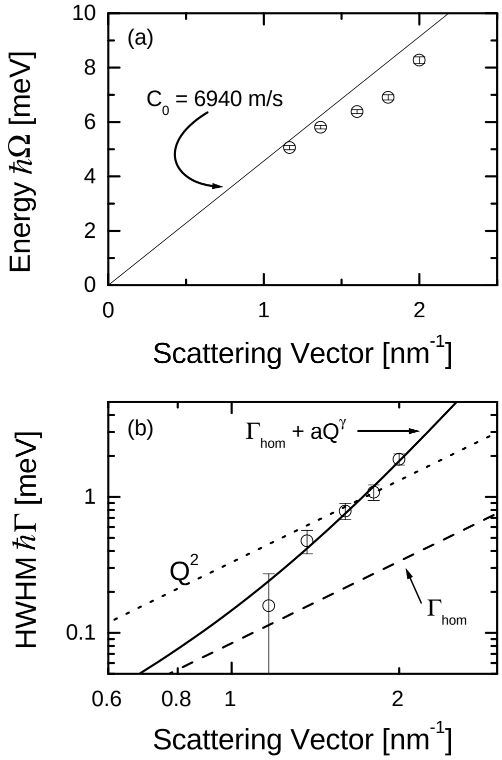

Figure 2

convoluted with the instrumental function. The baselines in Fig. 1 are fixed to the electronic noise of the detectors. Figs. 1b-f illustrate the inelastic part remaining after subtraction of the adjusted elastic contribution. The solid lines are DHO fits.

The values obtained for Ω agree with [5] and are shown in Fig. 2a together with the extrapolation of the Brillouin light scattering result (line). Those for Γ are shown in Fig. 2b. They increase very rapidly with Q. Also shown in the same figure is the expected Γ_{hom} (dashed line), extrapolated from the optical Brillouin-scattering determination. The total scattering rate is approximated by adding rates due to independent processes, $\Gamma = \Gamma_{\mathrm{hom}} + \Gamma_{\mathrm{inh}}$, where Γ_{inh} is adjusted to $\Gamma_{\mathrm{inh}} \propto Q^\gamma$. A fit of the five points gives the solid line with $\gamma = 4.6 \pm 0.7$. For comparison, the best fit with $\gamma = 2$ is very poor, as shown by the dotted line in Fig. 2. Further, we remark that the fifth point is too close to q_{co} to be unaffected by the Ioffe-Regel saturation of Γ_{inh} [5]. Fitting only the first four points with $\Gamma_{\mathrm{inh}}(\Omega) \propto \Omega^\alpha$, we find $\alpha = 5.7 \pm 1.0$.

Our results reveal the onset of strong scattering where the linewidth of LA phonons increases with a high power Ω^α or Q^γ. We find that α is at least 4 and possibly quite a bit larger which clearly deserves further investigations.

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