sections decrease much more rapidly for large angles than for small angles with an increase of E_p.

Note added in proof.—Coulomb effect of the incident proton wave was taken into account in the computations for $E_p = 6$ Mev and case (b) i.e., no proton nuclear scattering. The angular distribution is considerably flattened, its deep minimum being shifted towards larger angles. The corresponding maximum of negative polarization is also shifted in this direction P (in %) in $Si^{29}(p,n)P^{29}$ is given in Table II.

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Neutrons from the Proton Bombardment of P^{31}†

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The reaction $P^{31}(p,n)S^{31}$ has been studied at $E_p = 17.2$ Mev. The energy spectrum of the neutrons was determined by means of proton recoil measurements in nuclear emulsions. The mass excess, $M-A$, of S^{31} was calculated to be -10.04 ± 0.20 Mev. Excited states of S^{31} have been located at 1.15 ± 0.15, 2.28 ± 0.20, 3.35 ± 0.20, 4.51 ± 0.15, 5.94 ± 0.30, and 6.41 ± 0.20 Mev.

THE level structure of the $A = 31$ isobars is poorly known. In P^{31}, the excited states at 1.26- and 2.23-Mev excitation are well verified,[1–3] and levels have also been reported at 0.4, 0.9 and 3.4 Mev.[4] In the mirror nucleus, S^{31}, the mass of the ground state is known to within 200 kev from β-decay work,[4] but no excited states had been observed. The reason for this lack of information about S^{31} is that all reactions leading to it are either neutron-emitting reactions or very endoergic, or both, with the exception of the reaction $S^{32}(He^3,\alpha)S^{31}$, which has never been studied. It was decided to investigate S^{31} by means of the reaction $P^{31}(p,n)S^{31}$. The difficulty in accurately measuring neutron energies coupled with the beam spread of cyclotron protons, necessary because of the endoergic character of the $P^{31}(p,n)S^{31}$ reaction, precluded the possibility of obtaining very accurate information on the states of S^{31}. However, because of the difficulty in reaching this nucleus, it was felt than any information on S^{31} would be of value.

A target of P^{31} was prepared by dissolving red phosphorus in absolute ethyl alcohol, and painting it onto a thin polystyrene film. The thickness of the target corresponded to an energy loss of 100 kev for 17.5-Mev protons. Unfortunately, the target was reversed prior to the exposure, so that the proton

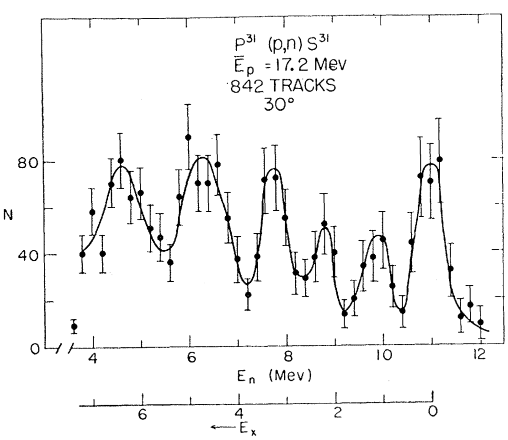

FIG. 1. Data at 30°. N is the corrected number of neutrons per 200-kev interval; E_n is the neutron energy; E_x is the excitation energy in S^{31}.

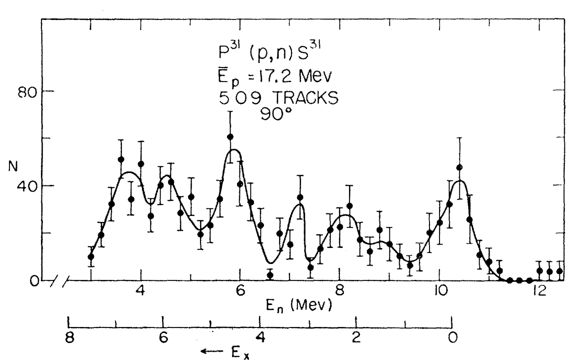

FIG. 2. The 90° data. (See caption of Fig. 1.)

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TABLE I. States of S^{31}. The energies are given in Mev. The weighting factor at each angle is indicated in parentheses after the Q value at that angle.

30°	60°	Q values at 90°	120°	150°	Weighted Q	E_x in S^{31}
−6.06(2)		−6.07(1)			−6.06±0.20	0
−7.26(3)				−7.06(1)	−7.21±0.20	1.15±0.15
−8.31(3)	−8.25(1)	−8.35(1)	−8.52(2)	−8.14(1)	−8.34±0.20	2.28±0.20
−9.25(3)		−9.36(2)	−9.60(3)		−9.41±0.20	3.35±0.20
−10.65(1)	−10.60(2)	−10.57(3)	−10.49(2)		−10.57±0.20	4.51±0.15
		−12.00			−12.00±0.30	5.94±0.30
−12.37(2)	−12.43(2)	−12.74(1)			−12.47±0.20	6.41±0.20

beam hit the polystyrene backing first. This degraded the energy of the incoming beam from 17.5±0.15 Mev to an average energy, $\bar{E}_p$, of 17.2 Mev in the target. The exposure was of 400 microcoulombs. Neutrons were detected by means of recoil protons in Ilford C-2 emulsions, 400 microns thick, placed at 5 angles to the incoming beam, at 30° intervals. The experimental arrangement has been described previously,[5] as have the development procedure, scanning method, and data analysis.[6] It was found after preliminary scanning that the low-energy neutrons formed a continuous spectrum, showing that the higher excited states of S^{31} were not resolved. Therefore only long tracks were measured, corresponding to neutron energies greater than ~3.5 Mev and to excitation energies, E_x, less than ~7 Mev. A total of 3372 tracks were scanned at the five angles.

Figures 1 and 2 show the data at 30° and 90°. The plates at 60°, 120°, and 150° were also scanned, but at these angles only a few of the levels were resolved.[7] For this reason, we could not obtain meaningful angular distributions of the neutron groups. Table I gives a summary of the Q values obtained and of the excitation energies in S^{31}. The ground-state Q value derived from results at 30° and 90° is −6.06±0.20 Mev, corresponding to an atomic mass excess, $M-A$, of −10.04±0.20 Mev and to a mass of 30.98922±0.00022 amu for S^{31}.

We may not have resolved all of the levels in S^{31} with $E_x \lesssim 7$ Mev because of the large widths of the neutron groups. There is no way of checking this because the corresponding region in P^{31} is poorly known. In addition to the levels listed in Table I, there is some evidence for another state at about 3.6-Mev excitation ($Q \sim -9.6$ Mev), but the evidence is not conclusive. The neutron group corresponding to the 4.51-Mev state has a width which is too large for a group corresponding to a single level: the data at 30° suggest unresolved levels at 4.4 and 5.0 Mev but here again the evidence is too poor to draw a firm conclusion. There is some possibility of neutrons from N^{14} and Na^{23} contamination of the target. It is not possible to check this because of the large neutron group width which obscures variations with angle. The target, however, is believed to have been sufficiently pure so that these possibilities are quite unlikely.

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