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Names and affiliations of applicants (* indicates experimentalists):

*****H. Schober, ILL

*M.M. Koza, University of Dortmund
A. Tölle, University of Dortmund
F. Fujara, University of Dortmund
*F. Sette, ESRF

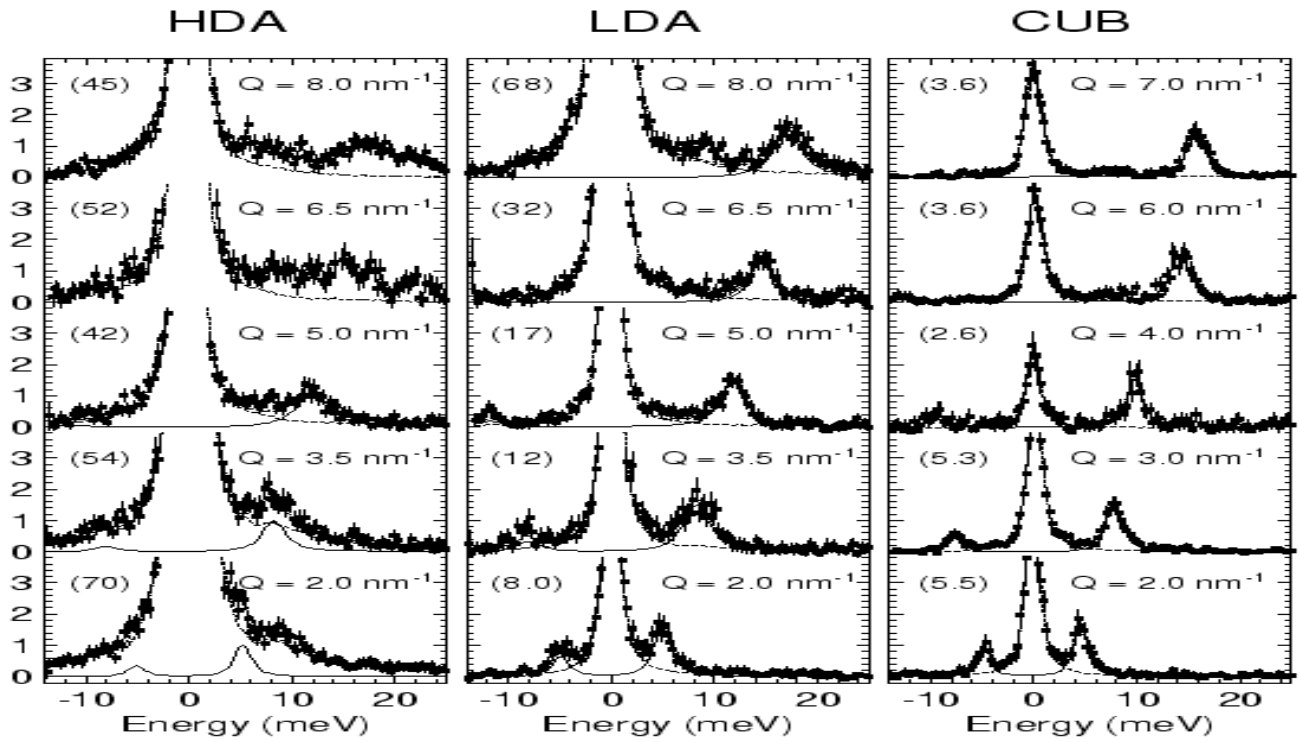
Report:

Using the very high energy resolution ID16 beamline we have determined the excitation spectrum of both amorphous forms of water, i.e. high-density (*HDA*) and low-density amorphous ice (*LDA*) and compared it to crystalline ice I_c. Details concerning the instrument setup can be found in cond-mat /0002340 (equally submitted to PRL).

A selection of inelastic spectra are reported in Fig. 1. In both amorphous ice phases and in the cubic crystalline phase there are well pronounced resonances. Increasing Q one initially observes a single feature with a marked dispersion. At Q-values higher than 5 nm^{-1} the spectra become more complicated by the appearance of additional inelastic features. As X-rays couple directly to the longitudinal component of the density fluctuations, the dispersive excitation can be readily identified with the longitudinal acoustic-like branches. In *HDA* these excitations can be clearly observed up to about 5 nm^{-1} while in *LDA* and I_c they can be safely distinguished from the other features up to 10 nm^{-1}.

In both *LDA* and *HDA* one observes that the resonances become broader with increasing Q-transfer. A systematic Q-dependence can, however, not be established.

Despite the difficulty to give full account of the observed broadening in the measured spectra, one can deduce the following important observation: As seen by the naked eye, the width of the resonances remains by far smaller than the excitation energy for all the considered Q-values. This result is very different from the observation made so far in other glassy systems.



There, in fact, one observes an acoustic phonon-like resonance with a linear dispersion of $\Omega(Q)$ vs. Q and a quadratic dispersion of $\Gamma(Q)$ vs Q.
Figure 1: Inelastic X-ray spectra of high density amorphous *HDA*, low density amorphous *LDA* and crystalline cubic ice I_c at the indicated Q values lying mainly in the first pseudo Brillouin zone. The dashed line is a fit to the sinal using a Lorentz-function convoluted with the resolution function (equally indicated). The solid line represents the inelastic contribution to the total fits.

A further observation coming from the analysis is that the spectra of *LDA*, at all considered Q-values, are very similar to those measured in ice I_c . In *HDA* the resemblance is less pronounced.This shows that these two states of the water molecule possess a surprisingly crystal-like dynamic response. These experimental findings are in sharp contrast to the results found so far in other glasses, glass forming materials, liquids, dense gases and disordered materials in general.
We deduce from our data highly intact hydrogen bond networks both in *LDA* and to some lesser degree equally in *HDA*. Due to the constraints of the network the number of states the system can sample on the ps time scale should be small, i.e. there is a small configurational entropy, a view which is compatible with thermodynamic data. *HDA* is expected to possess a larger configurational entropy, and on this basis one can justify that *HDA* has more "glassy behavior" than LDA.