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A Long Period Positron Activity: Na^{22}

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The bombardment of magnesium with 5.2 Mev deuterons was found to result in a long period radioactivity ascribable to Na^{22}. The half-life, as determined from measurements extending over a period of a year, is 3.0 ± 0.2 years. Absorption measurements on the positrons emitted agree with similar measurements made with a fluorine sample subjected to alpha-particle bombardment; the positron momentum distribution was investigated with a hydrogen-filled cloud chamber in a magnetic field, an upper limit being found at a value corresponding to 0.58 ± 0.03 Mev.

A RADIOACTIVITY ascribable to Na^{22} has been produced by Frisch,[1] who bombarded fluorine in the form of NaF and LiF with alpha-particles from radon. The equations applying are, then,

$$_9F^{19}+{}_2He^4={}_{11}Na^{22}+{}_0n^1,$$
$$_{11}Na^{22}={}_{10}Ne^{22}+e^+.$$

In this laboratory it has been found that, in addition to this long period activity showing up in various fluorides bombarded with artificial alpha-particles, quite strong samples can be produced by the bombardment of magnesium with high speed deuterons.[2] In the latter case we have the reaction

$$_{12}Mg^{24}+{}_1H^2={}_{11}Na^{22}+{}_2He^4;$$

it is the purpose of this paper to present some measurements made on the positrons from this radioelement which is perhaps particularly interesting because of its relatively long period.* The shorter periods arising in magnesium bombarded with deuterons have already been investigated by Henderson,[3] who found that the two negative electron emitters Mg^{27} (10 min. half-life) and Na^{24} (15 hr.) made their appearance.

That the long-period activity in question arises from an isotope of sodium has been confirmed by Dr. M. Kamen, who very kindly carried out a chemical separation on a portion of a sample which had aged six months. Although Na^{22} has

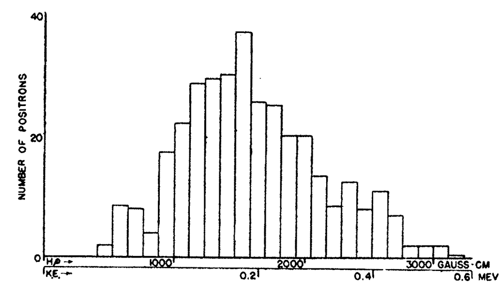

FIG. 1. Momentum distribution of positrons from Na^{22}.

been reported to occur in nature[4] in appreciable quantities, a careful investigation by Sampson

[1] O. R. Frisch, Nature **136**, 220 (1935).
[2] L. J. Laslett, Phys. Rev. **50**, 388(A) (1936).
* *Note added in proof.* The author has been kindly informed by Dr. A. H. Snell that neon, under deuteron bombardment, gives rise to a weak, long period activity. It is likely that this, too, may be ascribed to Na^{22} produced from Ne^{21} with the emission of a neutron.

[3] M. C. Henderson, Phys. Rev. **48**, 855 (1935).
[4] A. K. Brewer, Phys. Rev. **49**, 856(L) (1936).

and Bleakney[5] has convinced these authors this is not the case, an upper limit to the possible abundance being given as one part in fifty thousand of Na^{23}.

In connection with this investigation, two targets of magnesium metal have been bombarded in the Berkeley cyclotron, each with approximately 20 microampere hours of 5.2 Mev deuterons. The older of the two is being kept for

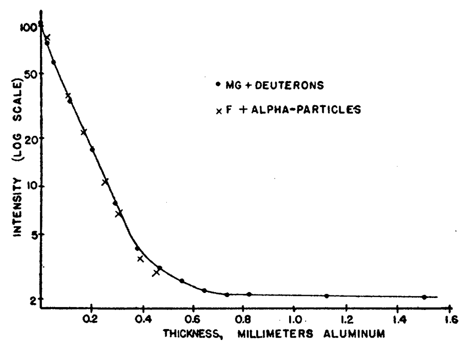

FIG. 2. Absorption curve of radiations emitted by Na^{22}.

further determination of its half-life. The decay of the sample has been followed by comparing the ionization produced by the annihilation radiation with that produced by a radium sample, a pressure ionization chamber coupled to an FP 54 electrometer tube circuit being used for this purpose. In addition, the decay has been followed by measuring the positron intensity and the annihilation radiation with a Lauritsen electroscope. These measurements have been taken over a period of a year and agree in assigning to the half-life the value 3.0 ± 0.2 years.

The momentum distribution of the positrons emitted has been investigated with a hydrogen-filled cloud chamber traversed by a magnetic field of 235 gauss. Some of the photographs were taken with a sample which had aged three months, others with one seven months old; the resulting histogram is shown in Fig. 1 in which the last track and some others in the body of the distribution have been given a weight of one-half, as they were considered poorer than the others. Even with a chamber filled with hydrogen, scattering in the gas distorts such a low energy spectrum, but the upper limit obtained by inspection may be taken as 0.58 ± 0.03 Mev. Absorption measurements made on a magnesium sample are shown in Fig. 2, a logarithmic scale being used. In this figure is also shown the absorption of the positrons from a fluorine sample bombarded in the cyclotron with 10 Mev alpha-particles; the two curves have been fitted at the 0.1 mm point and the similarity of their slopes confirms the belief that the radioactive substances are the same.

Measurements with the electroscope, confirmed by a Geiger counter into which samples could be placed, have indicated that the magnesium targets each emit about six thousand positrons per second. This estimate, together with the known exposure to the deuteron beam, enables one to compute the yield for a thick magnesium target as approximately 2 positron-producing atoms per 10^6 deuterons. This value, applying to 5.2 Mev deuterons, is, of course, much greater than that obtained by Henderson[3] for the similar reaction with Mg^{26} (forming Na^{24}) and 3 Mev deuterons.

The long period positron emission from Na^{22} is of some interest in connection with the theory of Yukawa and Sakata,[6] who suggest K electron capture and neutrino emission as an alternative process. Calculations by Lamb[7] on the basis of this theory and the Konopinski-Uhlenbeck modification of Fermi's β-ray theory show that, with these assumptions, this alternative K electron process is some thirty times more probable than bona fide positron emission—this figure, together with the yield given above, would lead, of course, to a suspiciously large yield of Na^{22} atoms.

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[5] M. B. Sampson and W. Bleakney, Phys. Rev. **50**, 456 (1936).

[6] H. Yukawa and S. Sakata, Proc. Phys. Math. Soc. Japan **17**, 467 (1935).

[7] W. E. Lamb, Jr., Phys. Rev. **50**, 388 (A) (1936).