Letters to the Editor

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The Yield of Neutrons from Deuterons on Carbon

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THE efficiency of the reaction

$$D^2+C^{12}\rightarrow(N^{14})^*\rightarrow N^{13}+n^1$$

as a function of the energy of the deuterons has been investigated by Bonner, Hudspeth, and Bennett[1] in the voltage range from 0.60 to 1.95 Mev. They found that the excitation curve exhibited broad resonances at 0.92, 1.16, 1.30, and 1.82 Mev superimposed on a slowly rising background.

Figure 1 shows the results of a study of this reaction in

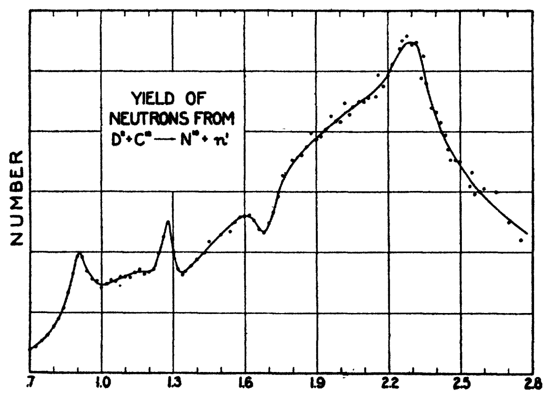

FIG. 1. Deuteron energy in Mev.

the energy range from 0.70 to 2.75 Mev. The energy of the deuterons, accelerated by our pressure electrostatic generator,[2] was controlled to within one percent. Magnetic resolution of the ion beam through small diaphragms, combined with paraffin and cadmium shielding, served to localize the source of neutrons entering a BF_3 chamber. Thin soot targets on heated tantalum backings and bare tantalum backings could be rotated into the ion beam in order to obtain the net yield from carbon.

It is evident that resonances exist in this reaction and that the two most prominent resonances found by Bonner, Hudspeth, and Bennett are in essential agreement with our values of 0.91 and 1.28 Mev. Furthermore, the half-widths of these peaks are of the same order of magnitude, 60 and 50 kev, respectively. The less prominent resonance at 1.16 Mev and the broad resonance at 1.82 Mev found by the Rice Institute group are not resolved in our experiments. On the other hand, the resonance at 1.6 Mev shown in Fig. 1 does not appear in the previous work. If one accounts for the form of the background in the manner suggested below one must conclude that a prominent resonance exists at 2.3 Mev. Only qualitative arguments can be made for the shape of the theoretical excitation function for a nucleus as light as C^{12}, but we should expect the resonances to be superposed on a smooth background representing the increasing penetration factor for incident deuterons. The total yield from all competing processes should thus rise with bombarding energy throughout the range of energies studied here. The observed resonances could all belong to the "first excited configuration" of N^{14}, and be reasonably sharp because of the dearth of levels lying lower.

In view of these considerations a noteworthy feature of the excitation curve for neutron emission is the sharp decrease beyond the 2.3-Mev resonance.

The yield of protons from the reaction

$$D^2+C^{12}\rightarrow(N^{14})^*\rightarrow C^{13}+p^1+Q$$

is at least as great as that for the neutrons reported above for the first two resonances of the excitation curve.[3] Proton emission is not a less probable process, even for low energies because $Q=+2.7$ Mev for this reaction, and hence there is very little barrier effect on the escape of protons from $(N^{14})^*$. It is reasonable that proton emission should gain slowly over neutron emission at high energies, but not sufficiently to account for a decrease in the neutron curve of the observed magnitude. Another competing process, ${}_1D^2+{}_6C^{12}\rightarrow{}_5B^{10}+{}_2He^4$, endothermic by about 1.2 Mev by calculation from the masses and hence energetically possible at these energies, may interfere to cause the large reduction in neutrons. The behavior of the curve is in qualitative agreement with the work of Newson[4] who also attributed the phenomenon to α-particle emission. Unfortunately these α-particles will be too short to be detected experimentally.

[1] Bonner, Hudspeth, and Bennett, Phys. Rev. **58**, 185 (1940).
[2] Williams, Rumbaugh, and Tate, Rev. Sci. Inst. **13**, 202 (1942).
[3] Bennett, Bonner, Hudspeth, Richards, and Watt, Phys. Rev. **59**, 781 (1941).
[4] H. W. Newson, Phys. Rev. **51**, 620 (1937).

Induced Color in Crystals by Deuteron Bombardment

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NUMEROUS investigations[1] have been made on the color changes produced in crystals by cathode rays, ultraviolet, x-rays, and the radiations from radium. On bombarding crystals in the cyclotron with deuterons of 10 Mev, color changes are similarly induced. In many crystals the effects are the same as found by the other ionizing radiations, but in some cases they behave differently.

In certain crystals only the bombarded surface actually