

Infrared Absorption Wavelengths for Solid LiH and LiD<sup>†</sup>

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(Received June 10, 1960)

The infrared absorption spectrum of thin films of LiH and LiD was obtained at room temperature for the region 12.5–25  $\mu$ . The primary feature of the spectrum is a broad but definite absorption peak which occurs at 17.0  $\mu$  for LiH and at 22.4  $\mu$  for LiD. The observed ratio of the wavelengths is  $1.32 \pm 0.02$ , in excellent accord with the ratio of the square root of the reduced masses, 1.33. This agreement is a confirmation of the elementary Born theory of lattice vibrations.

AMONG the experimental techniques for investigating the features of lattice-vibration spectra, the study of the infrared absorption of thin films is especially valuable because it permits direct determination of an important theoretical parameter, the infrared dispersion wavelength. To examine the range of validity of the Born formulation of lattice dynamics with respect to this quantity, we have studied the infrared absorption spectrum of thin films of lithium hydride made from different proportions of the isotopes Li<sup>6</sup> and Li<sup>7</sup>, H<sup>1</sup> and H<sup>2</sup>. In this note only the results with natural lithium depleted in Li<sup>6</sup> (Li:  $\sim 97\%$  Li<sup>7</sup>,  $\sim 3\%$  Li<sup>6</sup>) in combination with natural hydrogen (H:  $\sim 100\%$  H<sup>1</sup>) or deuterium (D:  $\sim 98\%$  H<sup>2</sup>) are described.

A sample of powder of the appropriate composition was placed in a molybdenum boat, and vacuum-evaporated onto a cleaved KBr plate forming one wall of a specially-constructed vacuum cell. The thickness of the film was estimated by interferometric observation of the deposit on a glass slide placed next to the KBr plate during the evaporation. Infrared absorption spectra from 12.5  $\mu$  to 25  $\mu$  were obtained at room temperature with a Perkin-Elmer Model 137 Recording Spectrophotometer ("Infracord") with KBr optics. With suitable sample thicknesses (0.03  $\mu$ –2  $\mu$ ), each material showed a broad but distinct and reproducible absorption maximum, as shown in Fig. 1, whose position could be read to 0.1  $\mu$ .

For LiH, the position of the absorption peak was found to be at  $17.0 \pm 0.2 \mu$ , and for LiD at  $22.4 \pm 0.2 \mu$ . The ratio of the two wavelengths is  $1.32 \pm 0.02$ . According to the elementary portions of the Born theory,<sup>1</sup> the ratio should be the same as that of the square root of the reduced masses, if the mixture of the lithium or

hydrogen isotopes can be considered as equivalent to a single species of the average isotopic mass. This latter ratio is 1.33, in excellent accord with the observed value. A similar result had been indicated in the findings of Montgomery and Misho<sup>2</sup> with Li<sup>6</sup>F and Li<sup>7</sup>F, but the present result is more definitive in view of the large relative difference in mass of the hydrogen isotopes in comparison with the lithium isotopes.

The observed value of 17.0  $\mu$  for the dispersion wavelength of LiH confirms the estimate of Filler and Burstein<sup>3</sup> from their data on the infrared reflectivity of thick crystals of LiH. Upon taking their value for the

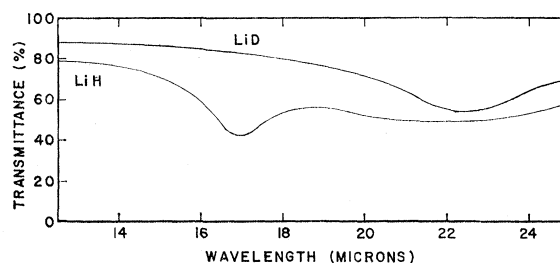


Fig. 1. Infrared absorption spectrum for evaporated films of LiH and LiD at room temperature. Film thicknesses: less than 0.1  $\mu$ .

longitudinal optical frequency (corresponding to 8.93  $\mu$ ), and that for the transverse optical frequency found in the present work (corresponding to 17.0  $\mu$ ), in conjunction with the value of 3.61 for the value of the high-frequency dielectric constant reported by Staritsky and Walker,<sup>4</sup> we obtain a value of 13.0 for the static dielectric constant. A direct measurement of this quantity would permit a more stringent test of the Born theory than that provided by the comparison above.

<sup>†</sup> This work was supported by the Air Force Office of Scientific Research and the U. S. Atomic Energy Commission.

<sup>1</sup> See, e.g., M. Born and K. Huang, *Dynamical Theory of Crystal Lattices* (Clarendon Press, Oxford, 1954), Chap. 2.

<sup>2</sup> D. J. Montgomery and R. H. Misho, *Nature* **183**, 103 (1959).

<sup>3</sup> A. S. Filler and E. Burstein, *Bull. Am. Phys. Soc.* **5**, 198 (1960).

<sup>4</sup> E. Staritsky and D. I. Walker, *J. Anal. Chem.* **28**, 1055 (1956).