

from spin-spin interactions are by no means negligibly small compared with those from spin-orbit interactions. In some cases the former is even larger than the latter. Three examples are given in Table I.

The detailed report will shortly be published in *Progress of Theoretical Physics*.

<sup>1</sup> G. Araki, Proc. Phys. Math. Soc. Japan, **19**, 128, 592 (1937).

<sup>2</sup> See reference 1; **21**, 508 (1939).

<sup>3</sup> G. Breit, Phys. Rev. **34**, 553 (1929); **36**, 383 (1930); **39**, 616 (1932).

<sup>4</sup> R. F. Bacher and S. Goudsmit, *Atomic Energy States* (McGraw-Hill Book Company, New York, 1932).

### The Self-Diffusion Coefficient of Argon

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THE diffusion coefficient for the diffusion of  $A^{41}$  into normal argon (99.6 percent  $A^{40}$ ) has been measured, using the beta- and gamma-radiation from  $A^{41}$  to determine the amount of that isotope diffused. This coefficient should be close to the self-diffusion coefficient of  $A^{40}$ .

The apparatus consists of two brass tubes 45 cm long and 1.2 cm i.d., mounted with their axes horizontal and in line with each other, and connected by a suitable valve.<sup>1</sup> One side was filled with argon containing  $A^{41}$  made by bombarding tank argon with deuterons, the other side with tank argon to the same pressure, and the gases allowed to inter-diffuse for a known time through the valve. The radioactivity of the gas in either side could be determined by Lauritsen quartz fiber electroscopes, one mounted on each tube over a "window" made by thinning the tube wall to 0.005 cm. From measurements of the activities in both tubes before and after diffusion, properly corrected for  $A^{41}$  decay, the fraction of  $A^{41}$  transferred from one tube to the other by diffusion could be determined, and from this figure and the geometry the diffusion coefficient  $D$  could be calculated. The weighted mean of six runs gives

$$D = 0.423 \pm 0.003 \text{ cm}^2/\text{sec.},$$

corrected to 32 cm Hg and 22°C. The error is the probable error calculated from the scatter of the data.

Kinetic theory gives the relation  $\rho D = \epsilon \eta$ ,  $\rho$  being the gas density,  $\eta$  the viscosity, and  $\epsilon$  a number which depends on the forces between two colliding molecules. Taking  $\rho$  of argon at 22°C, 32 cm Hg to be  $(0.6947 \pm 0.0003) \times 10^{-3}$  g/cm<sup>3</sup>,  $\eta$  at 22°C to be  $(0.225 \pm 0.001) \times 10^{-3}$  poise, we find  $\epsilon = 1.31 \pm 0.01$ . Assuming that the force between two molecules varies as  $r^{-n}$ , Chapman and Cowling<sup>2</sup> give a

TABLE I. Reported values of  $\epsilon$ .

Gas	Temp., °C	
H <sub>2</sub>	20	1.37 <sub>0</sub> ± 0.003 <sup>4</sup>
	-188	1.32 ± 0.06 <sup>4</sup>
	-252.8	1.28 ± 0.02 <sup>4</sup>
Ne	20	1.27 <sub>6</sub> ± 0.006 <sup>6</sup>
	22	1.31 ± 0.01
Kr	20	1.30 ± 0.06 <sup>6</sup>
Xe	20	1.24 ± 0.06 <sup>6</sup>
CH <sub>4</sub>	20	1.33 <sup>6</sup>
UF <sub>6</sub>	30	1.31 <sup>7</sup>

method of calculating a first approximation to  $\epsilon$ . Fitting the calculated dependence of viscosity on temperature to the experimental data, they find  $n = 7.36$ , which gives  $\epsilon = 1.47$ . The discrepancy between this value and the experimental value is larger than can be accounted for by experimental error.

Table I is a summary of measured values of  $\epsilon$  collected from the literature. Amdur<sup>3</sup> has pointed out that knowing the value of  $\epsilon$  will not permit an unambiguous determination of intermolecular forces. However, the small variation in  $\epsilon$  shown in the table is rather unexpected, and must have some significance.

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<sup>1</sup> L. E. Boardman and N. E. Wild, Proc. Roy. Soc. **162A**, 511 (1937).

<sup>2</sup> S. Chapman and T. G. Cowling, *Mathematical Theory of Non-uniform Gases* (Cambridge University Press, 1939), pp. 172, 198.

<sup>3</sup> I. Amdur, Phys. Rev. **72**, 642 (1947).

<sup>4</sup> P. Harteck and H. W. Schmidt, Zeits. f. physik. Chemie **21B**, 447 (1933).

<sup>5</sup> From a paper by W. Groth and E. Sussner, Zeits. f. physik. Chemie **193**, 296 (1944).

<sup>6</sup> E. B. Winn and E. P. Ney, Phys. Rev. **72**, 77 (1947).

<sup>7</sup> E. P. Ney and F. C. Armistead, Phys. Rev. **71**, 14 (1947).

### Precision Measurement of the Ratio of the Atomic 'g Values' in the $^2P_{3/2}$ and $^2P_{1/2}$ States of Gallium\*

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THE measurement of the frequencies associated with the Zeeman splittings of the energy levels in two different atomic states in a constant magnetic field permits a determination of the ratio of the  $g_J$  values of the atomic states. This determination involves only an accurate measurement of the frequencies, and does not require a knowledge of the value of the constant magnetic field.

Using the atomic beam magnetic resonance technique we have measured six lines in the Zeeman spectrum of the  $^2P_{1/2}$  state, and five lines of the  $^2P_{3/2}$  state of gallium at a field strength of 380 gauss. The spectrum is, of course, complicated by the level splittings produced by the nuclear magnetic moments and electric quadrupole moments. At the field strength employed in this experiment the nuclear energy level pattern is of an intermediate Paschen-Back character.

The procedure employed in the observations was to make a series of alternate measurements of the frequencies of the lines in the  $^2P_{1/2}$  and  $^2P_{3/2}$  states. In this way the effect of a drift in magnetic field was minimized.

Becker and Kusch<sup>1</sup> have recently determined with high precision the nuclear magnetic moment and electric quadrupole moment coupling coefficients as well as the nuclear  $g$  values of  $Ga^{69}$  and  $Ga^{71}$  in both states. Their determinations are independent of any knowledge of  $g_J$  in either state.