Inelastic X-ray Scattering Study on the Collective Dynamics in Liquid Hg

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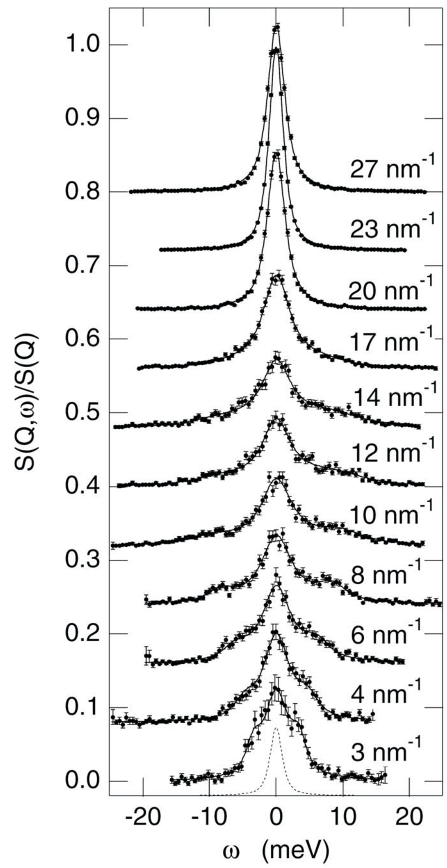
Introduction

Recently, the investigation of collective dynamics in liquid (l-) metals was considerably encouraged by the use of inelastic x-ray scattering (IXS). It permits studies of the Q dependence of excitations in the meV range, which has so far been exclusively the domain of inelastic neutron scattering (INS). Results of recent IXS experiments on l-Li[1,2] and Na,[3] as well as INS measurements for l-Rb[4] and l-Cs,[5] revealed that the positions of the phonon peaks in the low Q range lie on a line whose energies are higher than predicted by classical hydrodynamics. Namely, a so-called positive dispersion is observed in these systems. The most fundamental approach to a theoretical understanding of the positive dispersion in simple monatomic fluids is through the application of generalized hydrodynamics.[6] In the high-frequency limit, the sound velocity is no longer given by the compressibility of the system but ruled by elastic moduli, as in a solid. The low Q limit of the high-frequency sound velocity of a simple isotropic liquid can be estimated through the interatomic potential of the system. The potentials of l-alkali metals are attractive around the nearest neighbor distance, whereas that of l-Hg is purely repulsive. Thus, for this large contrast, l-Hg is a good candidate to prove a validity of the generalized hydrodynamic theory. Due to the extremely high absorption cross section of Hg for thermal neutrons, however, the microscopic dynamics of l-Hg has never been experimentally investigated, not even at room temperature. In this paper, we report our recent results of S(Q,ω) for l-Hg at room temperature obtained from a high-resolution IXS experiment.



Methods and Materials

The IXS experiments were carried out by using the newly developed inelastic scattering diffractometer installed at beamline 3-ID-C. The energy of the incident x-rays was around 21.657 keV, and the energy resolution function has a pseudo-Voigt shape with a width of 2.15 meV. The Hg sample was contained in a single-crystal sapphire cell with a wall thickness of 0.25 mm.[7] It is highly transparent to x-rays and contributes neither inelastic nor elastic to the scattering intensity. Strong x-ray absorption by the Hg sample is suppressed by using a sample thickness of only 0.02 mm. The cell was placed in a vessel with Kapton windows, which was filled with 1 bar of He gas.

Results and discussion

Figure 1 shows S(Q,ω) normalized to S(Q). Full circles represent the experimental data with error bars. At Q ≤ 17nm^{-1}, propagating excitations were clearly identified as shoulders at both sides of the quasielastic line. The spectra in this figure demonstrate that the dynamics of l-Hg is dominated by longitudinal propagating modes, analogous to l-alkali metals [1-5]. A detailed analysis of the phonon dispersion and the width of the quasielastic line will be given in a subsequent paper.[8]

Acknowledgments

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