Theory of \(^{3}\text{H}, \text{d}\) Reaction.

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Summary. — The differential cross-section of the reaction \(^{4}\text{X}(^{3}\text{H}, \text{d})^{4+1}\text{X}\) is obtained off and near a resonance level.

1. — Introduction.

In spite of the great success of the stripping theories, they proved to be inadequate in the following respects:

a) In predicting the correct magnitude of the cross-section in millibarns.

b) In predicting the correct angular distribution near a resonance level of the target nucleus.

Some authors \(^{(1,3)}\), discussed the effect of using a finite-range potential. The type of the potential used may also affect the cross-section \(^{(4)}\).

We shall derive the stripping cross-section for the reaction \(^{4}\text{X}(^{3}\text{H}, \text{d})^{4+1}\text{X}\) off and near a resonance level.

2. — General formulation.

We follow a way similar to that used by TOBOCMAN \(^{(4)}\), taking into consideration the following assumptions:

1) The Coulomb interaction is neglected.

2) The mass of the target nucleus is very great.


\(^{(3)}\) N. AUSTERN: Fast Neutron Physics, p. 120.

\(^{(4)}\) In a previous work in press this effect was illustrated.

In the reaction $^4X(\alpha, d)^{\alpha+1}X$, one neutron of the incident $^3H$ projectile is captured in the target nucleus in a bound state, while a deuteron is yielded with asymptotic momentum $\hbar k_d$.

From the conservation of energy,

$$\frac{\hbar^2 k_n^2}{2m_n} + \frac{\hbar^2 k_d^2}{2m_d} = \varepsilon,$$

where $\hbar k_n$, is the momentum of the captured neutron and $\varepsilon$ is the total energy of the incident $^3H$.

Taking the centre of the target nucleus as an origin; let, $r_1, r_2$ and $r_3$ denote the co-ordinates of the proton and the two neutrons constituting the incident projectile respectively.

In order to calculate the flux of the liberated deuterons with asymptotic momentum $\hbar k_d$, we write the Schrödinger equation for the interaction as

$$\left[ H_I + T_1 + T_2 + T_3 + \sum_{k=1}^3 V_{1k} + \sum_{i>j} V_{ij} - E \right] \Psi = 0.$$

$E$ is the total energy of the system, $\Psi \equiv \Psi(\xi, r_1, r_2, r_3)$ is the total wave function describing the interaction, $H_I$ is the total Hamiltonian of the target nucleus. $T_1, T_2$ and $T_3$ are the K.E. operators of the proton and the neutrons respectively.

$\sum_{k=1}^{3} V_{1k}$ is the interaction potential between the target and the incident projectile, and $\sum_{i>j} V_{ij}$ is the internal interaction potential between the constituent nucleons of the incident projectile. The wave function $\Psi(\xi, r_3)$ satisfies the equation

$$\left[ H_I + T_3 + V_3 - \frac{\hbar^2 k_d^2}{2m_d} \right] \Psi(\xi, r_3) = E_{a'} \Psi(\xi, r_3),$$

where $E_{a'}$ is the total energy of the final target nucleus, minus the k.e. of the captured neutron.

Thus eq. (2) is reduced to

$$\left[ T_1 + T_2 \sum_{k=1}^{3} V_{1k} + \sum_{k=1}^{3} \sum_{i>j} V_{ij} - \frac{\hbar^2 k_d^2}{2m_d} \right] \Psi(\xi, r_1, r_2, r_3) = B_d \Psi(\xi, r_1, r_2, r_3),$$

where $B_d$ is the binding energy of the deuteron.