LETTERS TO THE EDITOR

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Communications should not in general exceed 600 words in length.

Some New Reactions in Light Nuclei with High Energy Protons

Reaction processes in the simplest nuclear systems have the most hope of being understood in the light of theory, but as yet, even in this restricted part of the field of nuclear physics, not by any means all reactions possible with energies and sources now available have been observed, much less studied. In this note are reported some recent investigations in this region.

1. It was noticed that many materials when bombarded by high energy protons from the Princeton cyclotron gave a 21-minute period, apparently from a common contaminant. The following observations indicate that the reaction in question is N^{14} (H^1, He^4) C^{11}: (*a*) Recoil nuclei collected in nitrogen on platinum or lead gave the characteristic period. (*b*) Positrons are emitted. (*c*) The period coincides with that of C^{11} as determined by other observers. (*d*) The activity behaves chemically like carbon. Recoils were collected on paper and the paper burned in an atmosphere of O_2. When the products of combustion were bubbled through a solution of $Ca(OH)_2$, the activity appeared in the precipitate, which presumably was $CaCO_3$.

The excitation function, Fig. 1, was determined from the initial intensity of the 21-minute period observed on a series of equally spaced aluminum foils traversed by the beam in air. (After bombardment for 18 minutes in air with 5.7-Mev protons, the activity on a foil is due to F^{18} only to the extent of 1.4 percent. Aluminum itself is inactive with this proton energy.) The unavoidable range distribution in the proton beam has, of course, some effect on the shape of the excitation curve. In the figure, therefore, the limits determined by an analysis of the beam are indicated.

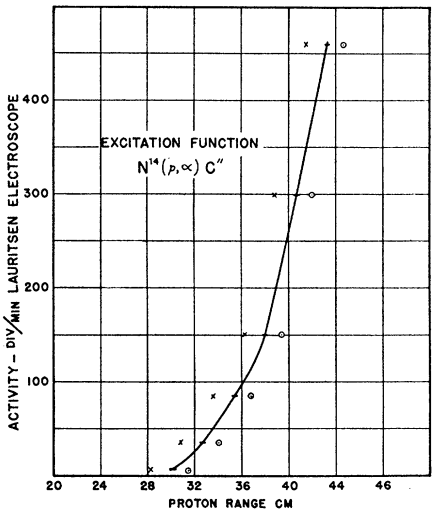

FIG. 1. Activity of C^{11} recoils *versus* proton range. Circles—maximum range of proton beam. Crosses—mean range of beam. Curve drawn through points corresponding to extrapolated range. Correction made for straggling. No correction applied for recoil of compound nucleus.

2. When boron was bombarded with 5.9-Mev protons, a very intense C^{11} activity was observed. The reaction B^{10} (p, γ) C^{11} is well known, but the C^{11} activity was so great that it is difficult to account for it by the (p, γ) reaction alone. The thick-target excitation function for such a resonance process rises only moderately with energy. It seemed plausible therefore to ascribe a large part of the activity to B^{11} (p, n) C^{11}. To test this hypothesis an observation on the neutrons released by this reaction was made. With a clean lead target for a "control" experiment the average initial activity observed in a silver detector after the neutrons were slowed down in paraffin was 29.9 $\pm$0.5 divisions per minute per microampere. Under similar conditions with a target of amorphous boron mechanically pressed into lead, the detector activity observed was 45.2 $\pm$0.8 divisions per minute per microampere. Neutrons might also be produced in the reaction B^{10} (p, n) C^{10}. Nothing is known about C^{10}, however. No strong period corresponding to this isotope of over a few seconds' half-life was observed; a weak period could have been obscured by the C^{11} activity. Since the threshold for the B^{11} (p, n) C^{11} reaction is about 3.5 Mev, whereas the B^{10} (p, n) C^{10} reaction has an expected threshold[1] at about 5 Mev, and considering the relative abundances of the boron isotope, it seems safe to conclude that most of the neutrons observed come from B^{11}.

3. A strong 2.5-minute activity has been produced in silicon by bombardment with 5.8-Mev protons, and is assigned to the reaction Si^{30} (p, n) P^{30}. It is of some interest to remark that no evidence for the reaction Si^{29} (p, α) Al^{26} was obtained, although the proton energy was far above the anticipated threshold.

The writer wishes to express his appreciation for the hospitality of the Palmer Physical Laboratory, and to record his indebtedness to members of the cyclotron group for their cooperation, without which this work could not have been done.

WALTER H. BARKAS*

Palmer Physical Laboratory,
Princeton, New Jersey,
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* Member, The Institute for Advanced Study, Princeton, New Jersey.

[1] H. A. Bethe, Phys. Rev. **55**, 439 (1939).