associated with isotope production problems are under the supervision of H. W. Savage, B. S. Weaver, and P. J. Hagelston. W. E. Leyshon and L. O. Love deserve particular credit for their contributions to the solution of the difficult calutron problems. All isotopic analyses on natural and enriched mercury were done in the mass spectrometer laboratory under the direction of R. F. Hibbs and J. W. Redmond.

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A Preliminary Note on Nuclear Periodic Scheme in Three Dimensions

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It appears to be well established that 2, 8, 20, 50, 82 numbers of neutrons or protons and 126 neutrons form particularly stable configurations.[1,2] In order to illustrate better how the properties of nuclei vary and to aid in discovering periodicities that exist, it seems worth while to arrange a nuclear periodic scheme analogous to the atomic periodic chart. However, since in the ordinary nuclear chart the isotopes proceed along two dimensions, the nuclear periods will have to advance along the third dimension.

It might be well to emphasize at this point that the properties of a nucleus are functions of two variables: Z, the number of protons, and N, the number of neutrons. Any particular nucleus, for instance, may have a complete shell in Z, but not necessarily in N, and conversely. Within limitations, there is then some independence in the variation of Z and N, and in the completion of shells in each of these variables.

We can build up the system with the assistance of a Segré chart, as illustrated in Fig. 1. It consists of successive planes; each plane starts with nuclei having a complete shell in either neutrons or protons, and ends with nuclei of the next complete shell in either nucleon. Only the first three planes are shown on the diagram.

Stable nuclei are indicated by cross-hatching; radioactive nuclei have the half-life on clear background; nuclei with a complete shell in either neutrons or protons are enclosed in heavy lines. Nuclei that are complete in both neutrons and protons ($_2He^4$, $_8O^{16}$, $_{20}Ca^{40}$) are darkened.

The complete scheme can be outlined as follows:

Plane I.—This consists of all nuclei up to those having a complete 2-shell in either neutrons or protons, or including the isotopes of He.

Plane II.—This starts with nuclei having 2 neutrons or 2 protons, and ends with a complete 8-shell in either nucleon, or including the isotopes of oxygen and F^{19}.

Plane III.—Similarly, this starts with all nuclei with 8 neutrons or protons, and ends with a complete 20-shell in either nucleon. After this, the neutron and proton periods proceed independently.

Plane IV.—This goes from nuclei with 20 nucleons of either type to nuclei with 50 protons, or the isotopes of Sn.

Plane V.—From nuclei with 50 neutrons to those with 82 neutrons.

Plane VI.—From the isotopes of Sn to nuclei with 82 protons or 126 neutrons (the isotopes of Pb and all nuclei with 126 neutrons).

Plane VII.—This goes from 82 protons or 126 neutrons, and includes all the remaining radioactive nuclei.

This arrangement should be very suggestive in bringing together species that have similar properties since it will tend to line up nuclei that are at the same stage of starting or completing a shell in either neutrons or protons. For instance, nuclei lacking one neutron to form a complete shell should have related properties; similarly for nuclei with one neutron more than a complete shell.

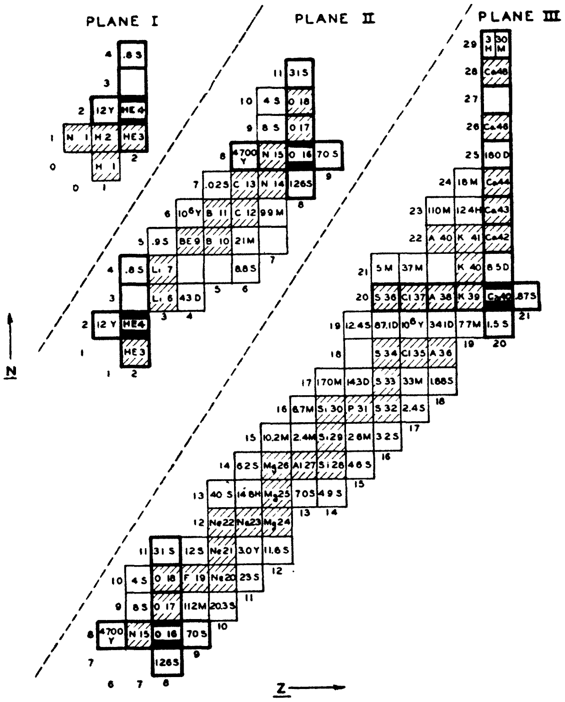

Fig. 1. Nuclear periodic scheme.

As an example of the use of this scheme, we may consider the following: $_8O^{17}$,[3] $_{36}Kr^{87}$,[1] $_{54}Xe^{137}$[1] are known delayed neutron emitters. They have 9, 51, 82 neutrons, respectively, or one neutron more than a closed shell. They decay by neutron emission to $_8O^{16}$, $_{36}Kr^{86}$, $_{54}Xe^{136}$ all with closed shells in neutrons, $N=8$, 50, 82.

In our scheme they appear on Planes II, IV, VI, respectively. One would expect that there should be a neutron emitter in a corresponding place on Plane III at $N=21$. This might perhaps be $_{16}S^{37}$, decaying to $_{16}S^{36}$, ($N=20$). It would then be analogous to $_{36}Kr^{87}$ and $_{54}Xe^{137}$ since they decay to stable nuclei of lowest Z consistent with a complete neutron shell.

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The Beta-Spectrum of Be^{10}

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The beta-decay of Be^{10} has a particular interest at this time because the transition $Be^{10}\rightarrow B^{10}$ is now known almost certainly to involve a spin change of three units, so that the transition is highly forbidden according to the Fermi theory of beta-decay. Marshak has shown[1] that the Fermi theory predicts an energy spectrum for the Be^{10} beta-rays which is substantially different from the allowed form. He gives a set of curves of correction factors for converting the allowed spectrum into other forms corresponding to the different types of transitions which theoretically might apply to this case. By arguments based on the half-life, he narrows the choice down to one curve (D_2). The D_2 curve corresponds to second- or third-forbidden tensor or second-forbidden axial vector type transitions if Gamow-Teller selection

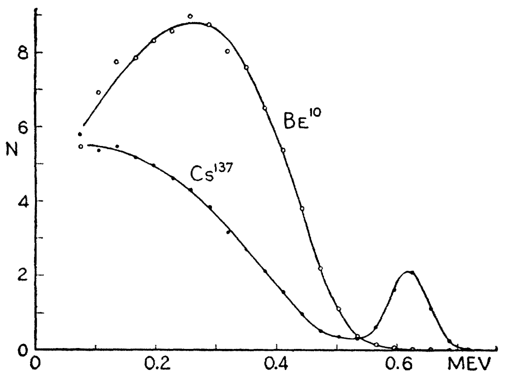

FIG. 1 Energy distributions of the beta-rays of Cs^{137} and Be^{10} as determined by means of a high pressure proportional counter. The energy scale was obtained from the known (see reference 4) 0.626 Mev energy of the metastable Ba^{137} conversion line. Ordinates are proportional to ten channel discriminator readings less backgrounds. The three lowest energy points are good to only about twelve percent because of the high background in that region.

rules are accepted, or to a third-forbidden vector transition if Fermi selection rules are accepted.

Hughes and co-workers[2] have estimated from absorption measurements that Be^{10} has an allowed type spectrum. Bell and Cassidy,[3] using a scintillation counter, have found some evidence for deviation from the allowed spectrum.

We have recently determined the shape of the Be^{10} spectrum by means of a high pressure proportional counter in which the sample was mounted on a 0.2 m/cm^2 aluminum foil suspended between two tungsten collector wires, so that all electrons emitted would be observed. This arrangement has a number of other advantages, among them the fact that primary electrons scattered through the foil will, if their energy is not too low, give secondary electron current pulses of about the correct size. Actually, two identical counters of this type were mounted inside the same high pressure vessel filled with argon at a pressure of 700 p.s.i. Be^{10} was placed in one; Cs^{137} was placed in the other. The amplifier could be switched from one side to the other. A calcium purifier was operated continuously. As the counter voltage was raised, saturation of the ionization electron current was observed before appreciable gas multiplication appeared. Approximately twofold gas multiplication was used. Use of greater gas multiplication would improve the resolving power at the expense of stability.

The Cs^{137} was deposited carrier-free by evaporation The Be^{10} in the form of BeO powder was deposited by evaporation of an amyl acetate suspension to which a trace of wax had been added to act as a binder. Three different samples of beryllium were used, having thicknesses ranging from 0.5 to 3.5 m/cm^2. All gave very similar results.

Typical results are shown in Figs. 1 and 2. The conversion line of metastable Ba^{137} has an energy spread at half-maximum of about 70 kilovolts. It was used for calibrating the system. Curves *a* and *b* of Fig. 2 are allowed spectrum plots of Be^{10} and Cs^{137}, respectively. Curve *a* has a marked bond, while curve *b* shows the slight bend expected from previous work.[5,6] The high energy tailing is due to the inherent limited resolving power of the system.

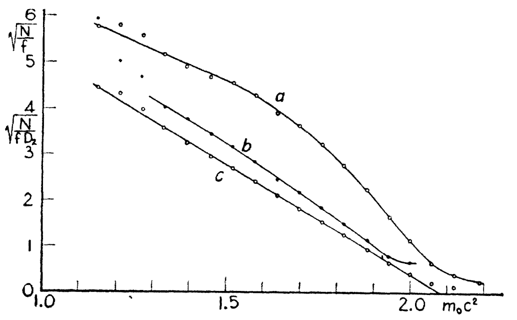

FIG. 2. Curves *a* and *b* are allowed spectrum plots of Be^{10} and Cs^{137}, respectively. Curve *c* is the result of transforming the ordinates of curve *a* by use of Marshak's D_2 correction curve. The end point of the Be^{10} spectrum is at 0.553±0.015 Mev.

Curve *c* of Fig. 2 shows the Be^{10} spectrum plotted as a forbidden spectrum by use of Marshak's D_2 correction curve. The points lie very nearly on a straight line, supporting the validity of the D_2 curve, hence supporting the Fermi theory. The other D_1 do not give satisfactory plots.

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The Disintegrations of Sn^{121} and Sn^{123} *

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THE 39.5-min. activity of Sn^{123} and the 28-hr. activity Sn^{121} were studied by means of a magnetic lens spectrometer.[1] Sources were prepared by irradiating metal foils of separated isotopes in the thermal column of a nuclear reactor. The separated isotopes**** contained 70.7 percent Sn^{122} and 95.4 percent Sn^{120}, respectively. The times of irradiation and measurement were selected so as to avoid interference from the activation of other periods. Decay rates were checked in the spectrometer and also directly. The sources were about 0.5 in. in diameter. The Sn^{120} sample was rolled at 7.5 mg/cm^2. The Sn^{122} sample was 6.2 mg/cm^2 thick. Calibration of the spectrometer was in terms of the 0.663-Mev gamma-ray which follows the decay of Cs^{137}. Most of the measurements were made with a resolution of 6.4 percent. The internal conversion line found in Sn^{123} was also investigated with a resolution of 2.4 percent in an attempt to resolve the *K* and *L* lines. However, the broadening of these low energy lines because of the thickness of the source prevented their separation. Detection was by means of a 3.5-mg/cm^2 mica end-window counter.

Figure 1 shows the momentum distribution of the electrons emitted by the 39.5-min. period of Sn^{123}. In addition to the beta-

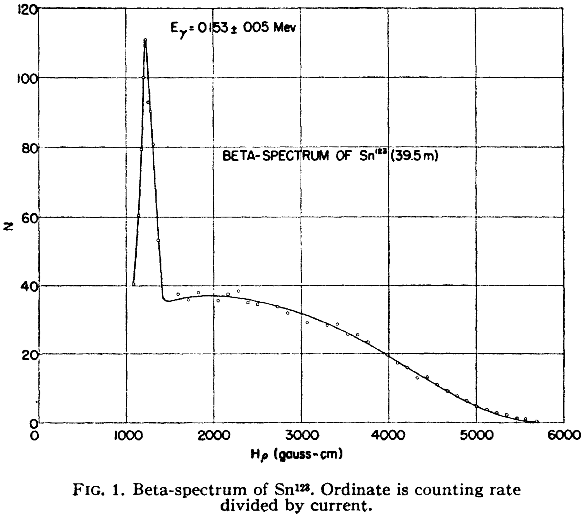

FIG. 1. Beta-spectrum of Sn^{123}. Ordinate is counting rate divided by current.