Letters to the Editor

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Total Neutron Cross Sections of Several Nuclei at 14 Mev*

ALBERT H. LASDAY
Department of Physics, Carnegie Institute of Technology, Pittsburgh, Pennsylvania
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THE total neutron cross sections of polyethylene (for hydrogen), beryllium, carbon, titanium,[1] vanadium,[1] zirconium,[1] and lead were obtained from a good geometry transmission measurement using neutrons from the University of Pittsburgh cyclotron, made available through the courtesy of Dr. A. J. Allen. Neutrons in the energy range of 13 to 15 Mev were detected by allowing the neutron beam to impinge on a polyethylene radiator and then detecting recoil protons by passing them through a proportional counter telescope[2] made up of four counters in a triple coincidence, anticoincidence arrangement. Suitable aluminum absorbers were placed between the polyethylene foil and the front counter of the telescope and between the last two counters in order to determine the lower and upper energy limits, respectively, of the sensitive range of the counter telescope. The mean neutron energy was 13.9 Mev.

The samples whose neutron transmissions were measured were placed midway between the cyclotron target and the polyethylene foil of the neutron detector. The largest sample subtended a plane angle of 5° at the detector. Hence, it was necessary to correct each observed cross section for the effect of neutrons scattered elastically into the detector from the sample. This correction was calculated using the method of McMillan and Sewell.[3] Table I lists the observed cross sections, the elastic scattering corrections, and the corrected cross sections. The errors due to counting fluctuations are considered to be much greater than any others inherent in the method used, since the measured transmissions were corrected by measurement of stray neutrons scattered into the detector from the surroundings. Hence, the standard deviations listed with the corrected cross sections were calculated only on the basis of counting statistics.[4] The last column of Table I lists nuclear radii calculated from the corrected cross sections by the relation:

$$\sigma_t = 2\pi R^2.$$

The nuclear radii obtained from the present experiment are compared with those of Amaldi, *et al.*,[5] also measured at 14 Mev,

TABLE I. Neutron total cross sections and nuclear radii.

Scatterer	Observed cross sect. (barns)	Scattering correction (% of obs.)	Corrected cross sect. (barns)	Standard deviation (barns)	Radius (10^{-13} cm)
Poly[a]	2.73	1.8	2.78	±0.09	···
H[a]	···	···	0.77	±0.04	···
Be	1.39	1.4	1.41	±0.11	4.73±0.21
C	1.23	0.8	1.24	±0.06	4.44±0.11
Ti	2.22	0.9	2.24	±0.29	5.98±0.36
V	2.49	1.2	2.52	±0.24	6.33±0.30
Zr	2.34	1.3	2.37	±0.35	6.14±0.45
Pb	4.80	3.5	4.97	±0.27	8.90±0.23

[a] The formula $(CH_2)_n$ was used for polyethylene in order to compute the hydrogen cross section: $\sigma_H = \frac{1}{2}(\sigma_{poly} - \sigma_C)$.

in Fig. 1. The best fit to the data of Amaldi, *et al.*, is given by the straight line:

$$R = (1.3 + 1.37A^{\frac{1}{3}}) \times 10^{-13} \text{ cm},$$

which is plotted on Fig. 1. The carbon, titanium, and vanadium cross sections agree very well with the straight line. The beryllium radius is anomalously high; however, the beryllium cross section agrees well with the beryllium curve in Adair's[6] recent compilation of neutron cross sections. Interpolation of his curve of the beryllium cross section as a function of energy between 4 Mev and 40 Mev gives a value of the beryllium cross section at 14 Mev of about $1\frac{1}{4}$ barns. The measured value from the present experiment is 1.41±0.11 barns.

The zirconium and lead radii are apparently significantly smaller than the notion of constant nuclear density leads one to expect. Amaldi, *et al.*, also give a small value of the lead radius ($9.00 \pm 0.13 \times 10^{-13}$ cm). Furthermore, it is worth noting that the titanium, vanadium, and zirconium cross sections were all measured as part of one continuous data run, as were polyethylene and lead. It is concluded that the anomalously small zirconium and lead radii are indications of closed shell structure[7] of $_{40}Zr^{90}$ (48 percent abundant isotope) with 50 neutrons, and of $_{82}Pb^{208}$ (52 percent abundant isotope) with 126 neutrons or 82 protons.

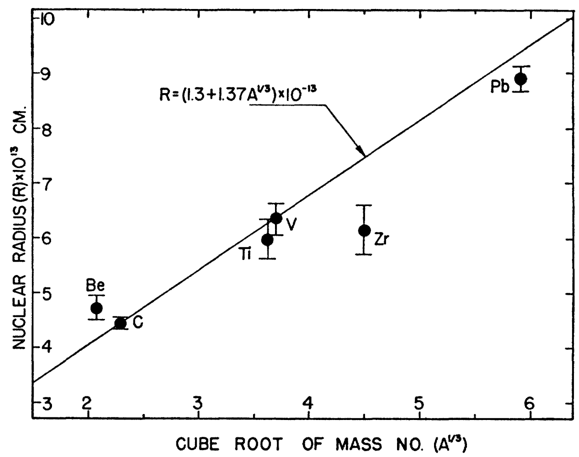

FIG. 1. Nuclear radius as a function of cube root of mass number. The straight line $R = (1.3 + 1.37A^{\frac{1}{3}}) \times 10^{-13}$ cm represents the best fit to the data of Amaldi, *et al.* The plotted points are calculated from the cross sections of the present experiment by the relation: $\sigma_t = 2\pi R^2$.

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[1] High purity samples very kindly loaned by the Argonne National Laboratory of the AEC.
[2] E. M. Baldwin, to be published.
[3] E. M. McMillan and D. C. Sewell, U. S. AEC publication MDDC-1558, unpublished.
[4] M. E. Rose and M. M. Shapiro, Phys. Rev. **74**, 1853 (1948).
[5] Amaldi, Bocciarelli, Cacciapuoti, and Trabacchi, Nuovo Cimento **3**, 203 (1943).
[6] R. K. Adair, Revs. Modern Phys. **22**, 257 (1950).
[7] M. G. Mayer, Phys. Rev. **74**, 235 (1948).

Mobilities of Electrons in High Electric Fields

E. J. RYDER AND W. SHOCKLEY
Bell Telephone Laboratories, Murray Hill, New Jersey
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IN ordinary theories of electrical conductivity it is supposed that the electric field is so small that the energy given to the electrons can be transferred to the lattice with no great alteration in the energy distribution of the electrons. In the case of electrical breakdown such changes are considered, but the equilibrium