ASSOCIATIONS IN THE TWO-NUCLEON TRANSFER REACTIONS

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For explanation the mechanisms of processes with nucleon transfer is widely used association model [1]. According to this model, transmitted neutrons in (*t, p*) reactions, exist in the nucleus as association. Bineutron association in the triton is different from free nucleons, as they are surrounded by other nucleons. This field leads to a change in the association properties as compared with the free neutrons [2].

Consider the reaction process $t + A \to B + p$ in the laboratory system and assume that the momentum transfer to the nucleus B can be ignored.

Wave function of the initial state can be written as:

$$\Phi_i = \Psi_A(\xi)F_t(\vec{r}_t)f^S(\vec{r},\vec{\rho})\chi_{1/2,m_t}, \tag{1}$$

where $\Psi_A(\xi)$ - wave function of the nuclei *A*, $F_t(\vec{r}_t)$- distorted wave function of the triton, $\vec{r}_t$ radius vector of the center of mass of the triton, $f^s(\vec{r},\vec{\rho})$- wave function of internal motion of the triton, $r = |\vec{r}_{n_1} - \vec{r}_{n_2}|$, $\vec{\rho}$ - distance from the proton to the center of gravity of the bineutron association, S indicates the spin state of the captured neutrons - spin function of the triton. The possible angular momenta were limited by the symmetry.

Association model neglect the internal structure of the associations and effects of the Pauli principle between the nucleons in the associations are taken into account by introducing a short range repulsion between the clusters. The orthogonality condition model and excluded state model treat the associations as elementary particles, but include effects of the Pauli principle in a more microscopic way.

The final-state function describes as state of the nucleus B, which consists of a nucleus A, bineutron association and the free movement of the proton. It can be represented as:

$$\Phi_f = \Psi_B(\xi,\vec{R})f(\vec{r}_p)\chi_{1/2,m_p}, \tag{2}$$

where $f(\vec{r}_p)$ distortion function of the proton, $\vec{R}$ - the radius vector bineutron association, $\chi_{1/2,m_p}$ - spin function of the proton.

Matrix element of the transition from state *i* to state *f* can be written as follows:

$$M_{i\to f} = \int f_p^*(\vec{r}_p)\chi^*_{1/2,m_p}\Psi_B(\xi,\vec{R}) \;\; V \;\; \Psi_A(\xi)F_t(\vec{r}_t)f^s(\vec{r},\vec{\rho})\chi_{1/2,m_t}d\xi d\vec{\rho}d\vec{r}d\vec{R} \tag{3}$$

Expanding the plane waves $F(\vec{k}_t,\vec{R}_t)$ and $f(\vec{k}_p,\vec{r}_p)$ of spherical functions and taking into account the orthogonally of the spin functions, for the transition matrix element we obtain the expression:

$$M_{i\to f}^{S=0} = \delta_{m_t m_p}\sum_{l,L}4\pi\sqrt{(2l+1(2L+1))}i^{l+l}\int\Psi_B^{*S=0}(\xi,\vec{R})\Psi_A(\xi)W(\vec{r})j_l(k_p\vec{R}')j_L(k_t\vec{R})d\xi d\vec{r}d\vec{R}'d\vec{R}, \tag{4}$$

where $\vec{R}' = \dfrac{A}{A+2}\vec{R}$.

The overlap integral $\int\Psi_B^{*S=0}(\xi,\vec{R})\Psi_A(\xi)d\xi$ is a major factor of the matrix element. It takes into account the structure of nuclei in the initial and final states. If the energy E_1 and E_2 of the first

and second neutrons are close to each other, radial functions strongly overlap and then are captured by
"correlated" pairs of nucleons.

Problem in solving such problems is the separation of variables, because it affects 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.

When associations overlap, resonating group wave functions and shell model wave functions can be very similar after antisymmetrization. On the other hand, when associations are somewhat separated then resonating group wave functions can include correlations which are not naturally described by shell model wave functions. It has been suggested that bineutron association is acceptable if the time during which the association maintains its structure, is large compared with the time when neutrons are in a dissociated form, and there is no exchange of nucleons between fragments associations. The best wave function was found by minimizing the energy. A better wave function is obtained by projecting angular momentum and minimizing after projection. A still better approximation is to take a linear combination of these wave functions.

In the argument, that the radial wave function of two neutrons which form association captured nuclei close to each other, this leads to the formation of bineutron association on the nuclei surface. In this approach, the proton is emitted at the same point, which is captured bineutron association. This approach gives a good description of the scattering at high energies.

In the work we used the zero radius approximation. If there is needs for a finite radius of interaction for the calculation of exchange processes are more or less obvious, in order to calculate the direct processes in reactions with light associations seemingly can restrict zero interaction radius.

References

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