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Time-dependent analysis of neutron transfer reactions ^{181}Ta(^{18}O,^{19}O) at near-barrier energies

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In previous our work [1, 2], differential cross sections for the formation of oxygen isotopes in the reaction ^{18}O + ^{181}Ta have been measured at projectile nucleus energy 10A MeV on the high-resolution magnetic spectrometer MAVR. Theoretical analysis has been performed in the DWBA formalism using the FRESCO code under the assumption of sequential neutron transfer mechanism. Despite a fairly good agreement with the experimental data on the cross sections obtained within the DWBA method, it is necessary to study more carefully the dynamics of the neutron transfer processes during the reaction ^{18}O + ^{181}Ta at an energy of 10 MeV/nucleon ($E_{\text{c.m.}}$ = 163.72 MeV). Additionally, we have carried out a study of the particularities of neutron transfer processes at near-barrier energies (V_B = **68.94 MeV**).

The description of the reactions ^{181}Ta(^{18}O,^{19}O)^{180}Ta was investigated in the framework of the time-dependent Schrödinger equation (TDSE) for the external neutron of the ^{181}Ta nucleus. The TDSE describing the evolution of the wave function of an external neutron $\Psi(\vec{r},t)$ in the field of colliding nuclei $V_1\left(\left|\vec{r}-\vec{r}_1(t)\right|\right)$ and $V_2\left(\left|\vec{r}-\vec{r}_2(t)\right|\right)$ has the form [3-6]

$$i\hbar\frac{\partial\Psi}{\partial t}=-\frac{\hbar^2}{2m}\Delta\Psi+\left(V_1\left(\left|\vec{r}-\vec{r}_1(t)\right|\right)+V_2\left(\left|\vec{r}-\vec{r}_2(t)\right|\right)\right)\Psi$$

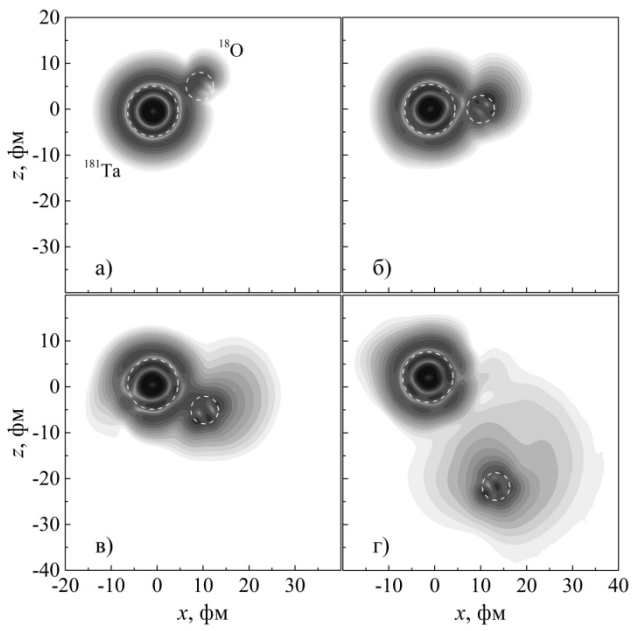

Figure 1. Evolution of the probability density of an external 3*p* neutron of the ^{181}Ta nucleus during the grazing collision of ^{18}O and ^{181}Ta at b = 8.6 fm (b corresponds to angel $\theta_{\text{lab}} = 12°$). **$E_{\text{c.m.}}$ = 163.72 MeV.**

It can be seen that the flux of the transfered probability density of a neutron from the ^{181}Ta nucleus to ^{18}O is slightly shifted relative to the internuclear axis, where the barrier between potential wells is higher than along the internuclear axis. Due to the high relative velocity of the nuclei, the neutron does not have time to transfer to free unoccupied levels of the bound state into the ^{18}O nucleus. Most of the transmitted probability density breaks away from the ^{18}O nucleus over time, passing into the states of a continuous energy spectrum.

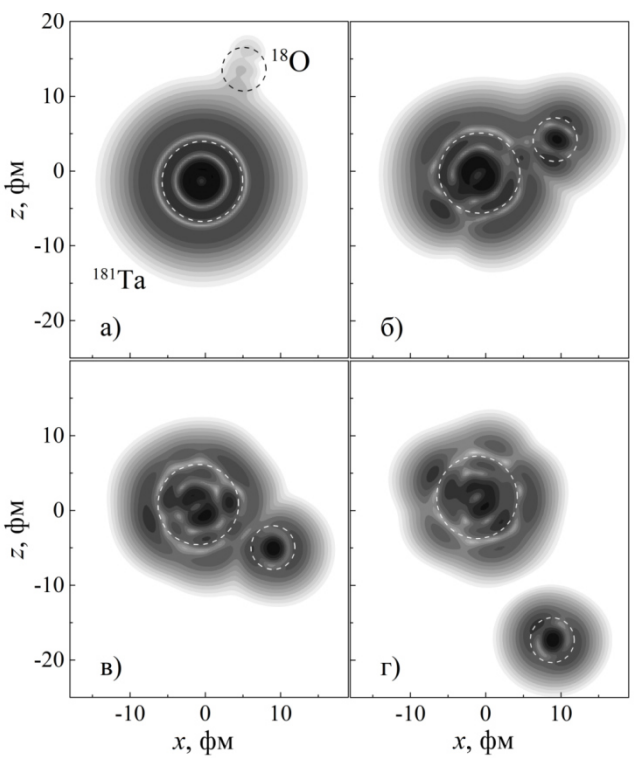

Figure 2. The probability density of an external 3*p* neutron of the ^{181}Ta nucleus during the grazing collision of ^{18}O and ^{181}Ta at b = 4.76 fm (b corresponds to angel $\theta_{\text{lab}} = 12°$). **$E_{\text{c.m.}}$ = 81.86 MeV.**

Neutron transfer occurs along the internuclear axis when the nuclei approach a distance of about 15 fm between the centers of the nuclei. Along the internuclear axis, the barrier between the two potential wells decreases more strongly.

Probabilities of occupation of levels into ^{19}O nucleus by the transferred neutron:

$$w_{1p}/p_{\text{tr}} \approx 0.01$$
$$w_{1d}/p_{\text{tr}} \approx 0.26$$
$$w_{2s}/p_{\text{tr}} \approx 0.74$$

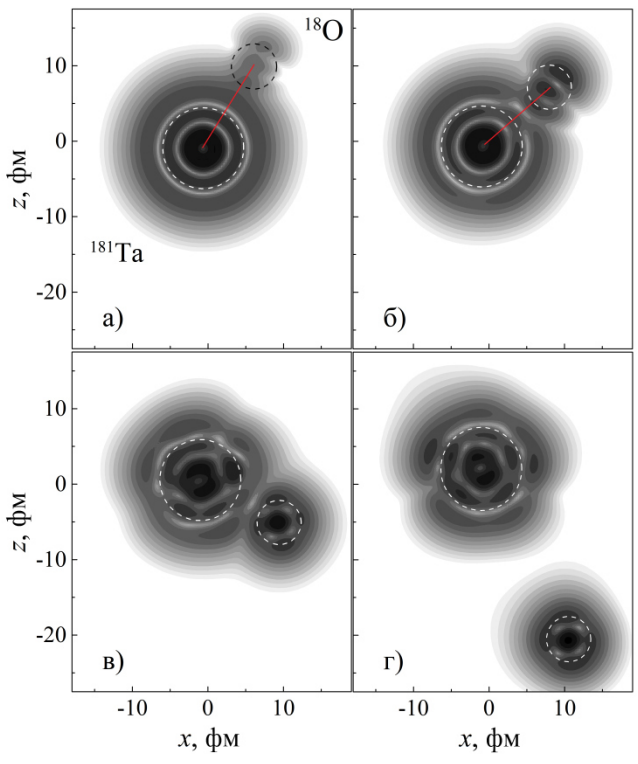

Figure 3. The probability density of an external 3*p* neutron of the ^{181}Ta nucleus during the grazing collision of ^{18}O and ^{181}Ta at b = 5.72 fm (b corresponds to angel $\theta_{\text{lab}} = 12°$). **$E_{\text{c.m.}}$ = 90.05 MeV.**

Probabilities of occupation of levels into ^{19}O nucleus by the transferred neutron:

$$w_{1p}/p_{\text{tr}} \approx 0.004$$
$$w_{1d}/p_{\text{tr}} \approx 0.22$$
$$w_{2s}/p_{\text{tr}} \approx 0.76$$

The calculated probabilities of occupation of levels into ^{18}O nucleus by the transferred neutron and the form of the transferred neutron probability density indicate that at near-barrier energies all transferred probability density corresponds to 1*d* and 2*s* states of neutron into ^{19}O nucleus.

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