High frequency acoustic modes in vitreous beryllium fluoride probed by inelastic x-ray scattering

T. Scopigno[a)]
Dipartimento di Fisica and INFM, Università di Roma "La Sapienza," I-00185, Roma, Italy

S. N. Yannopoulos and D. Th. Kastrissios
Foundation for Research and Technology — Hellas, Institute of Chemical Engineering and High-Temperature Chemical Processes, P.O. Box 1414, 265 00 Patras, Greece

G. Monaco
Euorpean Synchroton Radiation Facility, BP 220 F 38043, Grenoble Cedex, France

E. Pontecorvo and G. Ruocco
Dipartimento di Fisica and INFM, Università di Roma "La Sapienza," I-00185, Roma, Italy

F. Sette
European Synchroton Radiation Facility, BP 220 F 38043, Grenoble Cedex, France

(Received 9 July 2002; accepted 9 October 2002)

Inelastic x-ray scattering measurements of the dynamics structure factor have been performed on vitreous beryllium fluoride (v-BeF_2) at $T=297$ K in the momentum transfer, Q, range $Q=1.5$–10 nm^{-1}. We find evidence of well defined high frequency acoustic modes. The energy position and linewidth of the excitations disperse with Q as $\propto Q$ and $\propto Q^2$, respectively, up to about one half of the first maximum of the static structure factor. Their magnitude compares favorably with low-frequency sound velocity and absorption data. The results indicate worth mentioning similarities of the high frequency collective dynamics of different network forming glasses such as v-B_2O_3 and v-SiO_2. [DOI: 10.1063/1.1526097]

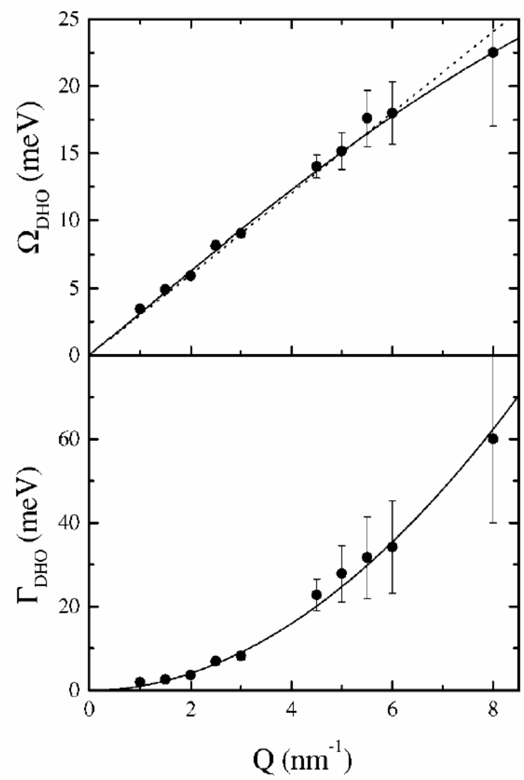

FIG. 2. Q-dependence of the sound frequency and attenuation. Upper panel: experimental sound dispersion (full dots) and best fit through a sine function (full line). The adiabatic sound speed, measured by ultrasonics, is also reported (dotted line). Lower panel: Acoustic attenuation as determined by the Brillouin linewidth (full dots). The solid line is a power law fit to the experimental data and gives $\Gamma_{DHO}=1.05Q^{1.96}$.

In conclusion, a room temperature IXS study of glassy BeF_2 has been undertaken in the present work. In accordance with all previous studies in strong and fragile glasses, evidence has been presented for well-defined propagating (high-frequency) acoustic modes, whose frequency position and linewidth scale as $\propto Q$ and $\propto Q^2$, respectively. The longitudinal speed of sound for glassy BeF_2 has been estimated to exceed its low-frequency (ultrasonic) limit by almost 5%; a case analogous to that found in studies of vitreous silica. The extrapolation of the high-frequency linewidth conforms nicely with the value obtained from ultrasonic studies, and exhibits a scenario similar to that of vitreous silica. Another similarity which deserves further study is that the temperature dependence (in a T_g-scaled plot) of the nonergodicity factor, as determined from the ratio of the elastic to the total scattered intensity, follows the behavior exhibited by SiO_2 (Fig. 5) while for less strong glasses the drop of f_Q is much faster with increasing temperature. Unfortunately, for BeF_2 it is up to now available as only one point in such a T_g-scaled plot, which however coincides with the f_Q data for silica. Further temperature-dependence studies on BeF_2 are expected to shed more light on this issue.