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^{181}Ta (^{14}N ; ^{17}N); ^{197}Au(^{14}N, ^{17}N)

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$^{181}Ta(^{14}N;\ ^{17}N);\ ^{197}Au(^{14}N,\ ^{17}N)$

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In refs.[1,2] the excitation functions of the two- and three-neutron transfer reactions for several elements were measured by means of detecting ^{17}N delayed neutrons[3].

In the present paper the angular distributions of ^{17}N from the bombardment of Ta and Au with ^{14}N ions are studied to obtain an additional information on the mechanism of the three-neutron transfer reactions. The experiments were performed with the external beam of the 150 cm Heavy Ion Cyclotron of the Laboratory of Nuclear Reactions (JINR, Dubna).

The ion beam passed along the axis of the cylindrical reaction chamber. The reaction products - ^{17}N nuclei were outgoing from the chamber through annular windows covered with a thin mylar foil. The windows were provided in the side surface of the chamber for performing measurements in the forward and backward hemispheres over the angular ranges of $14^{\circ}-80^{\circ}$ and $100^{\circ}-166^{\circ}$, respectively. The third window was provided in the end surface of the chamber for performing measurements at small angles from 4° to 24°. The emission angle of the reaction products was varied by moving the target along the chamber axis. During the bombardment, ^{17}N nuclei were gathered on the catcher and were periodically transported to the neutron detector.

The neutron detector consisted of a system of 24 proportional counters and a paraffin moderator. The counters were filled with enriched BF_3 (87% ^{10}B). The detector efficiency equal to 7% was determined by a calibrated photo-neutron source (^{24}Na + ^{9}Be) whose neutron energy spectrum is close to the delayed neutron spectrum of ^{17}N nuclei. The measurements were performed in pulsed conditions: the duration of each bombardment and each measurement periods was equal to 30 sec. Several runs of bombardment were performed at each value of the angle. As the background was measured, the catcher of ^{17}N remained fixed.

The ^{14}N ion energy measured by a semi-conductor detector equaled to 105 MeV and was varied by aluminium absorbers positioned in front of the bending magnet. A more detailed description of the arrangement will be given in a separate paper.

In all the measurements the half-life of neutron activity was equal to that of ^{17}N (4.15 sec). The background at the angles corresponding to the maximum yield was 5 per cent of the effect observed and was slightly sensitive to the angle.

The data on the angular distributions of ^{17}N nuclei from the bombardment of Ta and Au with ^{14}N ions are given in Figs. a,b. At larger angles (100^{o}-166^{o}) the measured effect coincided with the background within statistical error. The data in the laboratory system were converted into the c.m. system using the tables/4/ under the assumption that the transfer occurs without excitation of the final nuclei. The excitation of about 10 MeV leads only to an insignificant displacement (about 0.5^{o}) of the angular distribution maxima in the direction of large angles. The statistical error of the measurements was 0.2-2.0%. The angular resolution of the arrangement varied with angle and equaled to 0.5^{o} at 15^{o} and to 9^{o} at 80^{o}. The effect of the target thickness (6.8 mg/cm^2 for Ta and 5.4 g/cm^2 for Au) on the angular distribution was neglected. The ^{14}N ion energy spread measured by a semi-conductor detector did not exceed 1 MeV.

The data obtained indicate that the angular distribution shows distinct maxima which are characteristic of transfer reactions. The maxima are close to the Rutherford scattering angle corresponding to the ion tangential trajectory. This picture indicates that the three-neutron transfer is a direct reaction occurring in a narrow area of the nuclear surface. Hence, the decrease in the ^{14}N ion energy leads to the displacement of the maximum in the direction of large angles and to the reduction of the cross section.

The comparison of the angular distributions of the three-neutron transfer with that of the single-neutron transfer/5/ at the same incident energies per nucleon shows that the position of the maximum is slightly sensitive to the number of the nucleons transferred (the displacement in the direction of smaller angles does not exceed 1^{o}-2^{o}). However, the half-width of the angular distribution curve increases significantly (30^{o} instead of 20^{o}). This increase in the half-width is probably due to decrease in the effective width of the reaction layer around the target nucleus. As a result of this, the number of the partial waves mainly contributing to the three-neutron transfer decreases. It is noteworthy that the cross section for the three-neutron transfer reduces only by an order of magnitude as compared with that for the single-neutron transfer. By comparing the reaction geometrical area with the reaction cross section, one can determine the probability of the single-neutron transfer as approximately 1%/5/. When three neutrons are transferred independently, one could expect that the cross section for the three-neutron transfer will decrease more strongly as compared with that for the single-neutron transfer.

The authors continue to study the two- and three-neutron transfer reactions. The results of this work will be published later in a separate paper.

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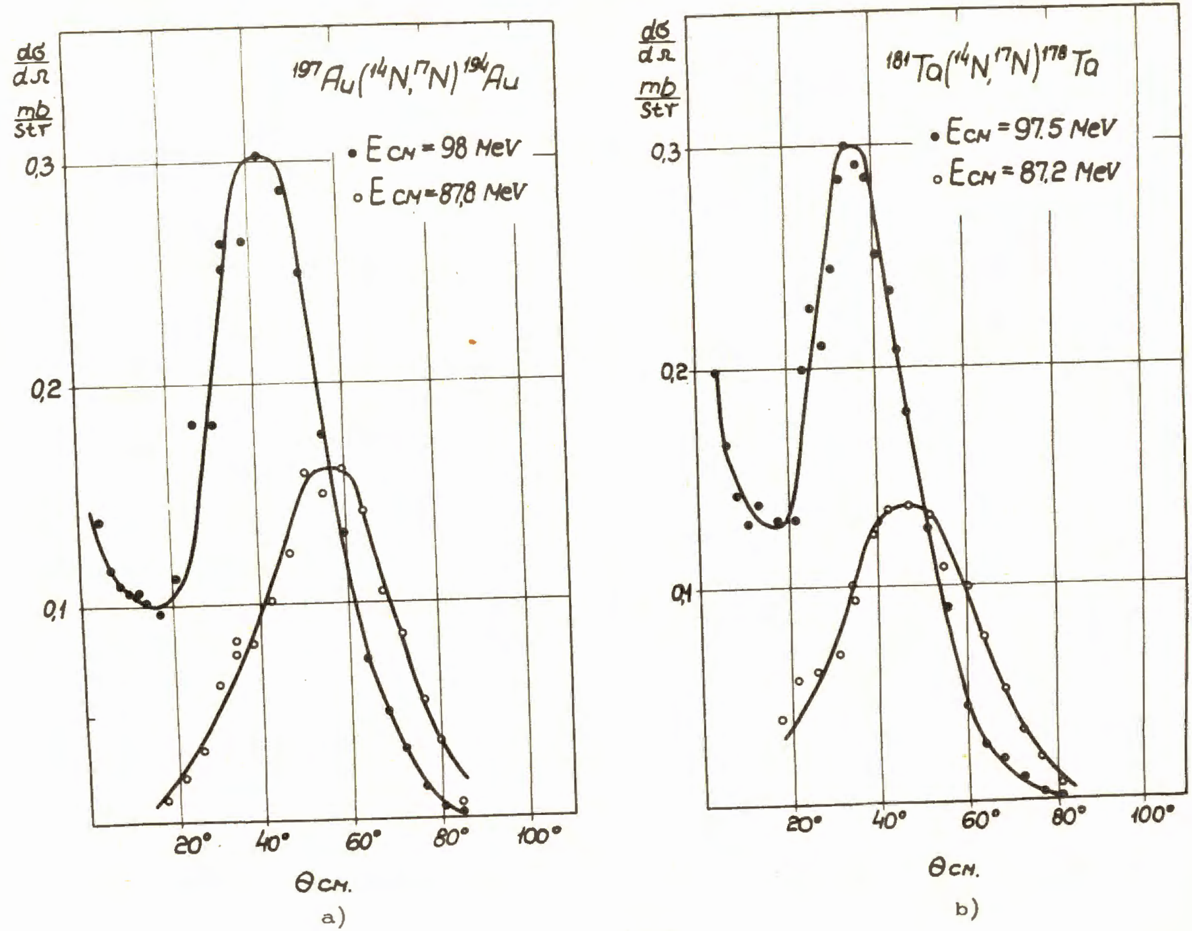

dσ/dΩ mb/Str
$^{197}Au(^{14}N,^{17}N)^{194}Au$
• E CM = 98 MeV
○ E CM = 87,8 MeV
0,3
0,2
0,1
20°
40°
60°
80°
100°
θ CM.
a)
dσ/dΩ mb/Str
$^{181}Ta(^{14}N,^{17}N)^{178}Ta$
• E CM = 97.5 MeV
○ E CM = 87.2 MeV
0,3
0,2
0,1
20°
40°
60°
80°
100°
θ CM.
b)

F i g.