ESRF

Experiment title: Acoustic Phonon Dispersion in CdTe at 7.5 GPa	**Experiment number:** HS 78

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Names and affiliations of applicants (*indicates experimentalists):

M. Krisch, A. San Miguel, A. Mermet, and F. Sette
Experiments Division, ESRF, BP. 220, F-38043 Grenoble Cedex, France

Report:

Inelastic x-ray scattering under high pressure, employing a diamond anvil cell (DAC), was used to determine the acoustic phonon dispersion curve of polycrystaliine CdTe in its NaCl phase at 7.5 GPa and room temperature [l]. The spectra were recorded with an energy- and momentum resolution of 7 meV and 0.4 nm^{-1}, respectively, for momentum transfers Q between 3 and 10 nm^{-1}, extending over the first Brillouin zone. We observe at all Q-values a substantial increase of the longitudinal acoustic phonon frequencies with respect to the corresponding dispersion curve of CdTe in its zincblende structure at ambient pressure [2]. The derived sound velocity, representing an average over all the crystalline directions, is increased by a factor 1.6 to 5100 ± 300 m/s.

Our results demonstrate the potential of inelastic x-ray scattering with very high energy resolution in the study of microscopic dynamics of matter in the GPa pressure regime. The diamond anvil cell is well adapted to the study of elements with atomic number Z ranging typically between 30 and 70, where, at the photon energies utilised, the photoelectric absorption length is in the order of the sample thickness of 20 to 40 μm, compatible with the DAC. Due to the capability to focus x-rays onto a small spot, there is essentially no loss of incident intensity on the sample, apart from about 50 % absorption by the diamond windows (at 13840 eV). In contrast to inelastic neutron scattering (INS), in inelastic x-ray scattering (IXS) energy- and momentum transfer are decoupled. An IXS experiment can therefore be performed at fixed momentum- and energy resolution over a wide range in the energy-momentum transfer space. The performed experiment is the first one of its kind, and from the promising result one can expect that high pressure studies using IXS will give important contributions, especially in cases where INS can not be applied, i.e. in systems with a large incoherent neutron cross section or where sufficiently large samples are not available.

[I] M.H. Krisch, A. Mermet, A. San Miguel, F. Sette, C. Masciovecchio, G. Ruocco, and R. Verbeni; Phys. Rev. B 56, 15. oct. (1997).
[2] J. M. Rowe, R. M. Nicklow, D. L. Price, and K. Zanio, Phys. Rev. B10, 671 (1974).

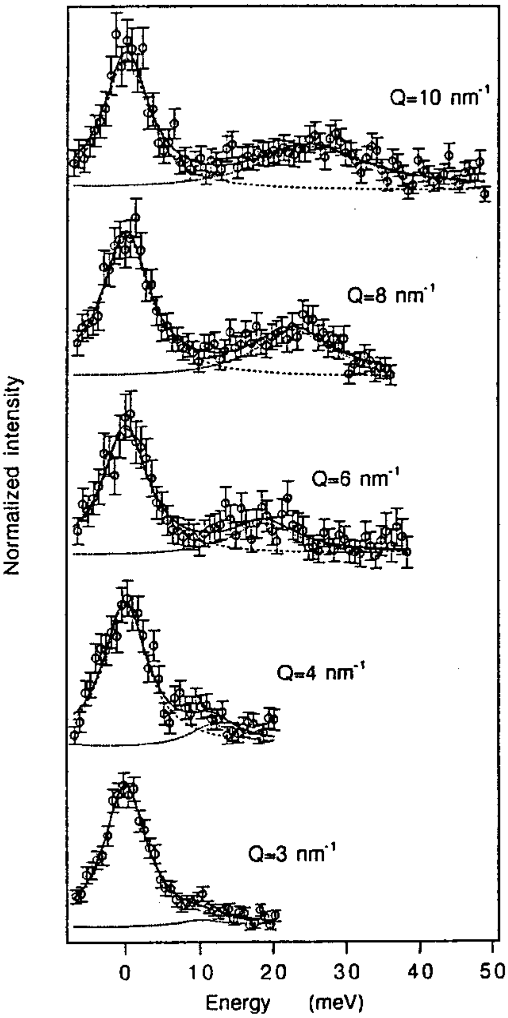

FIG. 1 - Inelastic X-ray scattering spectra of CdTe at 7.5 GPa. The experimental data (open circles), shown with the error bars, are superimposed to the fit (solid line), consisting of two Lorentzians. The dashed and dotted lines represent the elastic and inelastic contributions, respectively. The elastic contribution is due to nitrogen which was used as pressure transmitting medium. This contribution can be significantly reduced by using helium. The inelastic contribution is unambiguously assigned to be due to phonons of CdTe, since the diamond phonons are observed at higher energies due to the much higher sound velocity of ≈ 12000 m/s. The data are normalized to the intensity of the central peak. The integration time for each point was typically 300 seconds.

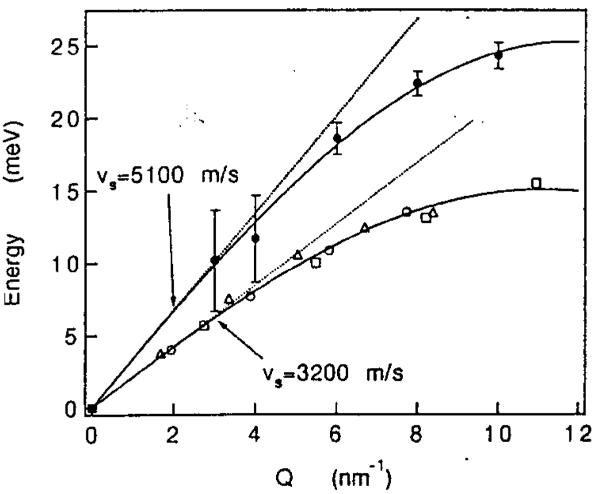

FIG. 2 - Longitudinal acoustic phonon dispersion curves of CdTe at 7.5 GPa (full symbols) and at ambient pressure from Rowe et al. (11, obtained by neutron inelastic scattering (open symbols; triangles correspond to the [111] direction, circles to the [100] and squares to the [110]). The MS data are shown with their error bars as obtained from the fit. We note that for Q = 3 nm^{-1} and 4 nm^{-1} the error is fairly large due to the lack of contrast between the central line and the inelastic feature. The solid lines through the data points represent the result of a sinus fit, and the dotted lines visualize its initial slope, yielding the sound velocities, as indicated in the figure.