Structure of the Spectrum of Protons from the $Te^{122}(n,p)Sb^{122}$ Reaction at 14.1 MeV

JAN TURKIEWICZ
Institute of Nuclear Research, Polish Academy of Sciences, Warsaw, Poland

(Received January 10, 1962)

The energy and angular distributions of protons from the $Te^{122}(n,p)Sb^{122}$ reaction at 14.1 MeV were studied. The results seem to indicate that the contribution of the direct-interaction mechanism is large and that mainly single-particle levels are excited.

THE study of the energy and angular distributions of protons from (n,p) reactions can throw some light on the mechanism involved in these interactions. We used the method of nuclear emulsions to investigate these distributions for the (n,p) reaction on Te^{122} at 14.1 MeV.

The geometry of measurement was similar to that used by Allan.[1] An Ilford C2 300-μ plate was placed at the axis of the cylinder, the interior surface of which had been covered with tellurium enriched to 80.4% tellurium-122. The mean thickness of the tellurium layer was about 10 mg/cm². Neutrons from the $T(d,n)He$ source had an energy of 14.1 MeV in the c.m. system.

The emulsion was processed by the temperature-cycle method and then the measurements were accomplished by a Leitz Ortholux microscope using an oil immersion objective (100×) and eyepieces (10×). Only tracks beginning at the surface of the emulsion were taken into account. The length and direction in space for such tracks were measured. The background was kept low by ensuring that only tracks of particles which could have come from the tellurium target were accepted for analysis. The results of energy measurements for $\theta < 60°$ are shown in Fig. 1, where the differential cross section $\sigma(E)$ taken in arbitrary units is plotted against the excitation energy of the residual nucleus. These results seem to indicate that a direct-interaction mechanism is involved and that single-particle levels are strongly excited.

A computation of the single neutron level density in a deformed potential based on Nilsson's work[2] is presented in Fig. 2 in diagrammatic form. The origin of the energy scale is set at the $1h_{11/2}$ level, i.e., the fundamental state of Sb^{122}. The value $\delta = 0.1$ is taken for the deformation parameter in accordance with the measured quadrupole moment of Sb^{122}.[3]

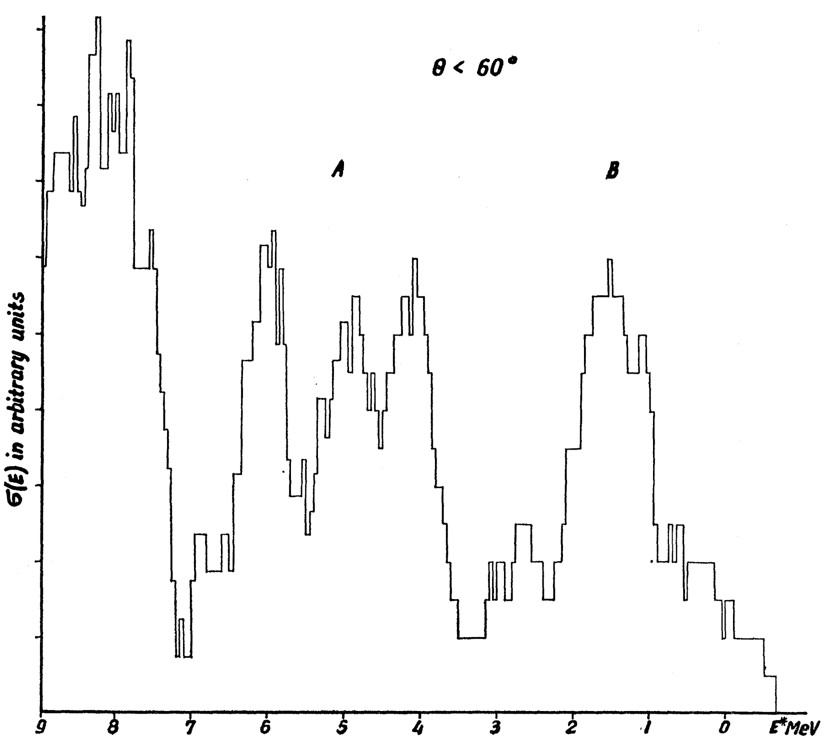

FIG. 1. Energy distribution of the protons. Background has been subtracted. The abscissa scale is the excitation energy of the residual nucleus Sb^{122} in MeV.

¹ D. L. Allan, Nuclear Phys. **6**, 464 (1958).
² S. G. Nilsson, Kgl. Danske Videnskab. Selskab, Mat.-fys. Medd. **29**, No. 16 (1955).
³ F. Pipkin, Phys. Rev. **112**, 935 (1958).

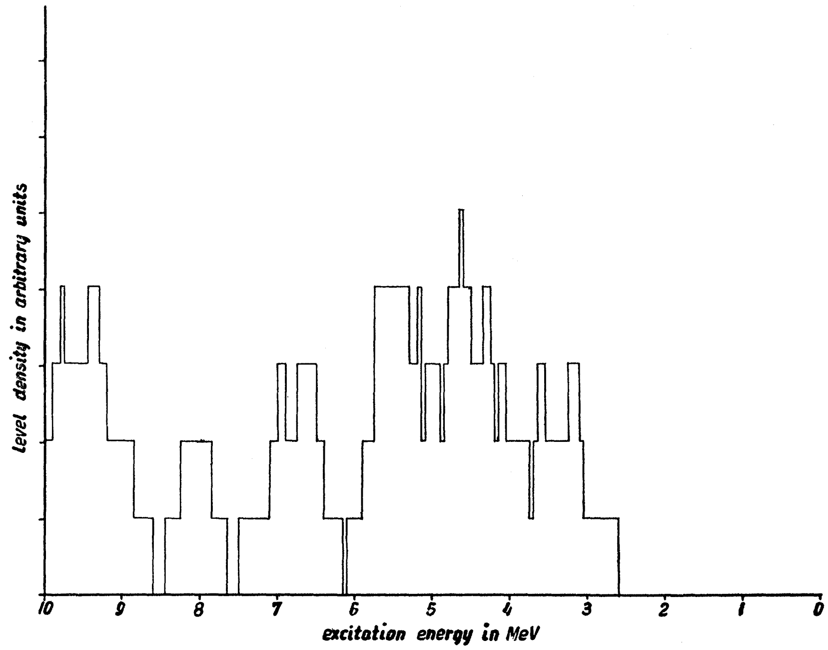

FIG. 2. Single neutron level density vs the excitation energy of the residual nucleus Sb^{122}. The calculations are based on Nilsson's paper.[2] The origin of the energy scale is set at the $1h_{11/2}$ level.

As can be seen, the position of the gross structure maximum A in Fig. 1 agrees with that of the maximum in level density in Fig. 2 if the energy scale is shifted about +0.6 MeV in relation to Nilsson's scale. Because the Nilsson scheme gives the location of levels only semiquantitatively, the agreement is surprisingly good. This agreement, together with the forward peaking of protons, shows that in the investigated reaction the contribution of the direct-interaction mechanism is large and that mainly single-particle levels of the captured neutron are excited. It is worth noting that similar results have been obtained by Peck[4] for the (n,p) reaction on some elements near $Z=50$ but the unresolved competition of deuterons from the (n,d) reaction made his interpretation less evident.

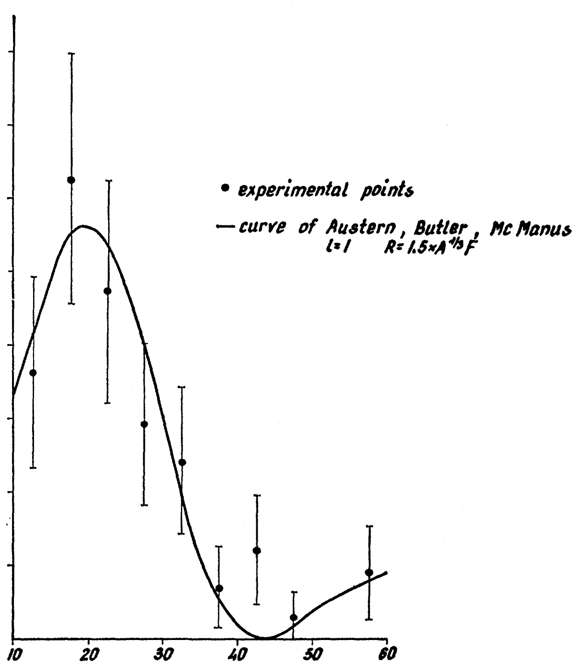

FIG. 3. Angular distribution of protons belonging to the maximum B. The curve represents calculations based on the theory of Austern, Butler, and McManus.[5]

The results of angular distribution measurement for protons belonging to the maximum B is shown in Fig. 3. The curve represents the angular distribution given by the theory of Austern, Butler, and McManus[5] for direct processes. The best fit was obtained for $l=1$ and $R=1.5A^{\frac{1}{3}}$ F. The shape of this angular distribution suggests that the protons from the maximum B are due to direct interaction. The maximum B may correspond to a single-particle excitation of the 51st proton in Sb^{122}. For Sb^{122}, having one proton behind the closed shell, that excitation seems to be probable. The strength of the maximum B favors this interpretation.

The other possible explanations of the existence of the maximum B seem to be rather less probable.

The author wishes to thank Dr. Z. Wilhelmi for stimulating discussions, support, and encouragement.

[4] R. A. Peck, Phys. Rev. **123**, 1738 (1961).
[5] N. Austern, S. T. Butler, and H. McManus, Phys. Rev. **92**, 350 (1953).