ROTATIONAL COUPLING EFFECTS ON THE NUCLEON MOLECULAR ORBITALS IN THE SCATTERING $^{17}O(^{16}O,^{16}O)\ ^{17}O^*(0.87MeV,1/2^+)$

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By using the two center shell model (TCSM), the level diagrams of the adiabatic potentials for the systems $^{12}C+^{17}O \leftrightarrow ^{13}C+^{24}Mg$ have been investigated by Park, Scheid and Greiner [1]. They have discussed the transition mechanism of these systems, especially the Landau-Zener transition mechanism. One of these crossings, the crossing between the adiabatic potentials related to the 2s1/2 and 1d5/2 states in ^{17}O nucleus is applied [2] to the anomarous phenomena observed in the excitation functions of the scatterings [3] which involve the excitation of ^{17}O mentioned above. In the studies, however, the radial coupling effects are discussed under the situation where the rotating couplings are neglected.

In this report we point out the essential importance of the rotational couplings in the inelastic scattering $^{17}O(^{16}O,^{16}O)^{17}O(0.87MeV,1/2^+)$, which is concerned with the same type of the transition mentioned above. We employ the rotating-molecular-orbitals (RMO) model [4] which includes the effects of the rotational couplings in the RMO's themselves. Thus, the RMO's depened on the total angular momentum J of the system and do not necessarity belong to pure K-quantum number - the Z-component of the J on the molecualr axis. Thus, we have only radial couplings for transition interactions.

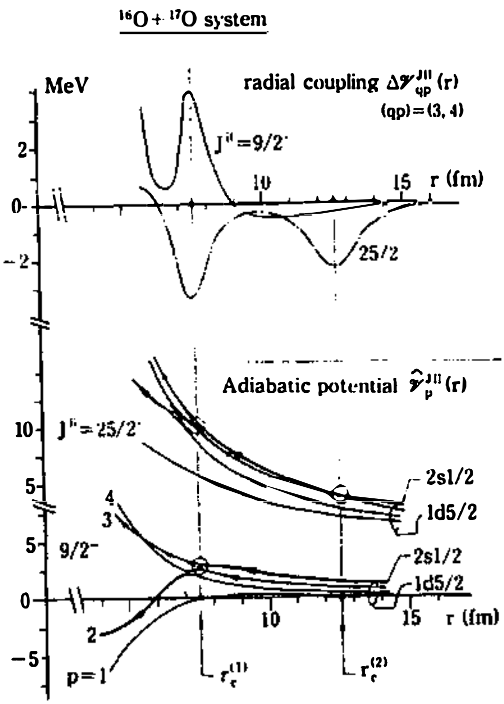

Fig. 1. The adiabatic potentials minus Coulomb+nuclear part for $J^\pi = 9/2^-$ and $25/2^-$, and the radial couplings between p = 3 and 4.

In the lower part of fig.1 we show the adiabatic potentials minus Coulomb plus nuclear part for $J^\pi = 9/2^-$ and $25/2^-$ for example, and in the upper part the radial couplings $\Delta\mathcal{V}^{(1)}_{qp}(r)$ for (q,p) = (3,4) which are directly responsible for the inelastic transition concerned here. We see that the pseudo-crossing appears between the adiabatic potentials for p = 3 and 4 at the distance r~7.5fm (= $r_c^{(1)}$) which corresponds to the crossing pointed out by Park, Scheid and Greiner [1], and Milok and Reif [5] in their "static" calculations. At higher angular momentum J, however, we have another crossing which is located at the distance $r_c^{(2)}$ larger than the grazing distance r_g and increases with the J (The $r_c^{(2)}$ is a crossing between the diagonal potentials of the 2s1/2 and 1d5/2 channels with the partial wave representation which is of the strong limit of the rotational coupling effects). The energy of the adiabatic potential $\gamma_p(r)$ at the $r_c^{(2)}$ is clearly lower than the barrier-top energy E_B because of $r_c^{(2)} > r_g$. Therefore, the transition occurs even though the bombarding energy is much lower than E_B so long as the incident wave reachs the distance $r_c^{(2)}$. As a result the partial cross sections $\sigma^{J\pi}$ (1d5/2→2s1/2) for higher J values rise up from the energy smaller than E_B as shown in fig.2 and increase slowly until the energy reach the E_B; that is, the $\sigma^{J\pi}$ takes the form of broad bump when J is large. Thus, the integrated cross section $\sigma = \Sigma\sigma^{J\pi}$ for the inelastic scattering $^{17}O(^{16}O,^{16}O)^{17}O^*(1/2^+)$ takes the saturated value of the cross section even at very low energies above the Coulomb barrier.

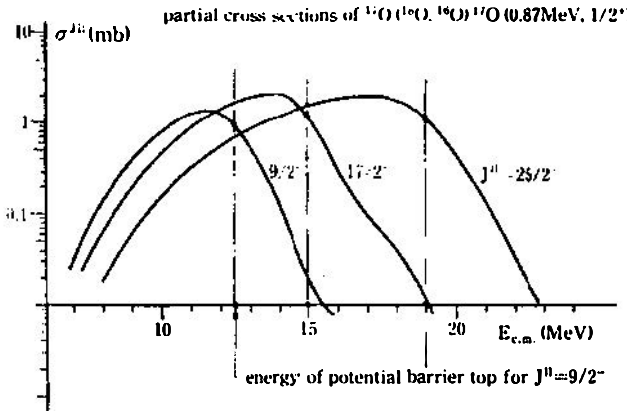

Fig. 2. The partial cross sections $\sigma^{J\pi}$ for $J^\pi = 9/2^-$, $17/2^-$ and $25/2^-$ for the inelastic scattering $^{17}O(^{16}O,^{16}O)^{17}O^*(0.87MeV,1/2^+)$.

The above discussion is applicable to the scattering concerned with the excitation of $^{17}O^*(1/2^+)$, for exmaple, $^{17}O(^{12}C,^{12}C)^{17}O^*(1/2^+)$. Thus, the structures predicted from the crossing with the "static" level diagram of the TCSM are probably smeared out by the rotational couplings. This is in strong contradiction to the data and the analysis in ref.2. The reaction mechanism for the structures observed in the experiment [3] is a problem to be solved in future.

References

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