ASSOCIATIONS IN THE NUCLEI PROCESSES WITH SPIN-ORBITAL INTERACTION

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In work [1] studied the scattering of protons by nuclei with knocking nucleon associations excluding the spin- orbit interaction. In this paper we take into account the impact of this interaction. Since we considered energy region lies below the threshold meson production, the impulse approximation is used.

Let proton momentum p_0 falls into the nucleus with mass number *A* and the reaction takes place *A* (*p, pX*)*A- X*, after that the proton momentum to become equal p_k. Association ejected from the nucleus acquires momentum p_X .

For the calculation of the matrix elements of the process should be to determine the wave function in the initial and final state. Wave function of the initial state we choose as

$$\Psi_i = e^{k_0 r_0} \Psi_A (J_i M_{J_i} T_i M_{T_i}) \quad , \tag{1}$$

where $k_0 = p_0 / \hbar$ -wave vector of the proton and Ψ_A is wave function of the nuclei *A*. The total wave function is the antisymmetrized product:

$$\Psi_A = \Psi_a \Psi_b \Psi(R_{ab}), \tag{2}$$

where Ψ_a and Ψ_b are inner antisymmetrized wave functions associations *a* and *b*. Wave function $\Psi(R_{ab})$ of relative motion of the clusters can be found by a variational principle and satisfies a Schrüdinger equation with a non-local Hamiltonian.

The wave function of the nucleus *A* is characterized by the total angular momentum and its projection J_i, M_i,, total isotopic spin *T* and its projection M_T. A similar set of quantum numbers (*j*, m_j) and (*t*, m_t) characterize clusters *a* and *b*. In this case, the wave function of the nucleus *A* has the form

$$\Psi_A = \psi(J_i M_{J_i} T_i M_{T_i}) = \sum_{sm_s l, m_l, j, m_j} i^i e^{i\delta_{lj}} R_{lj}\left(qR(a,b)\right) Y^*_{lm_l}(d\Omega) C^{sm_s}_{j_a m_a j_b m} G^{jm}_{lm_l sm_s}(d\Omega_{R_{ab}}) \tag{3}$$

where *q* is the momentum of the relative motion of associations, $Y^*_{lm_l}(d\Omega)$ - spherical function, $C^{sm_s}_{j_a m_a j_b m}$ odds on the Clebsch -Gordan coefficients, $G^{jm}_{lm_l sm_s}(d\Omega_{R_{ab}})$ spin - angular function.

For the final state wave function, we have

$$\Psi_f = e^{ik_k r_k} e^{ik_X r_X} e^{iqr_{A-X}} \varphi(J_X M_{J_X} T_X M_{T_X}) \phi(J_f M_{J_f} T_{T_X}) \tag{4}$$

Here $\varphi(J_X M_{J_X} T_X M_{T_X})$ the internal wave function of the association *X*, $\phi(J_f M_{J_f} T_{T_f})$ the wave function of the final nucleus *A-X*, r_X and r_{A-X} the coordinates of the centers of mass of these nucleus, *q* the momentum of the relative motion of association *X* and the final nucleus.

In the plane wave approximation the matrix element of the reaction has the form

$$F_{if} = \left(\Psi_f, T_{pX} \Psi_i\right), \tag{5}$$

$$T_{pX} = V_{pX} + V_{pX} \frac{1}{E_i - E_{\grave{e}\grave{e}i.} - U + i\eta} T_{pX}, \tag{6}$$

where V_{pX} the potential interaction of the proton with all nucleons association X; U potential, determines the interaction with other nucleons X nucleons; $E_i = p_i^2 / 2m_p - \varepsilon_{cв}$ ($\varepsilon_{cв}$ binding energy association in the initial nucleus A); T_{pX} the total kinetic energy of the proton and particles of the association.

Choose the potentials V_{pX} and U in the following form:

$$V = V_N + V_{ls}, \tag{7}$$

where V_N the nuclear potential as Woods - Saxon:

$$V_N = \frac{-V_0}{1 + \exp(r - R_0)/\alpha}; \tag{8}$$

V_{ls} the spin-orbit interaction:

$$V_{ls} = V_1 \frac{dV_N}{dr}(\bar{l}\bar{s}). \tag{9}$$

In the impulse approximation, the matrix element with the wave functions (1) and (4) has the form:

$$F_{if} = F^0 \begin{pmatrix} A \\ X \end{pmatrix}^{1/2} (2\pi\hbar)^{1/2} \left\langle A - X, J_f M_{J_F} T_{T_f}; X J_X M_X T_X \left| e^{iq(r_{A-X} - r_X)}; A J_i M_i T_i \right. \right\rangle \tag{10}$$

where F^0 the free - particle scattering amplitude p and X in the center of mass of the nucleus A

$$F^0 = \left\langle e^{iKr} \varphi_A \varphi_X \left| T_{pX} \right| e^{iK'r} \varphi'_A \varphi'_X \right\rangle. \tag{11}$$

Factor $\begin{pmatrix} A \\ X \end{pmatrix}$ takes into account the identity of nucleons, of which the association is formed [2].

The main feature of the integrals appearing in expressions (10) and (11) is that the interaction potentials and wave function of the relative movement and distorted waves also depend on the relative different combinations of variables. Furthermore, they are presented in nucleon variables. The problem of separation of variables is very important because of its solution depends on the possibility of analytical calculation of integrals over the angular variables, as well as for those variables that are not associated with the interaction of particles.

References

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