Disintegration of nitrogen by fast neutrons

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I. Introduction.

Nuclear energy levels can be studied by measuring the yield of nuclear reactions as a function of the energy of the incident particle. At certain energies maxima may appear. These so-called resonances occur when the incident particle has an energy which, after the particle has been captured by the initial nucleus, leads to a stationary state of the compound nucleus, thus formed. For these experiments particles of homogeneous and variable energy must be available. In the case of charged particles, this offers no difficulty, as they are produced by various types of accelerators. Monochromatic neutrons can only be obtained by a few reactions, the most important of which are

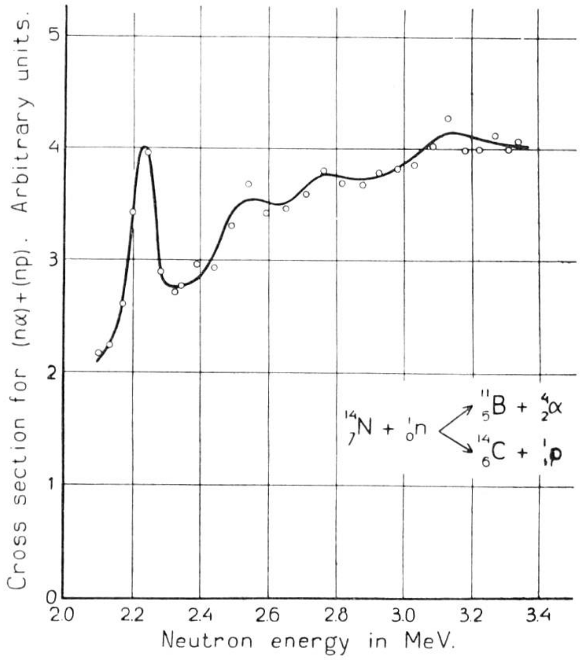
$$^{7}_{3}\mathrm{Li} + ^{1}_{1}\mathrm{p} \rightarrow ^{7}_{4}\mathrm{Be} + ^{1}_{0}\mathrm{n}$$
$$^{2}_{1}\mathrm{D} + ^{2}_{1}\mathrm{D} \rightarrow ^{3}_{2}\mathrm{He} + ^{1}_{0}\mathrm{n}$$

Barschall and Battat[1]) studied the $(n\alpha)$ and (np) reactions in nitrogen, using the first process as a neutron source. The neutron energy was varied between 0.2 and 1.7 MeV, by varying the accelerating potential of the protons above the threshold value of 1.8 MeV. We studied the same reactions, using the D + D neutrons[6]). They can be produced by deuterons of low energy. In this case the large variation of the neutron energy with the angle between the neutron path and the beam of deuterons can be used. With a deuteron energy of 475 keV, neutrons with energies between 2.1 and 3.4 MeV were obtained when the angle is varied between 30° and 132°. This follows from the laws of conservation of energy and momentum, and the value $Q = 3.31$ MeV for the D + D reaction.

Wilhelmy[2]), who first studied resonance effects with fast neutrons, followed a different method. He used a neutron source giving neutrons of continuous energy distribution. The total kinetic energy of the reaction products (α-particle resp. proton plus recoil nucleus) is measured in an ionisation chamber, and the distribution of the pulse heights is determined. In this distribution certain maxima appear. They represent reaction-products which are caused by neutrons with resonance energy. These energies can be calculated with the help of the value of the reaction energy. The most recent measurements of this type with nitrogen were carried out by STEBLER and HUBER[3]).

II. Method.

Deuterons were accelerated to a mean energy of 475 keV, and after magnetical separation from other ions, fell on the heavy ice target. The thin D_2O target was made by depositing a volume of



30 cm³ saturated D_2O vapour upon a copper surface, cooled by liquid oxygen. The target thickness was about 45 keV. It was measured by comparing the neutron yield with the thick target yield.

A proportional counter served as a detector for the reactions

$$^{14}_{7}N + ^{1}_{0}n \rightarrow ^{11}_{5}B + ^{4}_{2}\alpha$$
and
$$^{14}_{7}N + ^{1}_{0}n \rightarrow ^{14}_{6}C + ^{1}_{1}p$$

The counter is filled with 2 at. of nitrogen.

The diameter of the wire is 0.05 mm, of the cylinder 6 cm. The operating voltage is about 5000 V. The counter was exposed to neutrons of various energies by placing it in various positions with respect to the target. The intensity of the neutron source is, of course, not constant. Therefore the number of neutrons emitted during the time of measurement, is determined by a BF_3 proportional counter, which is kept in a fixed position. The number of neutrons getting into the nitrogen counter is then calculated with the aid of the function $1 + A \cos^2 \vartheta$ which gives the angular dependence of the neutron intensity in the centre of gravity co-ordinate system. In our case $A = 1.7$.

III. Result.

The combined cross section for the $(n\alpha)$ and (np) reactions is obtained as a function of neutron energy in the interval between 2.1 and 3.4 MeV. A sharp maximum appears at 2.23 MeV, which indicates a resonance level in the intermediate $^{15}_{7}N$ nucleus. The width may be estimated to be 50—100 keV. In the higher energy region no large variation in cross section is observed. STEBLER and HUBER[3]) from their measurements also concluded, that at 2.20 MeV neutron energy a resonance occurs. The results of WILHELMY suggested the presence of more pronounced peaks. It is, however, possible that the groups found by WILHELMY and others[4])[5]) are caused by neutrons of much higher energy, and therefore cannot be found in our experiment.

Bibliography.

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A later measurement is presented here.