component of the line of Li^7 should be the ratio of the nuclear g-values. The observed ratio is about 2.85, while the ratio of the g-values is 2.64. The resolution of our apparatus is somewhat variable, depending on the velocity of the molecules in the beam. The best resolution occurs, in these experiments for LiI, where, for a perfectly homogeneous magnetic field, the resolution half-width is about 1.2 kc/sec. It is thus evident that the entire width of the observed Li^6 line can be accounted for without any broadening due to the electric quadrupole moment of Li^6.

By use of a Hartree Model, Weisskopf[2] has calculated the quadrupole moment of the Li^7 nucleus to be -2.2×10^{-26} cm^2. Nordheim[3] has proposed a model which assumes that all nuclear properties are derivable from the last odd particle in the nucleus. Mr. Vernon Hughes of this laboratory has used the model to determine the appropriate mixture of wave functions necessary to give the observed spin and magnetic moment of the nucleus. From this wave function, the quadrupole moment of the nucleus may be calculated and it is found that $Q_7 = -2.0 \times 10^{-26}$ cm^2. If Q_7 is taken to be -2×10^{-26} cm^2, then $Q_6 \leqslant \pm 0.88 \times 10^{-27}$ cm^2. The quadrupole moment of the deuteron is known[4] to be 2.73×10^{-27} cm^2, and this arises because of a small admixture of a D state into the S state of the deuteron. Evidently since the quadrupole moment of Li^6 is at most one-third as great as that of H^2, the Li^6 nucleus is in very nearly a pure S state.

I wish to acknowledge my indebtedness to Professor I. I. Rabi for his interest in the experiments and their interpretation.

[1] B. T. Feld and W. E. Lamb, Phys. Rev. 67, 15 (1945).
[2] V. F. Weisskopf, private communication to I. I. Rabi.
[3] L. W. Nordheim, Bull. Am. Phys. Soc., 2, No. 1 (January 1947), and a privately circulated prepublication copy of a paper.
[4] J. M. B. Kellog, I. I. Rabi, N. F. Ramsey, and J. R. Zacharias, Phys. Rev. 57, 677 (1940).

The Absorption Spectrum of Neodymium Bromate Crystals

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THE visible absorption spectrum of neodymium bromate crystals with polarized light was studied by Kinsey and Krueger.[1] By the use of the theory of group representations, they obtained a quantum-mechanical explanation of the observed polarization effects and as-
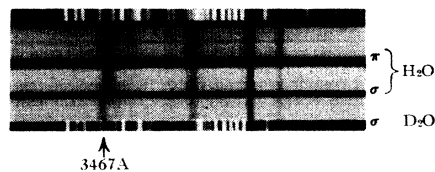

FIG. 1. The figure shows the absorption spectra of $Nd(BrO_3)_3 \cdot 9H_2O$ (labeled H_2O) and $Nd(BrO_3)_3 \cdot 9D_2O$ (labeled D_2O) taken with polarized light (π and σ denote E vector parallel and perpendicular, respectively, to the optic axis of the crystal). The πD_2O spectrum is omitted because it bears the same relationship to the σD_2O spectrum as does the πH_2O to the σH_2O.

signed quantum numbers to many of the energy levels of the neodymium ion in the crystal. We extended their work to the ultraviolet region of the spectrum. One interesting result of this work is that spectra obtained with thin (0.32 mm) crystals of $Nd(BrO_3)_3 \cdot 9H_2O$ and $Nd(BrO_3)_3$ $9D_2O$ are identical in all respects except one. The strong line which appears in the former at 3469A (28826 cm^{-1}) is displaced toward higher frequencies by 17 cm^{-1} in the latter, appearing at 3467A (28843 cm^{-1}). This shift of one and only one strong line, which occurs in both polarizations, is so remarkable that a photograph of it made on a large Littrow type Bausch and Lomb spectrograph is reproduced in this preliminary note (Fig. 1). The shift appears to be in some way connected with an interaction between electronic energy levels of the Nd^{+++} ion and those of curtailed rotations of the water molecules in the crystal lattice.

The ultraviolet absorption spectrum of neodymium bromate was found to have only one group of very strong, fairly sharp lines. The five lines of this group occur at 3562, 3552, 3538, 3509, and 3469A. By following an analysis similar to that employed by Kinsey and Krueger in their work on the visible spectrum of neodymium bromate, these lines were shown to be the result of electronic transitions from the $^4I_{9/2}$ ground state of Nd^{+++} to each of the five component levels into which the $^2G_{7/2}$ upper state is split by the crystal field. The analysis also furnished the M quantum numbers associated with each level.

After completion of the work in the ultraviolet, the spectra of $Nd(BrO_3)_3 \cdot 9H_2O$ and $Nd(BrO_3)_3 \cdot 9D_2O$ in the visible region were compared. No shift of any strong line of the type found in the ultraviolet was observed. Differences, however, in the two spectra appeared when very thick (4 mm) crystals were used. It was found that several very weak lines, present only with thick crystals, were displaced in the one spectrum relative to the other. A detailed analysis showed these lines to result from a coupling of the 3μ-vibrational terms of the water molecules in the crystal lattice with electronic terms of the Nd^{+++} ion.

[1] E. L. Kinsey and R. W. Krueger, Phys. Rev. 62, 82 (1942).

On The Compressibility of Metallic Cesium

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THE volume discontinuity of cesium[1] at 45,000 kg/cm^2 is too large (about 11 percent) to be accounted for by a change of crystal structure. The probable explanation is that the free electrons which normally occupy the $6s$ band are forced into the empty $5d$ band at higher pressures. A Wigner-Seitz[2] calculation shows that the energy versus volume curves for the bottom of the $5d$ band and the top of the $6s$ band cross at approximately the volume where

the phase transition begins. As the metal is further compressed, electrons from the top of $6s$ move into $5d$. The energy of the lattice does not increase as rapidly with decreasing volume as it would in the absence of $5d$. This effect is pronounced, because the energy of the bottom of the $5d$ band decreases while the energy of the bottom of the $6s$ band increases with decreasing volume in this region, and because the $5d$ band is narrower than the $6s$ band. When a reasonable correction is made for the change in the energy of the inner electrons, the resulting total energy *versus* volume curve has a region of downward curvature near the volume for which the phase transition is found experimentally. The volume changes discontinuously between the two points with common tangent. This gives a discontinuity of the right order of magnitude at a pressure of about 52,000 kg/cm².

The potential on which the Wigner-Seitz calculations are based is described and tabulated in a forthcoming paper. The essential quantitative agreement with the experimental pressure *versus* volume curve is partly caused by an empirical parameter in the energy of the inner electrons.

I would like to express my thanks to Professor E. Fermi, who suggested the line of approach to this problem and to Professor E. Teller for many helpful discussions.

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1 P. W. Bridgman, Phys. Rev. **72**, 533 (1947); Proc. Am. Acad. **76**, 55 (1948). I am very much indebted to Professor Bridgman for a table of the volume compression before publication.
2 E. Wigner and F. Seitz, Phys. Rev. **43**, 804 (1933); **46**, 509 (1934).

Search for Nuclear Isomers with Half-Lives between a Millisecond and a Second

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A SEARCH has been made for short-lived isomers with half-lives in the range of 10^{-3} to 1 sec. A rotating wheel method was employed similar to that of Nahmias and Walen.[1]

The sample, placed along the inside of a steel hoop 18 in. in diameter, was irradiated with slow neutrons from a 230-millicurie Ra−Be source surrounded by 2 in. of paraffin wax. Diametrically opposite the source and facing the sample was a thin-window Geiger-Müller counter, well shielded from γ-radiation from the neutron source.

Any short-lived activity produced in the sample would give a rate of counting depending upon the speed of rotation of the hoop.

The sensitivity of the experiment was limited by the γ-ray background from the neutron source (about 65 counts/min.) and by any β-activity produced in the sample. It was also dependent upon the internal conversion coefficient of the isomeric transition. The least cross section of formation of an isomer required to detect the isomer could thus not be simply stated, but in typical cases would be of the order of 5 or 10×10^{-24} cm². Therefore, the search had to be restricted to elements having fairly large slow neutron capture cross sections.

In the 16 elements examined (Li, B, Cl, Ni, Cu, Rh, Ag, Cd, In, Sm, Eu, Gd, Dy, Ir, Au, Hg) no isomers were found.

The above method applies only to metastable states formed as the immediate consequence of slow-neutron capture, in contrast to the delayed coincidence method[2] which detects metastable states formed by β-decay.

For half-lives greater than 10 sec., the known isomeric transitions are distributed roughly uniformly with respect to the logarithm of the half-life.[3] If the same were true for shorter-lived isomers, about as many could be expected between 10^{-3} and 1 sec. as between 10^{-6} and 10^{-3} sec. Within this latter range the delayed coincidence method has yielded four isomers out of the 62 isotopes investigated.[2]

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1 M. E. Nahmias and R. J. Walen, J. de phys. et rad. **8**, 153 (1937).
2 S. De Benedetti and F. K. McGowan, Phys. Rev. **74**, 728 (1948).
3 M. L. Wiedenbeck, Phys. Rev. **69**, 567 (1946), see Fig. 1.

Second-Order Stark Effect of Methyl Chloride

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THE first rotational transition, $(J, K) = (0, 0) \rightarrow (1, 0)$, of $C^{12}H_3Cl^{35}$ and $C^{12}H_3Cl^{37}$ has been measured and analyzed by Gordy, Simmons, and Smith.[1] We have re-examined these lines, using the square wave Stark Effect modulation technique[2,3] and find these lines to exhibit a second-order Stark Effect. This is expected, because that part of the Hamiltonian,

$$H_{K=0} = -\mu \cdot E + H_Q + H_0** \tag{1}$$

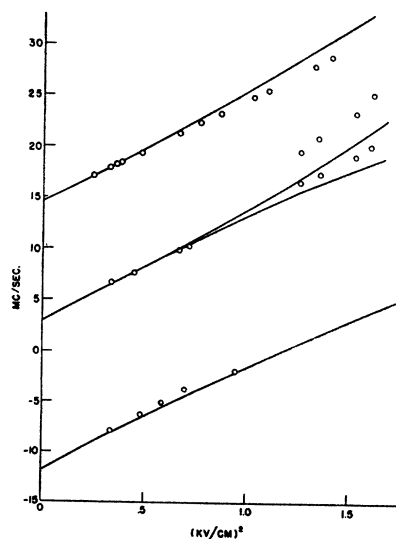(μ = electric dipole moment, E = electric field, H_Q = quadrupolar interaction between nuclear spin I, and molecular

FIG. 1. Stark splitting for $J = 0 \rightarrow 1$ transition of $C^{12}H_3Cl^{37}$. Solid lines—theoretical calculation for $\mu_0 = 1.70$ D and $eQ(\partial^2 V/\partial z^2) = -59.0$ Mc/sec. Circles—experimentally observed values.