



HAL
open science

Brillouin scattering from D20 at pressures up to 34 GPa

A. Polian, M Grimsditch

► **To cite this version:**

A. Polian, M Grimsditch. Brillouin scattering from D20 at pressures up to 34 GPa. *Physical Review B: Condensed Matter (1978-1997)*, 1984. hal-03059387

HAL Id: hal-03059387

<https://hal.science/hal-03059387>

Submitted on 12 Dec 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Brillouin scattering from D₂O at pressures up to 34 GPa

A. Polian

*Laboratoire de Physique des Milieux Très Condensés, Université Pierre et Marie Curie,
4 place Jussieu, F-75230 Paris, France*

M. Grimsditch

*Materials Science and Technology Division, Argonne National Laboratory,
Argonne, Illinois 60439*

(Received 19 January 1984)

A Brillouin scattering study of D₂O under hydrostatic pressure shows that the effective longitudinal modulus behaves the same as that of H₂O (reported earlier by the present authors). This is in contrast to the behavior found for the bulk modulus [reported by Munro *et al.*, *J. Appl. Phys.* **53**, 6174 (1982)].

In a recent publication¹ we presented the results of a Brillouin scattering study of H₂O up to 30 GPa in which an effective longitudinal elastic modulus was determined as a function of pressure. This study was later extended to pressures up to 67 GPa and a new phase (ice X) encountered.² In the cubic ice VII phase (2 GPa → 44 GPa) we compared¹ our values for the effective longitudinal elastic constant (*C*) with values of the bulk modulus (*B*) determined in Ref. 3. We found that within experimental error our value of $C' = \Delta(\log_{10} C) / \Delta(\log_{10} \rho)$ was equal to the value of $B' = \Delta(\log_{10} B) / \Delta(\log_{10} \rho)$ (where ρ is the density) determined in Ref. 3. The large difference³ in the values of *B'* for H₂O and D₂O and the differences⁴ in the transition pressures and temperatures from liquid to ice VI and ice VI to ice VII for these two substances prompted us to investigate the elastic properties of D₂O using Brillouin scattering.

We mention here that the difference between *B'* in H₂O and D₂O has recently been explained using thermodynamical considerations.⁵

The experimental setup is identical to that described in Ref. 1. Although data are analyzed in the same way as in Ref. 1, for clarity, the method will be briefly described here: we measured the Brillouin frequency shift $\Delta\omega_B$ from which the product of the refractive index *n* times the sound velocity *V* can be calculated. The velocity is, in turn, related to the density (ρ) and an elastic constant (*C*) by

$$V = (C/\rho)^{1/2} \quad (1)$$

Since the refractive index is known up to 1.1 GPa and is extrapolated¹ up to 34 GPa, and the density is known up to 36 GPa,³ the sound velocity and an effective elastic constant can be calculated. Analysis of this elastic constant in the framework of the Murnaghan equation of state leads to a linear dependence of $\log_{10} C$ vs $\log_{10} \rho$.

Analogous to the bulk modulus results,³ we find no difference in the values of *C* determined for H₂O and D₂O at a given pressure. In Fig. 1 we plot our values of $\log_{10} C$ (*C* in GPa) vs $\log_{10}(\rho/\rho_0)$; from these results we obtain for D₂O $C' = 4.00 \pm 0.15$ which is to be compared with the values 4.3 and 4.1 determined for H₂O in Refs. 1 and 2, respectively. The errors given for *C'* do not include a possible systematic error in the extrapolation of *n*; however, a change of 10% in the extrapolation of *n* only changes *C'* by 0.04.

The small (or zero) difference between the values of *C'* for D₂O and H₂O is in sharp contrast to the values found

for *B'*. In Ref. 3 *B'* is found to be weakly pressure dependent but at 15 GPa, for example, *B'* is 4.20 ± 0.15 for H₂O and 3.55 ± 0.02 for D₂O. Recalling that for a cubic crystal

$$B = \frac{1}{3}(C_{11} + 2C_{12}) \quad (2)$$

and assuming that our effective longitudinal elastic modulus mirrors the behavior of the constant *C*₁₁, we can infer that the changes in the elastic behavior of crystals of H₂O and

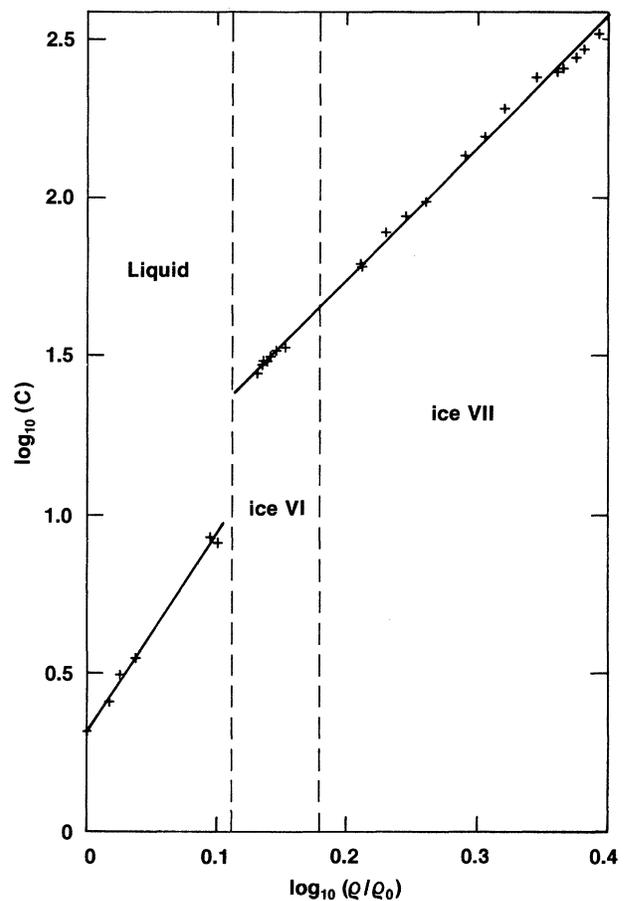


FIG. 1. Plot of $\log_{10} C$ (*C* in GPa) vs $\log_{10}(\rho/\rho_0)$ for D₂O at room temperature.

D₂O are principally due to changes in the constant C_{12} . Since this constant is critical in describing the shear elastic properties of a solid, it is of great interest to obtain information on the shear elastic moduli. In order to do this by Brillouin scattering, however, a modified diamond anvil cell such as that described in Refs. 6 and 7 is required.

ACKNOWLEDGMENTS

This work has been supported by the U.S. Department of Energy; the Institut National d'Astronomie et de Geophysique, Grant No. 83-070978; and the Direction des Recherches, Etudes et Techniques, Grant No. 80-500.

¹A. Polian and M. Grimsditch, Phys. Rev. B 27, 6409 (1983).

²A. Polian and M. Grimsditch, Phys. Rev. Lett. 52, 1312 (1984).

³R. G. Munro, S. Block, F. A. Mauer, and G. Piermarini, J. Appl. Phys. 53, 6174 (1982).

⁴G. J. Piermarini, R. G. Munro, and S. Block, in Proceedings of the IXth Association Informationale for Research and Advancement of High Pressure Science and Technology International High Pres-

sure Conference, Albany, NY, July 1983 (in press).

⁵S. Rodriguez and M. Grimsditch (unpublished).

⁶C. H. Whitfield, E. M. Brody, and W. A. Bassett, Rev. Sci. Instrum. 47, 942 (1976).

⁷H. Shimizu, E. M. Brody, H. K. Mao, and P. M. Bell, Phys. Rev. Lett. 47, 128 (1981).