

effects may be neglected. Under these conditions

$$\begin{aligned}\phi_1 &= J_{2\rho}(2x^{1/2}) \\ \alpha\phi_2 &= (j' - \rho)J_{2\rho}(2x^{1/2}) + x^{1/2}J_{2\rho+1}(2x^{1/2}) \\ \alpha &= 2\pi Z e^2 / hc, \rho = (j'^2 - \alpha^2)^{1/2}, x = 2Zr/a_H\end{aligned}$$

The  $J_n$  are Bessel functions of order  $n$ ;  $j' = -1, 1, -2$  for  $s, p_{1/2}, p_{3/2}$ . The results of calculation with the above formulas are represented graphically for  $\alpha = 0.661, Z \leq 91$ . The region close to the nucleus is seen to contribute more to the  $I$  for  $p_{1/2}$  than for  $p_{3/2}$ . The contribution to the effective value of  $(r^{-3})$  due to this region is expected to be large for  $p_{1/2}$  and of the same order as the customary  $2\pi\psi^2(0)$  of Fermi. In fact in the approximation of Schroedinger's non-relativistic equation we have to replace  $\alpha\phi_2$  for  $s$  terms by  $-x^{1/2}J_1(2x^{1/2})$ . This is also plotted on the figure as  $(\alpha\phi_2)_s$ . The scale of all curves is seen to be roughly the same. The normalizing factor is approximately  $K$  given by  $K^2(\phi_2(r)/r)^2 = 4\pi\psi^2(r)$ . Hence  $K^2 = 2\pi\psi^2(0)$  and  $K^2 4\pi I / \Lambda \cong 4\pi^2 (a_H/\Lambda Z)\psi^2(0) \int \phi_1\phi_2 x^{-2} dx$ . The integral in  $x$  is seen to be of the order of 1 and the whole of the order of  $2\pi\psi^2(0)$ . For comparison we

have also given the  $\phi_1\phi_2/x^2$  curve for  $s$  terms in the non-relativistic approximation. Dirac's equation gives higher values for  $s$  terms as well.

We may say therefore that for the calculation of the hyperfine structure intervals the  $p_{1/2}$  states of heavy atoms should be considered as penetrating orbits in the neighborhood of the nucleus. For this reason alone their hyperfine structure may be anomalously great. Other effects must of course also be considered. According to Goudsmit's estimates there is no special reason to believe that they are very important. Nevertheless their effect and the contribution of regions of higher  $r$  to  $I$  must be taken into account before a quantitative comparison with experiment may be made. At present the observed deviations from simple approximate formulas are qualitatively in agreement with theory being in the correct direction and of the proper order of magnitude.

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#### On the Infrared Absorption by Hydrogen Sulphide at $8.0\mu$

Papers published by Rollefson<sup>1</sup> and Mischke<sup>2</sup> on the infrared absorption spectrum of hydrogen sulphide report the presence of an absorption band at about the wave-length  $8.0\mu$ . In a more recent paper, one of the authors working with E. F. Barker<sup>3</sup> at the University of Michigan, reported that a diligent search for this band had failed to confirm it. Each time when it was looked for and not found, the existence of the other two bands reported, at  $2.65\mu$  and  $3.8\mu$  respectively, were first checked. It was therefore concluded that the region at  $8.0\mu$  could not be attributed to hydrogen sulphide.

A series of measurements have been carried out with a Wadsworth prism spectrometer, especially in the region from  $7.0\mu$  to  $9.0\mu$  further to investigate the nature of the effect observed by Rollefson and Mischke. For this purpose a cell eight inches long, and equipped with rock-salt windows was used; so arranged that it could be tipped in and out of the beam. The cell was first filled with air passed through wash bottles containing KHS and then dried through towers containing successive layers of glass wool on which was sprinkled phosphorus pentoxide. A curve was first made from data taken between the dried air and the

atmosphere, then a similar curve was run with the cell filled with hydrogen sulphide, purified and dried as before, and the curves were plotted for comparison. These two curves were very similar in appearance, at first glance much resembling absorption bands. It was noticed, however that the ratio of the radiation apparently transmitted through the cell to that of the beam when the cell was removed (i.e. the apparent percentage absorption) was much less on the short wave side than on the long wave side. This suggested the possibility that the observed effect might be ascribed to water vapor falsification arising from the water vapor band at  $6.2\mu$  which in moist weather may well extend out beyond  $8.0\mu$ . The object of the remainder of this experiment was to test this point.

Water vapor falsifications may be very annoying, especially when long cells are used. The cell used in this experiment was equiva-

<sup>1</sup> A. H. Rollefson, Phys. Rev. **34**, 604 (1929).

<sup>2</sup> W. Mischke, Zeits. f. Physik **67**, 106 (1931).

H. H. Nielsen, and E. F. Barker, Phys. Rev. **37**, 1931.

lent to about one tenth of the entire light path. Consequently it is to be expected that in regions of water vapor absorption, when the cell, filled with very dry air, is tipped into the beam that more energy may be transmitted than when the cell is out of the beam, since by inserting the cell the path through which atmospheric water vapor absorption may occur has actually been shortened. Hence in regions of strong atmospheric absorption, one may observe what appears to be negative absorption, while in regions of less intense absorption this is less apparent or disappears entirely. These falsifications may however be quite deceiving, giving the appearance of an absorption band in the dry gas in the cell—maxima in the water vapor spectrum producing what appear to be minima in a spectrum of the gas under observation, and vice versa. To compensate for the final readings, the final readings were plotted against transmission through the cell filled with atmospheric air. Curves for comparison representing percentage absorbed were made from data taken on hydrogen sulphide and dried air against atmospheric air and these were found to reproduce one another even in minute details. A similar curve was plotted of data taken on wet hydrogen sulphide against atmospheric air. The resulting curve appeared as a mirror image of the previous ones.

In Fig. 1 curve *A* represents ratios of transmission through the cell filled with dry hydrogen sulphide and through the cell filled with dried air. On another occasion a curve was made representing ratios of data taken on transmission through dry hydrogen sulphide and dry air. In spite of the fact that the data were all taken on the same day it was found that the humidity had changed a great deal during the time of the experiment. This curve was very similar to *A*. It indicated that the amount of water vapor displaced by the cell was less in the measurements made on dry air than those made on dry  $H_2S$ . This was actually the case since hygrometer readings showed the humidity at this time to be much higher than when the data on dry air were taken. Curve *B* is a sketch of Rollefson's curve for  $H_2S$  at  $8.0\mu$  placed there for com-

parison, while *C* represents the general appearance of Hettner's curve for water vapor in this region. We wish to call attention to the general agreement between that observed by us and Rollefson's curve and in addition to point out that nearly every maximum in Hettner's curve coincides with a minimum in our curve and vice versa.

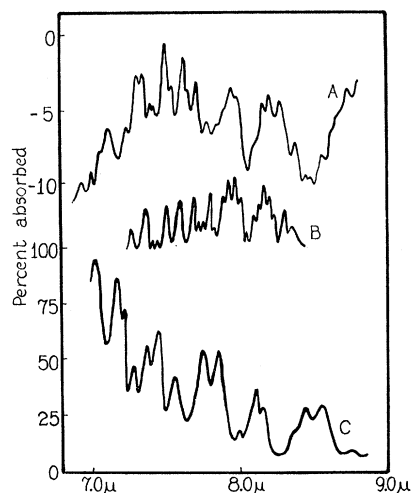


Fig. 1.

We suggest therefore, as an explanation of the band reported by Rollefson and by Mischke at  $8.0\mu$  in hydrogen sulphide, that it is not due to hydrogen sulphide, but rather due to water vapor falsifications which may arise when a long cell is used. This evidence is further supported by the fact that the spacings between the lines as given by Rollefson are of the same magnitude as those given by Sleator and Phelps<sup>4</sup> in their work on water vapor absorption rather than those observed in the bands of hydrogen sulphide.

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<sup>4</sup> W. W. Sleator, and E. R. Phelps, *Astrophys. J.* **62**, 28 (1925).

#### Measurement of the Kerr Effect in the Infrared Spectrum

The work of Szivessy and Dierkesmann (*Ann. d. Physik* (5) **3**, 507 (1929)) in extending dispersion measurements of the Kerr elec-

tro-optic effect beyond the customary visible spectrum into the ultraviolet would seem to call for a similar extension into the infrared, if