Energy Spectrum of Neutrons from Po-Be

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(Received November 17, 1953)

The energy spectrum of neutrons from a Po-Be source has been observed by means of a coincidence scintillation spectrometer.

A NEUTRON coincidence scintillation spectrometer has been used in this laboratory to study the neutron spectrum of Po-Be. The spectrometer utilizes the recoil proton pulse amplitude principle and has been described by Owen *et al.*[1] The experimental arrangement and the block diagram of the apparatus are shown in Fig. 1. A 15-curie Po-Be source was placed 40 cm from the first anthracene scintillation detector, which consisted of a crystal 1 cm thick and 16 cm^2 in cross-sectional area and 5819 photomultiplier. A second similar detector was placed 50 cm from the first at a laboratory scattering angle of 60°. Pulse-height analysis was performed upon the signals from the first detector, and signals from the two detectors placed in coincidence defined the angle of scattering by supplying a triggering pulse to the electronic analyzer. Suitable delays were inserted in the first channel of the coincidence circuit to compensate for the neutron time-of-flight between the two detectors.

Energy calibration of the instrument was accomplished by comparing the pulse height produced by protons with the pulse height produced by internal conversion electrons of Cs^{137}. Data obtained by Taylor *et al.*[2] for anthracene were then used to convert proton pulse height into energy.

Owen has described the energy dependence of the efficiency of this type of spectrometer in terms of the *n-p* cross-section of the crystals and the coincidence circuit discrimination against small pulses arising in the second crystal as the result of proton recoils occurring at all possible angles. The cutoff due to the coincidence circuit was approximated by obtaining an upper bound for the effect. A linear extrapolation to zero counting rate at the low-energy end of the spectrum provided this upper bound and gave the cut-off energy as 0.6 Mev. In the present analysis additional energy-dependent corrections were introduced to account for the attenuation of the primary beam in the first crystal and the attenuation of the scattered beam in escaping the first crystal and entering the second crystal.

The differential counting rate data obtained were treated using the above corrections. The resulting neutron spectrum is shown in Fig. 2; the vertical bars indicate the probable errors in the mean, and the horizontal bars indicate the electronic channel widths used in the experiment. Two possible distortions in the spectrum result from the detection of the Po-Be gamma rays and from neutron reactions with the carbon in the anthracene detectors. The 4.45-Mev gamma ray[3] of Po-Be detected by the Compton effect would apparently alter the neutron spectrum near 9.96 Mev. However, two experimental arrangements tend to suppress this distortion. The delay which was inserted in the first coincidence channel to insure neutron coincidences acts together with the 15-millimicrosecond resolving time to suppress gamma coincidences. Also background data in this experiment were taken by inserting 40 cm of paraffin between the detectors while leaving the source in place; this procedure would tend to cancel in part the effect of the gamma rays. An energetically possible neutron reaction with the carbon content of the first

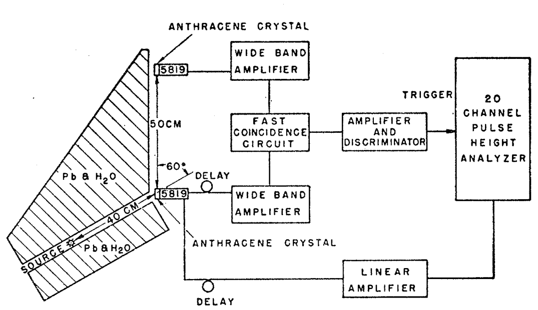

FIG. 1. Experimental arrangement and block diagram of the apparatus.

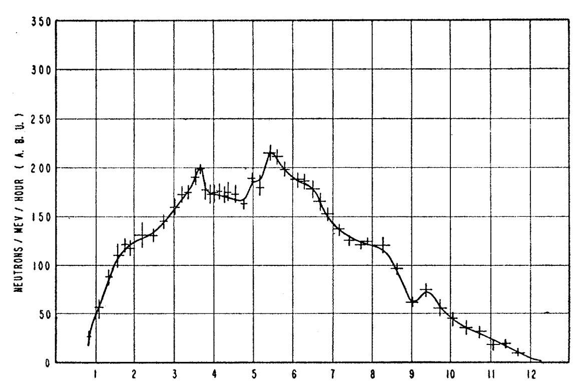

FIG. 2. Neutron spectrum of Po-Be as observed by coincidence spectrometer.

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anthracene crystal, which would also produce a coincident particle for the second detector, is $C^{12}(n,n)3\alpha$ having a threshold of 7.88 Mev as computed from the isotopic mass values.[4] It can be shown that such processes may distort the neutron spectrum below 1.3 Mev.

Various spectral distributions obtained for Po-Be neutrons have been reported in the literature.[5–10] Of these spectra the results of Whitmore and Baker are in good agreement with our results. Location of intensity maxima as reported by Gursky *et al.* also agrees within experimental error with our results.

The authors wish to thank Dr. E. H. Krause for his interest and support and to express their appreciation to W. L. Myers for aid in performing the experiment.

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PHYSICAL REVIEW VOLUME 93, NUMBER 6 MARCH 15, 1954

Some Possible Relationships between π-Meson Nucleon Scattering and π-Meson Production in Nucleon-Nucleon Collisions

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(Received December 3, 1953)

For a reaction such as $p+p\rightarrow\pi^++n+p$, it is known that the interaction of the emitted neutron and proton will frequently result in the formation of a deuteron. An analogous effect is that of the interaction of the π meson with either the neutron or the proton. This interaction is known to be strong from studies of meson-nucleon scattering. Explicit calculations are made, which indicate that pronounced qualitative effects may indeed result from the meson-nucleon interaction. In particular, the $p+p\rightarrow\pi^+$ cross section is expected to be considerably larger than is the $n+p\rightarrow\pi^+$ cross section.

I. INTRODUCTION

As is well known, there is an implication from strong coupling meson theory[1] that the state of the meson-nucleon system which has an isotopic spin of $\frac{3}{2}$ and a spin of $\frac{3}{2}$ [to be designated as the $(\frac{3}{2},\frac{3}{2})$ state] should be one of strong interaction. An analysis accepting this possibility for the pion-nucleon scattering[2] made by Brueckner[3] has led to a very reasonable qualitative explanation of the magnitudes of these cross sections. A field-theoretic calculation by Chew[4] has led to results in general agreement with these suggestions.

Further implications of a strong interaction in the $(\frac{3}{2},\frac{3}{2})$, state of the meson-nucleon system have been suggested[5] for photomeson production. These have been in not unreasonable agreement with observed[6] angular distributions and magnitudes of the cross sections.

The modest successes of these suggestions would seem to indicate that it is worth seeking further implications of the hypothesized strong $(\frac{3}{2},\frac{3}{2})$ interaction. In this connection two suggestions have been made in respect to pion production in nucleon-nucleon collisions. The first of these[5] concerned the reactions

$$p+p\rightarrow\pi^++d, \tag{A}$$

$$p+p\rightarrow\pi^++n+p. \tag{A'}$$

To a first approximation, the angular distribution in the rest system and near the energetic threshold should be of the form

$$1+3\cos^2\theta,$$

where θ is the angle between the meson momentum vector and that of one of the incident protons. This is in rough agreement with measured cross sections.[7] The second suggestion in this connection[8] was that for the

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