High-Frequency Acoustic Modes in Liquid Gallium at the Melting Point

T. Scopigno,[1] A. Filipponi,[2] M. Krisch,[3] G. Monaco,[3] G. Ruocco,[1] and F. Sette[3]
[1]*Dipartimento di Fisica and INFM, Universitá di Roma "La Sapienza," I-00185, Roma, Italy*
[2]*Dipartimento di Fisica and INFM, Universitá di L'Aquila, I-67010, L'Aquila, Italy*
[3]*European Synchrotron Radiation Facility, B.P. 220 F-38043 Grenoble, Cedex France*
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The microscopic dynamics in liquid gallium at melting has been studied by inelastic x-ray scattering. We demonstrate the existence of acousticlike modes up to wave vectors above one-half of the first maximum of the static structure factor, at variance with earlier results from inelastic neutron scattering [F. J. Bermejo *et al.*, Phys. Rev. E **49**, 3133 (1994)]. Despite structural (extremely rich polymorphism) and electronic (mixed valence) peculiarities, the collective dynamics is strikingly similar to the one of van der Waals and metallic fluids. This result speaks in favor of the universality of the short time dynamics in monatomic liquids rather than of system-specific dynamics.

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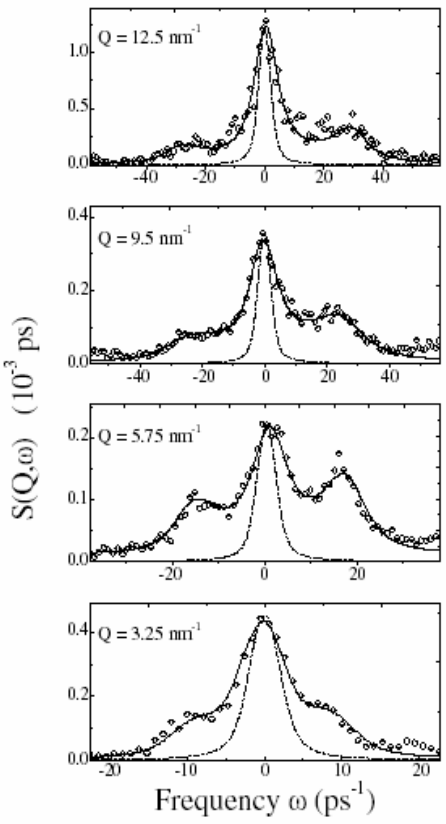

FIG. 2. Selection of IXS spectra (○) plotted with the fitting function (—) described in the text. The instrument resolution function ($\delta E \approx 3.0$ meV) is also shown (· · ·).

In conclusion, we presented an experimental study of the collective high frequency dynamics in liquid gallium at the melting temperature. Evidence for collective acoustic modes has been found in a Q region extending beyond the hydrodynamic regime up to one-half of the structure factor main peak. A generalized hydrodynamic analysis allows a quantitative determination of relevant parameters such as the structural relaxation time and the generalized viscosities. More importantly, it reveals how the main features of the collective dynamics in this system are very similar to the ones reported in different elements such as Li, Na, Al [7] and noble gas fluids [14,15]. This is an important indication of how—despite *quantitative* differences—the high frequency dynamics in simple fluids exhibit universal features which go beyond system dependent details such as the electronic structure, bond nature, atomic interaction, and structural properties. Since on the observed time scale the structure of the liquid is frozen [$\omega_l(Q)\tau_\alpha(Q) \gg 1$], one can think of the high frequency dynamics as that of a system with well-defined equilibrium position ("glass"). Therefore, the details of the dynamics (microscopic relaxation times, residual viscosity) are fully determined by the vibrations of the disordered structure, explaining the observed universality [12,13]. Finally, although we did not find any evidence for additional modes in the explored Q range, on the basis of the findings of Ref. [11] we believe that further investigations should be devoted to the higher Q region.