while the spin-orbit triplet term c^2 predominates in the upper interval.

To determine the phases and to make a numerical estimate of the amplitudes, we obtain the lacking data from the calculations performed for 140 Mev (see reference 8) and for 315 Mev (see reference 9, solution No. 4).

We then obtain the following values for the amplitudes and phases:

E, Mev	b^2,%	c^2,%	h^2,%	δ_C	δ_H
140	5	13	82	0°	60°
315	25	62	13	—90°	143°
400	30	56	14	$\delta_C - \delta_H = 90°$	
635	24	76	12		

If we assume that at energies on the order of several Bev the nucleon is a black sphere, which apparently does not contradict the available experimental data, then only the amplitude B differs from zero, and $b^2 = 100\%$. Consequently, as the energy increases, the contribution of the triplet interaction, due to the terms h^2 and c^2, should decrease.

Similar results are obtained for p-p scattering at 90° from the following type of nucleon interaction. Let the phases of all waves (the number of which is arbitrary) be imaginary and large. Then at 90° only the amplitude B differs from 0, as in the case of a black sphere. But unlike the latter, such a model leads to an angular dependence of the Wolfenstein parameters and of the correlation tensor:

$$D(\theta) = 2\cos\theta\,\frac{1+\cos^2\theta}{1+3\cos^2\theta}, \qquad R(\theta) = 4\cos\theta\,\frac{\cos^3(\theta/2)}{1+3\cos^2\theta},$$

$$A(\theta) = -\sin 2\theta\,\frac{\cos(\theta/2)}{1+3\cos^2\theta}, \qquad C_{nn}(\theta) = \frac{-1+\cos^2\theta}{1+3\cos^2\theta}.$$

In this model there is no polarization at all.

Note added in proof (May 28, 1959). A recent communication on triple scattering at 143 Mev (C. F. Hwang et al., Phys. Rev. Lett. **2**, 210, 1959) reports a different result than in reference 2: $D(90°) = 0.3 \pm 0.15$ at 90° in the c.m.s., hence $30 \le c^2 \le 70\%$ and $0 \le h^2 \le 35\%$.

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[1] L. Wolfenstein, Phys. Rev. **96**, 1654 (1958).

[2] A. E. Taylor, Annual International Conference on High Energy Physics, CERN, 1958.

[3] L. Wolfenstein, Bull. Am. Phys. Soc. **1**, 36 (1956).

[4] Kane, Stallwood, Sutton, and Fox, Bull. Am. Phys. Soc. **1**, 9 (1956).

[5] Ashmore, Diddens, Huxtable, and Suarsvag, Proc. Phys. Soc. **72**, 289 (1958).

[6] Kumekin, Meshcheryakov, Nurushev, and Stoletov, J. Exptl. Theoret. Phys. (U.S.S.R.) **35**, 1398 (1958), Soviet Phys. JETP **8**, 977 (1959).

[7] P. S. Signell and R. E. Marshak, Phys. Rev. **109**, 1229 (1958).

[8] Stapp, Ypsilantis, and Metropolis, Phys. Rev. **105**, 313 (1957).

[9] Ashmore, Diddens, and Huxtable (preprint, 1959).

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PARAMAGNETIC RESONANCE IN POTASSIUM OZONIDE

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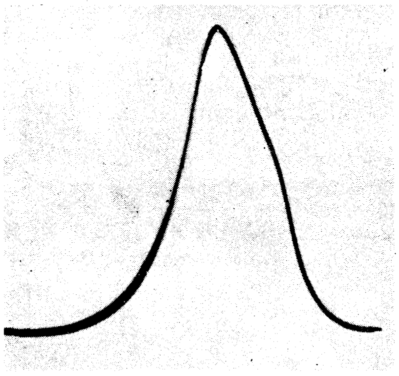
KAZARNOVSKIĬ, Nikol'skiĭ, and Abletsov[1] have proposed that the magnetism of potassium ozonide, KO_3, is due to the molecular ozone ion O_3^- and that the latter has the character of a free radical with one unsaturated valence. It is of interest to investigate potassium ozonide by the method of electronic paramagnetic resonance (EPR), in order to investigate in greater detail the nature of its paramagnetism.

We have investigated paramagnetic resonance in polycrystalline specimens, containing approximately 90% KO_3, at frequencies of 2580, 9375, 12,000 and 37,000 Mcs at room temperature and at temperature of liquid nitrogen. At 2580, 9375, and 12,000 Mcs we observed one symmetric absorption line, the width of which was 31 ± 3, 39 ± 2, and 45 ± 3 gausses respectively. At 37,000 Mcs the observed line is noticeably asymmetric and has a width of approximately 77 gausses at the level of half the intensity of the principal peak. For illustration, the diagram shows an oscillogram of the absorption line, observed at 37,000 Mcs at room temperature. The dependence of the width of the EPR line on the frequency, and particularly the asymmetry of the line at 37,000 Mcs, are direct evidence of anisotropy of the g-factor. It is seen from the diagram that this anisotropy is due to the actual symmetry of the electric field of the crystal. Since the investigated specimens were polycrystalline, the relative contribution of the crystals with axis perpen-



dicular to the external magnetic field is greater than the contribution of the crystals with parallel orientation. Measurements of the g-factor for the perpendicular and parallel orientations yielded respectively

$$g_\perp = 2.012 \pm 0.002, \qquad g_\parallel = 2.005 \pm 0.003.$$

The line width may be due to spin-lattice, magnetic-dipole, and exchange spin-spin interactions. For a given frequency, the width of the KO_3 line did not change at room temperature and at liquid-nitrogen temperature, within the experimental error, indicating the absence of noticeable influence of spin-lattice interaction on the line width at these temperatures. It is known that in the case of magnetically-concentrated systems with spin $S = \frac{1}{2}$, dipole spin-spin interactions should lead to a line width of approximately 100 gausses. From the value obtained for the line width at 2580 Mcs (at which the anisotropic broadening is small) it follows that in KO_3 there are considerable exchange interactions, which reduce the effectiveness of the dipole interactions and thus cause narrowing of the line.

The fact that the value obtained for the g-factor is close to 2 and the presence of considerable exchange interactions confirm the previously advanced suggestion[1,2] that the magnetism of the molecular ion of ozone, O_3^-, to which the observed paramagnetic resonance in KO_3 is due, has the character of a free radical. The deviation of the value of the g-factor from that of a free electron and the observed anisotropy indicate the presence of a considerable orbital contribution to the paramagnetism of KO_3.

The values obtained by Neĭding[3] for the static magnetic susceptibility of potassium ozonide, are different from the pure-spin value, in agreement with our results.

Bennett, Ingram, and Schonland[4] report an investigation of EPR of sodium ozonide, in which the absorption line at a wavelength of 1.25 cm has a weak asymmetry towards the higher fields, analogous to that observed in KO_3. Within the experimental accuracy, the values of the g-factor coincide with those we obtained for potassium ozonide. This may serve as a confirmation that in ozonides the bond between the metal and the molecular group O_3 is ionic.

We have also investigated the kinetics of the spontaneous decomposition of KO_3 at 295° K. Such investigations were previously made by chemical methods.[2] The comparison standard used was the time-stable free radical of diphenylpicrylhydrazyl (DPPH). A specimen of diphenylpicrylhydrazyl, covered with a film of polystyrol glue to prevent its oxidation, was placed together with the investigated specimen of KO_3 in the cavity of the radio spectroscope. The intensity of the paramagnetic-resonance line of KO_3 was measured relative to the intensity of the diphenylpicrylhydrazyl line at definite time intervals. These measurements show that the decomposition of KO_3 in a time interval of 47 to 168 hours after the preparation of the compound follows approximately an exponential law with a time constant of 0.02 hr^{-1}. A detailed analysis of the results of the investigation of the kinetics of the decay of potassium ozonide will be published elsewhere.

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[1] Kazarnovskiĭ, Nikol'skiĭ, and Abletsova, Dokl. Akad. Nauk SSSR **64**, 69 (1949).

[2] Kazarnovskiĭ, Raĭkhshteĭn, and Bykova, Dokl. Akad. Nauk SSSR **108**, 641 (1956).

[3] A. B. Neĭding, Dissertation, L. Ya. Karpov Physico-Chemical Institute, 1950.

[4] Bennett, Ingram, and Schonland, Proc. Phys. Soc. **A69**, 556 (1956).

Translated by J. G. Adashko
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