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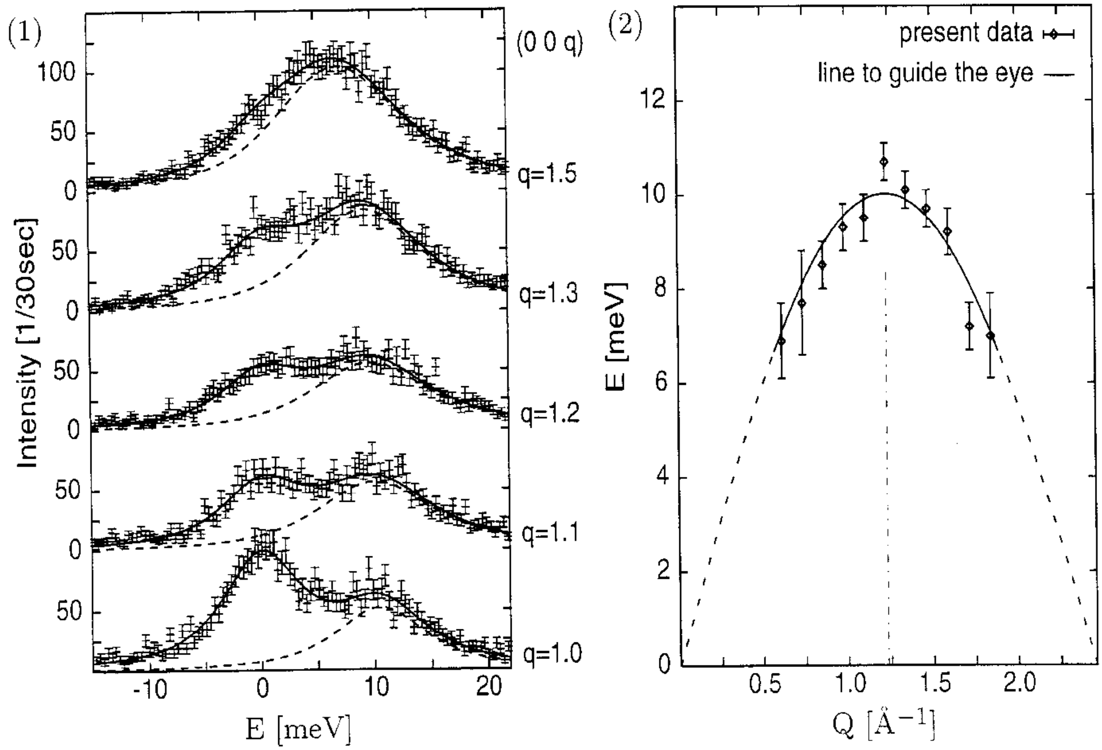
First Observation of Phonons in solid ^{3}He

Condensed helium of both isotopes, ^{3}He and ^{4}He is a model substance to study quantum effects in liquids and solids. Thus, inelastic neutron scattering has been employed to study the dynamics in liquid and solid ^{4}He and in liquid ^{3}He [1]. However, up to now no experimental data of the dynamics in solid ^{3}He are available. This is mainly caused by the very high absorption cross section of ^{3}He for thermal neutrons. Therefore, the technique of inelastic x-ray scattering with meV resolution is the method of choice to study the dynamical properties of this quantum solid. It is isotope independent and has been used successfully to measure the phonon dispersion in hcp ^{4}He [2].

Since helium only solidifies at low temperature and externally applied pressure the sample environment consists of a closed cycle cryostat and a high pressure system to grow helium crystals in situ. With the high pressure system the ^{3}He pressure was increased from 2 MPa to 90 MPa, the pressure used for nearly isobaric growth of hcp ^{3}He crystals with a molar volume of 13.2(l) cm^3. The single crystals were oriented and kept at 11 K. Energy scans at fixed momentum transfer were performed along the highly symmetric [100] and [001] directions in the first two Brillouin zones. The energy resolution was 8.6 meV at a wavelength of 0.896 A.

Sample spectra for different momentum transfers Q=q$\cdot 2\pi/c$ along the [001] direction are shown in fig. (1). The elastic contributions from the beryllium sample cell and the ^{3}He phonons are visible. For the preliminary data analysis, the phonons were described (dashed line) by the Fåk & Dorner [3] model, ignoring multi-phonon contributions. The dispersion of the phonon energy with momentum transfer is obvious. It is displayed in fig. (a), showing the LO branch in the second Brillouin zone. The vertical line indicates the zone centre, i.e. the forbidden (001) reflection. Within the errorbars, the phonon energies seem to show the expected symmetry about the zone centre.

Due to drifts of the zero of the energy transfer axis, each scan had to be calibrated individually, using the elastic line from the sample cell. This imposes a lower limit to the accessible energy transfer range since the elastic signal has to be distinguishable from the phonon part. Thus, only the highlying longitudinal phonon branches could be studied. However, a follow-up experiment with better energy resolution has already been performed, the analysis is in progress.



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