LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twentieth of the preceding month; for the second issue, the fifth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Protons from the Disintegration of Lithium by Deuterons

It was found in this laboratory[1] that lithium bombarded with deuterons yields β-rays with a continuous distribution in energy extending to 10.5 ± 1.0 MEV and having a half-life of 0.5 ± 0.1 second. In order to account for these β-rays the following reactions were suggested:

$$_3Li^7+{}_1H^2\rightarrow{}_3Li^8+{}_1H^1, \quad (1)$$
$$_3Li^8\rightarrow{}_4Be^8+{}_1\epsilon^0. \quad (2)$$

We have recently attempted to determine the range and energy of the protons accompanying the formation of radioactive Li^8. A target of lithium metal was so disposed that disintegration particles could be admitted through a copper foil into a cloud chamber operating at a pressure of three atmospheres. Diaphragms between the target and the window limited observation to particles making an angle of $90°\pm5°$ with the incident ions. Ethyl alcohol was employed in the chamber and the stopping power of the resulting air-vapor mixture was computed from the measured chamber pressure and the vapor pressure of alcohol at the operating temperature. A polonium alpha-particle source installed in the chamber served to check the computed results. The stopping power of the copper foil (9.6 mg/cm^2) was found to be 4.7 cm by measuring the residual range of the alpha-particles yielded by bombarding lithium with protons. The stopping power for alpha-particles and protons of other ranges was computed from the data given by Mano[2] and the necessary corrections incorporated in the ranges given in Fig. 1.

The distribution in range of the particles resulting from the disintegration of lithium by 700 kv (peak) deuterons is shown in Fig. 1. The "extrapolated" ranges of 31.7 ± 0.5 cm, 13.8 ± 0.7 cm, and 8.9 ± 1.0 cm, respectively, for the longer range protons and two alpha-particle groups are in good agreement with the ranges which have been measured at Cambridge.[3] The group of particles at 26 ± 1 cm has not been reported previously. The energy of protons of this range is 4.3 ± 0.1 MEV. If the particles are produced in the manner indicated by reaction (1) then the energy released in the disintegration is $Q=4.3$ MEV and the masses of Li^8 and Be^8 are on the Bethe scale:

$$Li^8=8.0185,$$
$$Be^8=8.0072=2He^4+0.5\pm1.0 \text{ MEV}.$$

Possible contamination effects could arise from the presence of protons in the ion beam or from oxygen, nitrogen, deuterium, or carbon in the target. No particles corresponding to the 26-cm group are known to be emitted in the transmutation of the last-named elements. We have found correspondence within a factor of two or three between the number of electrons from reaction (2) and this second proton group.

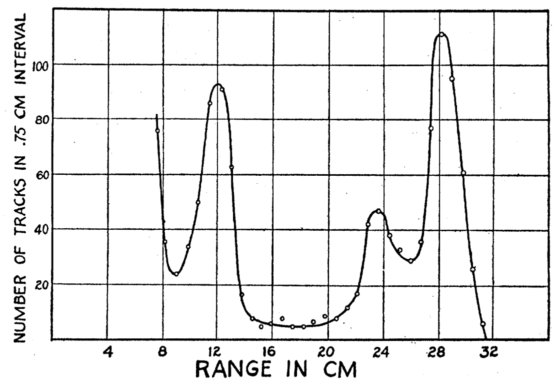

FIG. 1. Distribution in range of alpha-particles (short range groups) and protons (long range groups) emitted in the disintegration of lithium by 700-kv peak deuterons.

Oliphant, Shire and Crowther[4] employing 160-kv deuterons have reported protons from a thin Li^6 target but not from Li^7 targets of equal thickness. The fact that the yield with the latter targets would be but 2 percent of that from the former may account for their results. If the 26-cm protons are emitted in the transmutation of Li^6 then they may accompany the formation of excited Li^7 and the subsequent emission of a γ-ray. The 30.5 ± 1.0-cm protons observed by Cockcroft and Walton[5] at 500 kv extended over a range of 10 cm, a fact consistent with the existence of two unresolved groups of particles.

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October 29, 1935.

[1] Crane, Delsasso, Fowler and Lauritsen, Phys. Rev. **47**, 971 (1935).
[2] Mano, J. de phys. et rad. **5**, 628 (1934).
[3] Oliphant and Cockcroft, Int. Conf. on Physics, 1934.
[4] Oliphant, Shire and Crowther, Proc. Roy. Soc. **A146**, 922 (1934).
[5] Cockcroft and Walton, Proc. Roy. Soc. **A144**, 704 (1934).

On Dirac's Equation in Rotating Systems

In a previous publication[1] two relations were given (Eqs. (25) and (35)) which expressed Dirac's equation in a rotating frame of reference. We now give a third one which is of interest. The matrices

$$\bar{\bar{\gamma}}_k=\mathring{\gamma}_k \ (k=1,2,3), \qquad \bar{\bar{\gamma}}_4=\mathring{\gamma}_4+i\omega'(y\mathring{\gamma}_1-x\mathring{\gamma}_2)$$

satisfy the commutation relations exactly, and lead to the equation

$$\bar{\bar{H}}\chi\equiv[-\pi_t+\alpha\cdot\pi+mc\beta-\omega' L_Z-\tfrac{1}{2}\hbar\omega'\sigma_Z]\chi=0.$$

$\bar{\bar{H}}'$ is connected with H' and $\bar{H}'$ [2] by the spin transformations

$$\overline{\overline{H}}'=Q^{-1}\overline{H}'Q, \qquad H'=R^{-1}\overline{\overline{H}}'R,$$

where
$$Q=\cos \tfrac{1}{2}\omega t-i\sigma_Z \sin \tfrac{1}{2}\omega t,$$
$$R=1+\tfrac{1}{2}\omega'(x\alpha_y-y\alpha_x)+\tfrac{1}{8}\omega'^2(x^2+y^2).$$

Q is exact, R is accurate to second-order terms in ω'. It follows that $S=QR$, $H'=S^{-1}\overline{H}'S$.[3]

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October 25, 1935.

[1] O. Halpern and G. Heller, Phys. Rev. **48**, 434 (1935). The present note follows the notation of this reference.
[2] H' denotes the covariant form of the Hamiltonian, $H'=\beta H$.
[3] The accents were erroneously missing in Eq. (7a), reference 1.

The Ionosphere, Sunspots, and Magnetic Storms

During recent years there has been much published speculation concerning the relations between the condition of the ionosphere, radio transmission, and the phenomena of magnetic storms and sunspots. It has been observed that it is difficult to maintain high frequency communication over certain paths during magnetic disturbances and there is some evidence that the maximum useful frequency is lower during the minimum of a sunspot cycle than during the maximum. The following striking phenomena which corroborate and extend these data, have been observed by us at the National Bureau of Standards.

The normal-incidence noon value of $f_{F_2}{}^x$[1] which had been below 7500 kc/sec. during the summer, rose gradually during October, attaining the hitherto unobserved peak of 12,600 kc/sec. on October 21. This period of high $f_{F_2}{}^x$ approximately coincided with a period of high sunspot activity. On October 21 a series of magnetic disturbances set in. These were intermittent and at first mild, but reached considerable sustained intensity on October 23 and 24. The $f_{F_2}{}^x$ decreased slightly from October 21 to October 23, dropped very decidedly to 6400 kc/sec. on October 24, then rose slowly during the following days, as shown in Fig. 1. The noon $f_{F_2}{}^x$ was representative of the day values. The F critical frequencies during the night of October 24–25 were below those obtained on the preceding nights but not as much of a decrease as for the day values occurred.

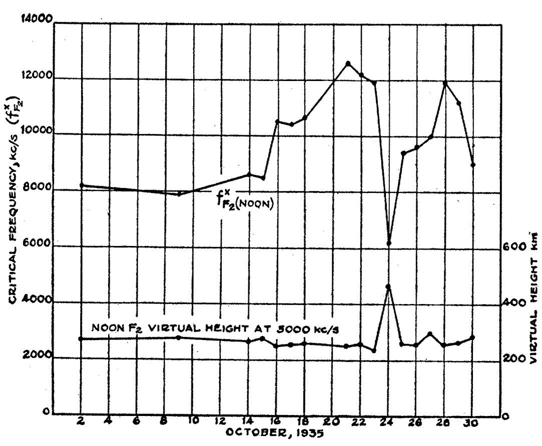

FIG. 1.

The F_1 critical frequencies were sharply defined on October 24. Both components were present. During the other days of this period $f_{F_1}{}^0$ was blunt and poorly defined as is normal for this season, and the extraordinary ray was not observed. The high values of $f_{F_2}{}^x$ were accompanied by low virtual heights of the F_2 region and *vice versa*, as shown in Fig. 1. The sharply defined F_1 critical frequencies seemed to be produced when the F_2 region rose and separated from the F_1. This is a normal summer day condition such as prevailed before the F_2 critical frequencies rose in October.

The high critical frequencies were accompanied by excellent transmission conditions for frequencies up to 30 megacycles per second, the limit of the receiver available, and probably conditions continued good up to 40 mc/sec. On October 24, the day of the low critical frequencies, transmission conditions were not as good as on previous days, many transmissions which had been received regularly on previous days failed, and others were much weaker. The critical-frequency data indicated that the maximum useful transmission frequency on October 21 was about twice that of October 24. The F_2 ionization density found on October 24 was about 23 percent of that found on October 21.

No deviations from normal were observed for the F_1 critical frequencies or virtual heights. No unseasonable change was observed during this period in the conditions of the E region, which is the region usually controlling transmission at the ordinary broadcast frequencies (550 to 1500 kc/sec.).

Dr. E. O. Hulburt[2] has given a reasonable theory for the low ionization densities and great virtual heights of the F_2 region during summer days. According to this theory these conditions are caused by atmospheric expansion produced by heating. Similar conditions seem to exist during the latter part of a magnetic storm. The results given above then indicate the probability that some agency acting during magnetic storms, heats the F_2 region to values abnormal for the season, causing the atmosphere there to expand, and in this manner reduces the ionization density and increases the virtual height of this region.

The effect of the sunspot activity seems to be to increase the ionization density of the F_2 region. On the other hand, though magnetic disturbances are more frequent and intense during the active part of the sunspot cycle, some agency acting for short times during these periods serves to decrease the ionization density of the F_2 region much below normal and increase the height of this region much above normal.

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November 2, 1935.

[1] $f_{F_2}{}^x = F_2$ critical frequency, extraordinary ray, i.e., the highest radiofrequency which is returned to earth by the F_2 region of the ionosphere.
[2] Hulburt, Phys. Rev. **46**, 822 (1934). Terr. Mag. 193, June (1935).