ELECTRONIC PARAMAGNETIC RESONANCE SPECTRA OF FROZEN OH *RADICALS*

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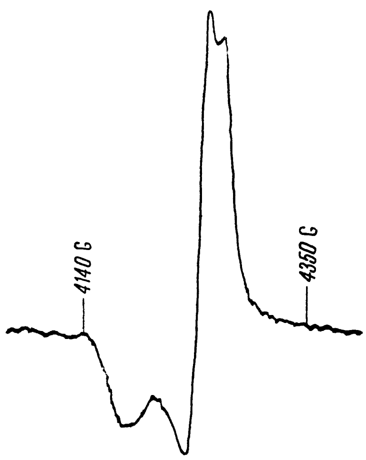
THE observation of an electronic paramagnetic resonance spectrum of radicals obtained by freezing the electric discharge products in H_2O or H_2O_2 vapor, was reported previously.[1,2] Subsequent investigation of these radicals* did not permit identification of the radicals obtained from the discharge.

To determine these radicals, we decided to investigate in detail the spectrum of the radicals obtained by ultraviolet irradiation of frozen H_2O_2 and to compare these spectra. We assume that the radicals obtained by ultraviolet† irradiation of frozen H_2O_2 ($T = 77°K$) are OH radicals, since the spectrum of the mercury arc lamp employed by us (SVDSh-1000) contains no quanta capable of breaking the O—H bond (110 Kcal/mole). Since the spectrum of the radicals does not depend on the peroxide concentration in 5 to 98% aqueous solutions, it is assumed that there are no secondary reaction.

We observed the electronic paramagnetic resonance spectra at 12,000, 9400, 2600, 1300, and 850 Mcs. At all these frequencies, the spectrum of the OH radicals coincided with the spectrum of the radicals obtained from the discharge. Consequently, the radical obtained by freezing the discharge products in H_2O and H_2O_2 vapor is essentially the OH radical.



At 850 Mcs there is a clearly pronounced doublets with a distance of 12 ± 1 Gauss between components, produced by the nuclear moment of the hydrogen proton.

At 12,000 Mcs the shape of the spectrum is determined essentially by the anisotropic broadening ($g_\perp \neq g_{||}$). The derivative absorption line for 12,000 Mcs is shown in the figure. The shape of the observed line is readily explained by the presence of anisotropic broadening and the presence of hyperfine splitting. From this curve, we estimate that $g_\perp \approx 2.00$ and $g_{||} \approx 2.03$.

*The investigation was made by us in collaboration with A. B. Tsentsiper, and the results will be published.

†Ingram[3] also observed the electronic-magnetic resonance spectrum of the radical obtained by ultraviolet irradiation of the peroxide at 9400 Mcs.

[1] Kaĭtmazov, Prokhorov, Tsentsiper, and Gorbonev, Журнал физической химии (J. of Phys. Chem.) **31**, 515 (1957).

[2] Livingston, Ghormley, and Zeldes, Chem. Phys. **24**, 483 (1956).

[3] G. J. E. Ingram, Nature **176**, 1227 (1955).

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ON ELECTRON OSCILLATIONS IN A PLASMA

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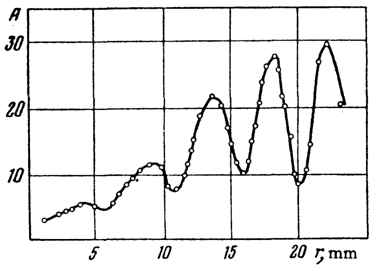
THE oscillations of the electrons in a plasma have been observed in numerous experiments, although many details of these oscillations remain obscure. Experiments with a plasma and a beam, independent of the plasma, have been described in a number of papers. To some degree there is a contradiction between the different results obtained. According to Looney and Brown,[1] regular oscillations are impossible without the formation of standing waves, while the paper by Kojima et al.[2] confirms Bohm and Gross' theory.[3]

In the present research oscillations were observed in inert gases. We could change the pressure from 3×10^{-1} to 5×10^{-4} mm Hg. The oscillations were detected by a superheterodyne system with a separate decimeter range generator and a separate amplifier of an intermediate frequency, the frequency and passband of which were 30 and 10 Mcs, respectively. The amplifier could be varied within wide limits.

It turned out that the upper limit of the pressure for which regular oscillations could still be observed was different for different gases. We established that this limit was for He about 2×10^{-1}, for A about 10^{-2}, and for Xe about 6×10^{-3} mm Hg. The total effective cross sections for the interaction of the atoms with the primary electrons, taken for the above mentioned gases and pressures and taking the velocity of the electrons in the beam into account, were approximately equal (they differed by less than 25%).

A very important problem from the point of view of elucidating the mechanism of exciting the oscillations is that of the distribution of the oscillations along the axis of the discharge. The results obtained in this direction up to now are not free from distortions produced by the probe.[4] The elimination of the influence of the probe should therefore give a truer picture.

The distribution of the oscillations was studied in a cylindrical tube of diameter 7 cm, a distance of 2.2 cm between the cathodes, and a pressed powder cathode with a 3 mm diameter. A cylindrical probe of 0.1 mm diameter could be moved along the axis of the tube to any position between the cathode and anode, and its position was noted after every 0.5 or 1 mm by a reading microscope with an accuracy of 0.2 mm. When the probe moved into the beam itself, the perturbation of the beam by the probe was observed, and the measurement was thus performed under such conditions that the probe only touched the beam and that there is no noticeable influence, whatever on the beam. This was attained by turning the edge, on which the cathode was mounted slightly asymmetrically, round.



In the figure we have given a picture of an intensity distribution of the oscillations which is typical for pressures when the mean free path of the primary electrons is larger than the distance between the electrodes (the intensity of the oscillations A in arbitrary units is given along the ordinate axis, and the distance r of the probe from the cathode in mm along the abscissa axis). It is clear that the measurement of the intensity along the axis of the discharge is detected by the detector in the form of a periodic function, the zero value of which increases in the direction towards the anode. The intensity of the oscillations and the coefficient of its increase increase with decreasing pressure. The intensity of the oscillations could be varied along the beam by more than a factor of one thousand in order to determine the conditions in the discharge. For sufficiently high pressures, when the mean free path of the electrons was less than the distance between the electrodes, the oscillations were damped in the direction towards the anode, and only one maximum could be observed.

The measurements showed that the spatial period can be well approximated by the formula $l = 2\pi v_0/\omega$, where v_0 is the velocity of the electrons in the beam in cm sec^{-1} and ω the cirular frequency of the observed oscillations; the deviation of the measured period from the one calculated from the formula is always in the lower direction and was less than 10 — 25%. Visually we could not observe any periodic inhomogeneity along the beam in the discharge glow. The discharge was often characterized by well distinguished inhomogeneities, caused by the non-uniform emission from the pressed powder cathode, along the cross section of the beam.

In the region where sufficenly strong oscillations start the anomalous scattering of the primary bean was observed visually. This scattering could occur both before and after the narrowing of the beam produced by the focusing action of the positive space charge. When the anomalous scattering took place before the narrowing, we clearly distinguished smaller beams in the primary beam against the general background different. When the scattering occurred after the narrowing, the beam was nearly uniform. In the first case, the convergence of the beams stopped at the position of the scattering so that no nodes could form; in the second case, there was in general not observed any tendency to form later nodes.

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[1] D. H. Looney and S. C. Brown, Phys. Rev. **93**, 965 (1954).

[2] Kojima, Kato, and Hagiwura, J. Phys. Soc. Japan **12**, 1276 (1957).

[3] D. Bohm and E. P. Gross, Phys. Rev. **75**, 1851 (1949).

[4] R. A. Bailey and K. G. Emeleus, Proc. Roy. Irish Acad. **A57**, 53 (1955).

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POSSIBILITY OF DETERMINING THE CHIRALITY OF THE MUON BY MEANS OF δ-ELECTRON CASCADES FROM MAGNETIZED IRON

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It is known that the violation of spatial parity in weak interaction causes the muons produced by pion (or $K_{\mu 2}$-meson) decay to be polarized. However, the direction of muon polarization has not been experimentally determined to date. We propose here a method for measuring both the direction and magnitude of muon polarization, and consider possible experiments with accelerators and cosmic rays to solve this problem.

Berestetskiĭ (private communication) derived a formula for the cross section for the scattering of a polarized muon by polarized electrons

$$\sigma d\varepsilon = \sigma_0 d\varepsilon + \mathbf{P}_e\mathbf{P}_\mu \sigma_1 d\varepsilon$$
$$= 2\pi r_0^2 \frac{m d\varepsilon}{\beta^2\varepsilon^2}\left[1 - \beta^2\frac{\varepsilon}{\varepsilon_m} + \frac{1}{2}\frac{\varepsilon^2}{E^2} - \mathbf{P}_e\mathbf{P}_\mu \frac{\varepsilon}{E}\left(1 - \frac{\varepsilon}{\varepsilon_m} + \frac{\varepsilon}{2E}\right)\right],$$

where m, β, and r_0 are the rest energy, velocity, and classical radius of the electron; ϵ and ϵ_m are the energy and maximum energy transferred to the electron by collision with the muon; E is the muon energy; $\mathbf{P}_e$ and $\mathbf{P}_\mu$ are the electron and muon polarization vectors. It is seen from this formula that σ_1/σ_0, the relative magnitude of the cross section that is sensitive to the polarization, will be noticeable, if large energy transfers to electrons colliding with high-energy muons are separated out. This can be done by registering δ cascades with specified number of particles, produced by muons in magnetized iron.

The probability of a cascade with more than n electrons being produced by a polarized muon in magnetized iron can be calculated from cascade theory:[1]

$$b(E, n) = \int_0^{\varepsilon_m(E)} f(\varepsilon, n)\,\sigma(E, \varepsilon)\,d\varepsilon$$
$$= b_0(E, n) + \mathbf{P}_e\mathbf{P}_\mu b_1(E, n),$$

where $f(\epsilon, n)$ is the probability of producing a cascade with more than n particles by a δ electron of energy ϵ, and b_0, b_1 are the polarization-sensitive and polarization-insensitive probability of cascade occurrence.

To obtain a specified accuracy in the measurement of muon polarization it is necessary to register, in minimum time, such cascade in which the number of particles is greater $n_0 = n_0(E)$, a value at which the expression $b_1(E, n)/\sqrt{b_0(E,n)}$ has a maximum.

We give here the values of b_0 and $P_e b_1/b_0$ at 8% polarization of electrons in magnetized iron, as a function of the muon energy, for cascades with more than n_0 particles

E^{-1}_{Bev} =	1.8	3.3	4.6	6.5	8.7	12
n_0 =	1	2	3	4	5	6
$P_e b_1/b_0$ =	2.6%	2.8%	3.0%	3.0%	3.0%	3.0%
$10^3 b_0$ =	8.6	7.5	6.6	6.6	6.6	6.6

If we register δ cascades with more than n_0 particles, produced in iron magnetized along and opposite the direction of motion of muons in an accelerator beam, then, to measure muon polarization with 30% accuracy at $P_\mu = 100\%$, it is necessary to have 1.5×10^6 muons pass through the apparatus.

The proposed method can also be used to measure the chirality of muons from cosmic rays. If the muons are not separated by energies, but by sign, the probability of producing a shower with more than n cosmic muons can be found as

$$b(n) = \int_0^{\varepsilon_m(E)}\int_E^{\infty} f(\varepsilon, n)\,S(E)\,\sigma(E, \varepsilon)\,d\varepsilon dE$$
$$= b_0(n) + P_e P_\mu b_1(n),$$

where $S(E)dE$ is the muon spectrum.

We give here the values of b_0 and $P_e b_1/b_0$ for $P_e = 8\%$ as a function of the number of particles in the registered shower:

n =	1	2	4	6
b_0 =	$2.2\cdot10^{-2}$	$5.8\cdot10^{-3}$	$1.4\cdot10^{-3}$	$6.4\cdot10^{-4}$
$P_e b_1/b_0$ =	1.4%	2.1%	3.0%	3.3%

If the aperture ratio of the apparatus is such that it transmits $\sim 10^3$ muons per minute with polarization $P_\mu > 30\%$, approximately 30 days