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A FAST NEUTRON SCINTILLATION SPECTROMETER*

R. F. Mozley and F. C. Shoemaker

Palmer Physical Laboratory, Princeton University
Princeton, New Jersey

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A proton recoil counter has been made for examining neutron groups in the energy range from 2 to 18 Mev. Two anthracene crystals are mounted in such a manner that the first crystal is the source of protons while the second defines the angle of proton recoil. The pulses from both scintillation counters are added together to give the energy of the recoil proton and thus the neutron energy. Compton and photo-electrons from target gamma rays lose less energy in the crystals than most of the proton recoils, but due to the non-linearity¹ of anthracene can give pulses as large as those from 6 Mev protons. To eliminate background of this type a proportional counter is placed between the two crystals and a dE/dx measurement made to identify the recoiling particle. The output pulses from the addition circuit are recorded only when there is a triple coincidence of pulses from the two crystals and the proportional counter. (See Fig. 1)

The protons passing through the proportional counter may have any energy up to 18 Mev. The difference in energy loss of fast and slow protons in the counter must be small compared to the energy resolution required. For this reason the anthracene crystals were mounted inside the proportional counter by cementing each to the face of a 5819 photo-multiplier tube and inserting the end of the photo-multiplier into the counter through an "O ring" seal. A 1/40 mil aluminum reflector was placed over the face of each crystal.

The efficiency of the counter is determined by three factors: the neutron - proton cross section, the recoil proton range, and the solid angle of recoil protons received by the second crystal. The range of the recoil proton determines the thickness of the first crystal useful as a proton source. The efficiency is approximately proportional to the energy. With the geometry used in these tests, one inch diameter crystals spaced three inches apart, the approximate efficiency is 2×10^{-4} at 20 Mev and 2×10^{-5}

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at 2 Mev. The geometrical energy spread resulting from this arrangement is 4-1/2% effective width. (See the insert on Fig. 2).

The device has been tested by examining the ground state neutron group from the $\text{Li}^7(p,n)\text{Be}^7$ reaction. Fig. 2 shows a histogram of counting rate versus pulse height with and without the use of the proportional counter. The non-linearity of anthracene makes the half width on an energy scale less than that on a pulse height scale. The target thickness and geometry give an energy half width of approximately 7%. A small contribution may come from transitions to the 430 Kev level in Be^7 . Therefore, the principal spread in the peak must be due to the photo-multiplier resolution. This is not unreasonable with the unselected photo-multipliers and the simple crystal mounting used.

1. W. Franzen, R. W. Peelle and R. Sherr, Phys. Rev. 72, 742 (1950).

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Figure Captions

- Fig. 1. Scintillation counter arrangement and associated circuits. Anthracene crystal No. 1 serves as a source of recoil protons. Crystal No. 2 defines the angle of recoil.
- Fig. 2. Pulse height spectrum from $\text{Li}^7(p,n)\text{Be}^7$ neutrons at 45° to the direction of the incident 18.2 Mev proton beam. The shaded histogram was obtained with the use of the proportional counter to reject counts due to recoil electrons. The part from 10 to 30 volts was taken with 10 volt channels, and that from 30 volts up with 5 volt channels. The dashed histogram was obtained without the use of the proportional counter and was taken with 10 volt channels.

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TOTAL COUNTS PER CHANNEL