NEW ISOTOPE OF BERYLLIUM†

M. J. Nurmia* and R. W. Fink
Departments of Physics and Chemistry
University of Arkansas
Fayetteville, Arkansas
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As part of a systematic investigation on the reactions in light nuclei caused by 14.8 - Mev neutrons, several samples of B_4C, BN, B_2O_3, and elemental boron[1] of natural isotopic composition were irradiated with a flux of 10^8 - 10^9 neutrons/cm^2 sec produced in the d-T reaction from the 400-kv Cockcroft-Walton accelerator at the University of Arkansas[2]. The samples were pressed with paraffin to form circular disks 1.5 cm in diameter and about 2 mm thick, which were mounted in holes in pieces of 3-mm thick polyethylene plates 2.7 cm square. Beta and gamma scintillation counters and end-window GM tubes were used as detectors in connection with a rapid transfer and recording system[3]. This system enables counting to begin in less than 1 second after the end of bombardment.

A representative decay curve is shown in Fig. 1. Two half-lives are seen, the (0.86±0.02)-second activity[4] being due to the decay of well-established Li^8 arising from the $B^{11}(n,\alpha)$ reaction[5]. The 14.1-second activity, which has not been reported previously, is assigned tentatively to a new isotope of beryllium, Be^{11}, from the B^{11} (n, p) reaction. From a series of measurements, a value of 14.1±0.3 seconds is derived for the half-life, while by assuming equal detection efficiencies for both activities, a value of 10.0 ± 1.5 is obtained for the ratio of the $(n,\alpha)/(n,p)$ cross sections for B^{11} at 14.8 Mev. The decay of 14.1-second Be^{11} appears to proceed predominantly by high-energy (>5 Mev) beta-emission.

Neither activity was produced with neutrons from the d-D reaction (2.95 Mev) owing to the high threshold energy requirements for both reactions, which in the case of the $B^{11}(n,\alpha)Li^8$ reaction is approximately[6] 6.62 Mev and is at least 6 Mev for the $B^{11}(n,p)Be^{11}$ reaction.

A more detailed investigation concerning the absolute cross sections and decay scheme of

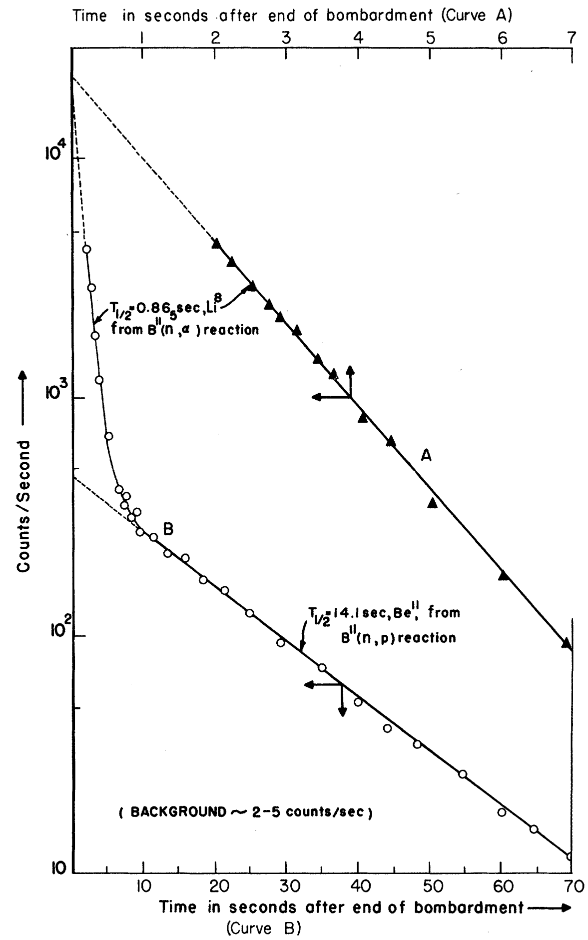

FIG. 1. Typical gross beta decay curve (B) taken with a $1\frac{1}{2}\times1\frac{1}{2}$-inch plastic scintillation counter (biased to detect betas above 1 Mev following a 7-second irradiation of natural boron with 10^8-10^9 neutrons/cm^2-sec from the d-T reaction (14.8 Mev). In other runs, the detector bias was varied in the range between 1 and 5 Mev with very little change in the decay curve. Curve A shows the shorter-lived Li^8 activity plotted on a 10-fold expanded time scale. Background plots (not shown) exhibited a very low counting rate, the highest of which decayed from about 10 to about 2 counts/sec during the first 100 seconds after bombardment.

Be^{11} is in progress. We are indebted to Mr. J. E. Wray of the Accelerator Laboratory for assistance in carrying out the bombardments.

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*Present address: University of Helsinki, Helsinki, Finland.

[1] Containing 0.09% C, 0.26% Fe, balance B, obtained from A. D. Mackay, Inc., New York.

[2] Bronner, Ehlers, Eukel, Gordon, Marker, Voelker and Fink (to be published); for a detailed report on this accelerator see Annual Progress Report, U. S. Atomic Energy Commission Contract, University of Arkansas, March 1, 1958 unpublished), pp. 1-32.

[3] To be described in detail elsewhere.

[4] W. F. Hornyak and C. C. Lauritsen, Phys. Rev. 77, 160 (1950).

[5] A. M. Lawrance, Proc. Cambridge Phil. Soc. 35, 304 (1939).

[6] Li, Whaling, Fowler, and Lauritsen, Phys. Rev. 83, 517 (1951).

SPACINGS OF NUCLEAR ENERGY LEVELS*

Norbert Rosenzweig
Argonne National Laboratory, Lemont, Illinois
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Recently, attempts have been made to discover the law which governs the distribution of spacings of adjacent energy levels, of the same spin and parity, of highly excited nuclei.[1-3] It was pointed out by Wigner[4,5] and also by Landau and Smorodinsky[6] that one expects, on the basis of the "crossing theorem" for the eigenvalues of Hermitian matrices,[7] that the probability density for very small spacings is proportional to the spacing itself. If one retains the same description for all spacings (i.e., a Poisson process in the square of the spacing), one obtains the distribution law

$$p(x) = \frac{\pi}{2} x \exp\left(-\tfrac{1}{4}\pi x^2\right) , \qquad (1)$$

in which x is the value of a particular spacing divided by the mean value. Indeed, a careful analysis of the experimental data indicates that small spacings (say $x<0.3$) occur relatively infrequently.[2,3]

Wigner has suggested the following statistical model for obtaining the correct distribution law for all values of x. There exists a representation in which spin and parity are diagonal, and in which the matrix elements of the energy are randomly distributed according to a frequency function which is symmetric about the value zero. (One of the best known examples of such a distribution is a Gaussian with zero mean.) Furthermore, Wigner conjectures that the distribution law for x does not depend sensitively on the precise distribution law for the maxtrix elements[8] and that the correct p(x) is given approximately by Eq. (1).

In order to study these ideas we have resorted to a numerical analysis, which is easily carried through with modern computing machinery. We have considered a set of 200 real symmetric matrices of order 20. The matrix elements were chosen at random from a symmetric uniform distribution. (It can be shown rigorously that the distribution law for the relative spacing x is independent of the dispersion of the uniform distribution.) After diagonalization, the 19 spacings resulting from one particular matrix are divided by the mean spacing for that matrix to yield 19 values of x. In this way all 3800 values of x may be considered together (in exact analogy with the procedure adopted in the treatment of the experimental data), and the result is shown in the form of a histogram in Fig. 1, which also contains a plot of p(x).

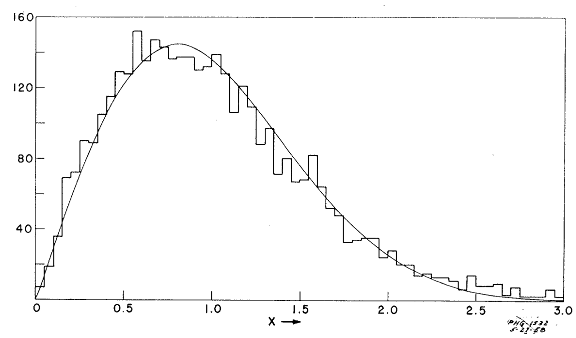

FIG. 1. The results for the uniform distribution of matrix elements as shown in the form of a histogram. The ordinate represents the number of spacings per 0.05 unit of x. Fourteen spacings had values exceeding 3. The distribution given by Eq. (1), suitably normalized by the factor 3800/20, is plotted for comparison.

The above calculations were repeated, with the matrix elements selected at random from a Gaussian distribution $(0, \sigma)$. Again, the result is rigorously independent of σ and turns out to be quite similar to the histogram of Fig. 1.

Thus, Wigner's conjectures are very well confirmed within the limited scope of our calculations. Our results, based on two different distributions of the matrix elements, are well described by the function (1), except for very