the predictions associated with the mass difference between the charged and neutral pion and between the proton and neutron on one hand, and with Coulomb effects on the other, experiments should be conducted with light nuclei at the highest possible meson energies.

The role of the constancy of the isotopic spin in nucleon-pion problems was called to the author's attention by Professor Fermi's stimulating lectures on pion scattering at the University of Rochester last January. Thanks are due to Dr. Marshak for his interest in this research and for several helpful comments and criticisms.

Note added in proof:—Since this letter was sent in, Dr. J. M. Luttinger has informed me that he has independently derived Eqs. (9) and (10).

* This work was supported jointly by the AEC and the French Direction des Mines. Some of the calculations were presented at the Rochester Conference on Meson Physics (January 11–12, 1952).

[1] As usual, "charge independence" denotes the equality of $n-p$, $p-p$, and $n-n$ forces for states of the same spin and partity; "charge symmetry" refers to the equality of $n-n$ and $p-p$ forces alone.

[2] For a general discussion of the applications of charge independence to pion-nucleon problems and of the extension of the isotopic spin formalism to the pion field, the reader is referred to the treatment of K. M. Watson [Phys. Rev. **85**, 852 (1952)] and also to W. Heitler [Proc. Roy. Irish Acad. **51**, 33 (1946)] and K. M. Watson and K. K. Brueckner [Phys. Rev. **83**, 1 (1951)].

[3] In particular for final states containing the deuteron, as was pointed out by Dr. Chew.

[4] Equation (10) reduces to Eq. (21) of Watson and Brueckner (reference 2) when, in accordance with their assumptions, the production of π^0 in $p-p$ collisions is forbidden.

[5] Equation (11) arose out of a discussion between Dr. Marshak, Mr. Petschek, and the author.

Regularities in the Total Cross Sections for Fast Neutrons*

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(Received March 17, 1952)

Recently Miller, Adair, and others[1] have measured the total cross sections for fast neutrons of many of the heavier elements in the energy range from about 0.1 to 3 Mev. It was found that, disregarding the effect of individual resonances, neighboring elements show very similar variations of cross section with energy while there are marked differences in the shape of the cross section curves between elements of appreciably different atomic number. This behavior is shown in Fig. 1. In this figure the measured cross sections divided by the geometrical area of the nucleus are plotted against neutron energy. The nuclear area was calculated for a nuclear radius of $1.45\times A^{\frac{1}{3}}\times 10^{-13}$ cm. The elements are arranged according to their atomic weight A, since in the case of Te and I it was found that a smoother surface resulted from such an arrangement than if the elements were ordered according to their atomic number. No attempt has been made to include details of the fluctuations in cross section; in particular, the behavior at thermal and epithermal energies has been ignored, since the cross sections at the lowest energies depend primarily on the presence of individual resonances.

An interesting feature of the surface shown in Fig. 1 is the large value of the cross section at low energies for elements around Sr. This peak appears to shift to higher energies with increasing atomic weight. Furthermore, the cross section of the elements heavier than Ir exhibit a minimum at neutron energies around 1 Mev.

The behavior shown in Fig. 1 is in disagreement with the continuum theory proposed by Weisskopf and his collaborators,[2] since this theory predicts a monotonic decrease of the total cross section with energy. Following a suggestion by Wigner, Weisskopf[3] has more recently calculated the energy dependence of the cross section on the basis of a single particle interaction and finds that variations of the total cross section with energy similar to those shown in Fig. 1 may be obtained.

* Work performed under the auspices of the AEC.

[1] Miller, Fields, and Bockelman, Phys. Rev. **85**, 704 (1952); more complete reports will be published later.

[2] Feshbach, Peaslee, and Weisskopf, Phys. Rev. **71**, 145 (1947); H. Feshbach and V. F. Weisskopf, Phys. Rev. **76**, 1550 (1949).

[3] V. F. Weisskopf, Bull. Am. Phys. Soc. **27**, No. 1, 7 (1952).

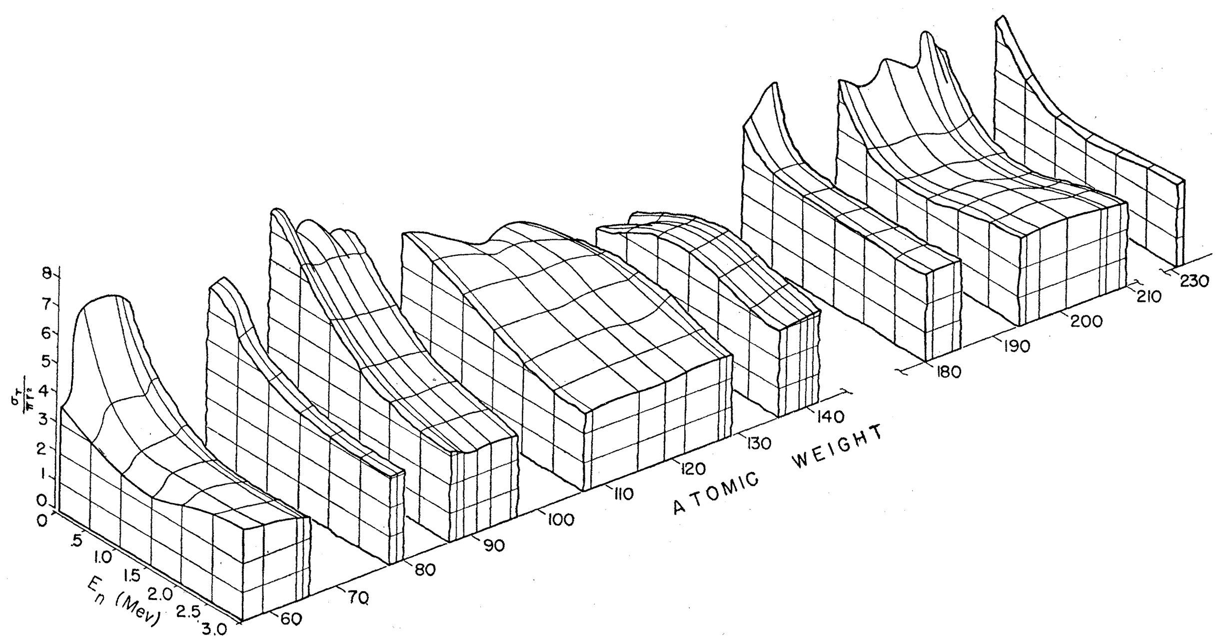

FIG. 1. Total neutron cross sections of elements heavier than Mn as a function of neutron energy. The surface is based on measurements for the atomic weights at which straight vertical lines appear in the figure.