dividual poles now combine to give a field momentum of $2e_0g_0/c$. Setting this equal to $\hbar$ again gives the value of g_0.

The angular momentum of a charge and a pair of poles with finite separation has a definite magnitude in the special case that the charge and poles are colinear. Then the angular momentum is $\hbar$ if the charge lies between the poles and 0 if it does not.

One might suppose that an electron could be represented by a charge e_0 and two magnetic poles $\pm g_0$. If the distance between poles is e_0^2/mc^2, a value sometimes given for the electron diameter, the magnetic moment has the correct value but the angular momentum is $\hbar$ instead of $\hbar/2$. The correct spin is obtained if the charge spends only half its time between the poles.

[1] P. A. M. Dirac, Phys. Rev. **74**, 817 (1948).
[2] H. A. Wilson, Phys. Rev. **75**, 309 (1949).

Search for the Transition of Streamer to Townsend Form of Spark in Air

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March 11, 1949

THE present view of the mechanism of spark discharge in air is that a streamer process is effective at atmospheric pressure and that a Townsend mechanism is active at lower pressures.[1] The Townsend mechanism in air may be secondary emission of electrons by positive ion bombardment of the cathode, or photoelectric emission at the cathode. There is little or no evidence to decide between these two mechanisms at low pressure, but Loeb[2] has expressed the opinion that the former is probably the predominating process. It thus may be possible to determine the transition region from the streamer to the Townsend mechanism by a study of the formative time lags of spark breakdown as a function of pressure and gap length.

Experiments were undertaken to measure these lags, using voltages as close to the static breakdown as possible. Previous measurements of formative time lags in air have been made with overvoltages of at least one percent, and usually much more.[3]

The cathode of a one-centimeter plane parallel gap was illuminated by ultraviolet light, and an approach voltage below but close to the static breakdown was applied. Then an additional small square voltage pulse (rise time 0.1 μsec.) was applied across the gap. The pulse started the sweep of a Sylvania P4 synchroscope. An electrode surrounding the transmission line to the chamber actuated the vertical deflection plates (no amplification) and thus allowed detection of the spark. The primary photoelectric current was about 50 electrons/μsec.

The results for 0.2 percent overvoltage are shown as a function of pressure in Fig. 1. These are average results. Minimum values follow a curve of the same shape, but lower at this particular overvoltage by a factor of about two. The distribution of results obtained at any given pressure and overvoltage shows that the measured lags are not statistical. The formative time lags are very long, although the lags decrease rapidly with increasing overvoltage. With an overvoltage of about one percent, the formative time lags are a small fraction of a microsecond *at all pressures* studied.

The immediate problem of separating streamer from Townsend mechanism cannot be answered. Indeed, the results obtained indicate the desirability of a general reexamination of the breakdown mechanisms when more data of this kind are available.

The ripple in the power supply (0.1 percent) prevented measurements from being made much closer than 0.2 percent above threshold. The ripple probably accounts in large measure for the distribution of results at a given pressure and overvoltage.

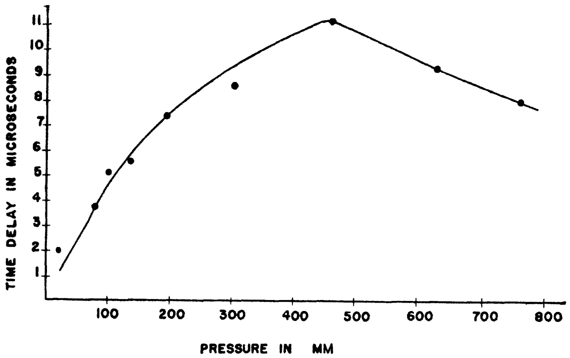

FIG. 1. Average formative time lag of spark breakdown in air as a function of pressure for 0.2 percent overvoltage in a one-cm gap.

Acknowledgment is made to the Research Corporation for a grant in support of this work, and to Professor L. B. Loeb of the University of California for the loan of the discharge chamber.

[1] L. B. Loeb and J. M. Meek, *The Mechanism of the Electric Spark* (Stanford University Press, Stanford, 1941).
[2] L. B. Loeb, Proc. Phys. Soc., London, **60**, 561 (1948).
[3] See for example Harry J. White, Phys. Rev. **49**, 507 (1936); Robert R. Wilson, Phys. Rev. **50**, 1082 (1936).

Decay of 8-Day Iodine^{131} to a Metastable State of Xenon^{131} *

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March 31, 1949

A RADIOACTIVE gas with a half-life of approximately 12 days has been found associated with the 8-day I^{131} produced at Oak Ridge National Laboratory. This radioactive gas is present in I^{131} preparations whether these are made from fission products or from neutron-bombarded tellurium. Removal of gas from a sample of I^{131} at intervals has shown the gaseous activity to be the daughter of a parent with an 8-day half-life. Inertness to calcium vapor indicates that this daughter is a radio-isotope of a noble gas.

Lead and tantalum absorption curves show that the 12-day activity decays with an approximately 165-kev gamma-ray as well as softer x-radiation. Tin and antimony absorption curves indicate that the x-rays are the K radiation of xenon. Lead absorption curves taken with a coincidence counter show that electrons are coincident with x-rays but not with gamma-rays. Assuming that the electrons are monoenergetic conversion electrons, the aluminum absorption curve indicates a strong component with an energy of approximately 130 kev and a much weaker component with an energy of approximately 160 kev. These energies differ from the observed gamma-ray energy by K and L binding energies of xenon.

Comparison of the electron disintegration rate of daughter 12-day xenon activity with the absolute disintegration rate of parent 8-day iodine, indicates that about one percent of the I^{131} atoms decay to this excited state of xenon^{131}. A rough calibration of the counter used for counting efficiency of 165-kev gamma-rays gives an internal conversion coefficient, N_e/N_Q, of approximately 20.

The 12-day xenon^{131} isomer reported here is probably the same one that Camac[1] obtained by fast neutron bombardment of xenon. It may also be the same as the approximately 14-day xenon activity found in 0.03 percent fission yield by Chackett.[2] In a beta-ray spectrometer study of 8-day iodine^{131}, Owen, More, and Cook[3] found conversion electrons with an energy of 128 kev which were not found by Metzger and Deutch.[4] It is believed that these electrons were from the 12-day xenon daughter trapped in their source. The results reported here lend support to the suggestion of Owen, Moe, and Cook that a small fraction of the 8-day iodine^{131} atoms, which decay with a 600-kev beta-ray, emit a 286-kev gamma-ray followed by a 165-kev gamma-ray.

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* This document is based on work performed under Contract No. W 7405. Eng 26, for the Atomic Energy Project at Oak Ridge National Laboratory.

** Now at Mellon Institute, Pittsburgh, Pennsylvania.

[1] M. Camac, Metallurgical Project Report CC-2409 (1944).

[2] W. J. Arrol, K. F. Chackett, and S. Epstein, Canadian Research Council Report No. 297 (1947).

[3] Owen, Moe, and Cook, Phys. Rev. **74**, 1879 (1948).

[4] F. Metzger and M. Deutch, Phys. Rev. **74**, 1640 (1948).

A Time-of-Flight Mass Spectrometer with Varying Field

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March 15, 1949

Of several time-of-flight mass spectrometers that have been proposed recently, only that of Goudsmit[1] gives promise of attaining very high resolution because of the favorable focusing property. The perfect focusing in this instrument can be considered a special case of that obtained in uniform crossed electric and magnetic fields[2] with $E=0$ in this case. It has been recognized that the crossed-field instrument with E having a constant value other than zero could also be used as a time-of-flight instrument in the manner proposed by Goudsmit, but this does not possess some of the advantages of the method proposed here.

In Fig. 1, there is a uniform magnetic field H in the x direction and a uniform electric field E in the z direction. The field E has the value E_0 at $t=0$ and decreases linearly with time to the value $E=-E_0$ at $t=T$. In a coordinate system moving with the proper varying velocity, the ions describe circular paths in which the time for one revolution is given as in Goudsmit's case by

$$T_1 = 670M/H \text{ microseconds,}$$

where M is the mass of the ion in atomic weight units and H the magnetic field in gauss. The y component of the velocity of the moving coordinate system is independent of the initial conditions and the mass of the ions. The z component of this velocity is also independent of the initial conditions, but does depend on the mass of the ions (the present discussion is concerned with singly charged positive ions). However, the distance B in the z direction to the exit slit is chosen only large enough to allow the beam to miss the electrode structure around the source and receiver and to provide sufficient space for the source and receiver.

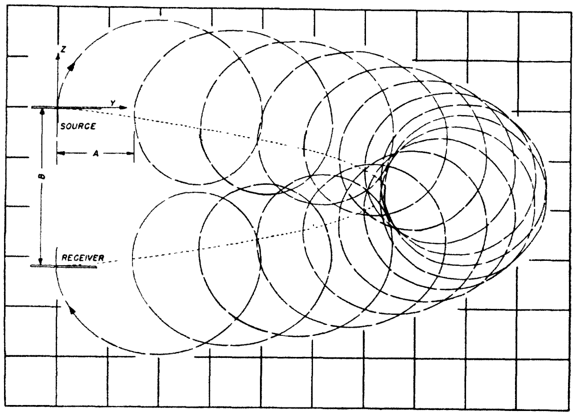

FIG. 1. Path of ions in the case of uniform magnetic field H in the x direction and uniform electric field E in the z direction.

The field E is adjusted so that a selected reference mass M_0 passes through the exit slit after an integral number of cycles n_0. Except for the small z dispersion which has an almost negligible effect in this application but which may be calculated, other ions having the proper mass to undergo an integral number of revolutions n_1 will also be perfectly focused regardless of the initial conditions. Ions having made a non-integral number of revolutions, n, when the moving coordinate system has returned to $y=0$, will be dispersed slightly in the y direction when n does become an integer. This may not be too serious as the exit slit may be made quite wide when a pulsed ion beam is used and the transit time measured in the manner of Goudsmit's instrument. However, as it may be possible to make n_0 very large by a modification of the method of varying E which will be described later, its value could be chosen so that n for the ion being measured will be fairly close to an integer when M_0 is detected. The value n_0 for the reference mass M_0 can be measured experimentally, and the nearest whole number to n may be calculated from the approximate known value of the mass M. The experiment then determines the deviation of n from this whole number by measuring the difference in the arrival times of M_0 and M.

By changing the variation of E with time, the transit time could be increased; for instance, E might be kept at zero at the turning point (maximum value of y) for a period of time while the ions revolve in the magnetic field before increasing E in the negative direction to bring the ions back to the collector. With this technique, the extent of the magnetic field in the y direction may be decreased; in fact, if the variation in E is made in a time less than that for one cycle, a ring-shaped magnet could be used. The displacement of the ion beam might be effected by a small variation in the magnetic field although this compromises somewhat the perfect focusing condition.

The chief difficulties with this scheme appear to be the long ion path and the lack of focusing in the direction of the magnetic field. However, the possibility of detecting some of the ions after a fairly long transit time looks sufficiently promising to justify some exploratory experiments. Furthermore, it appears to be possible to incorporate weak axial focusing if E is kept at zero for an appreciable portion of the time.

A very attractive variation would be to decrease E to zero, allowing the ions to spin at the maximum y displacement of the moving coordinate system and subsequently displace them in a helical path by a weak electrostatic field in the direction of the magnetic field. With this arrangement, perfect focusing is obtained for all masses except for the small z dispersion which is unimportant since this is a time-of-flight device. Using the proton moment[3] to measure the value of the magnetic field, this device could be used to determine e/M (and from it the Faraday) with good accuracy since all measurements would involve only time. Preliminary plans have been completed for the construction of the equipment to do this.

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[1] S. A. Goudsmit, Phys. Rev. **74**, 622 (1948).

[2] W. Bleakney and J. A. Hipple, Phys. Rev. **53**, 521 (1938).

[3] Thomas, Driscoll, and Hipple, Phys. Rev. **75**, 902 (1949).

Search for Stable Pd^{100}, W^{178}, and Pb^{202} *

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April 8, 1949

It has been pointed out[1] that the stability curve got by plotting the mass of the lightest isotope against atomic number shows marked linearity among the heavier elements of even atomic number. Since the breaks in such a stability curve must have significance in a precise theory of nuclear