FINITE RANGE COULOMB STRIPPING
IN (t, p) AND (He\textsuperscript{3}, n) REACTIONS

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The theory of two-nucleon stripping reactions is considered, taking into account the Coulomb distortion and the finite-range effects at projectile energies below the Coulomb barrier. Applying the results to the reactions \( {\text{N}}^{14}(t, p)\text{N}^{16} \) and \( \text{Be}^{9}(\text{He}^{3}, n)\text{C}^{11} \) reliable agreement is observed with the experimental data especially in the forward direction.

1. Introduction

Recently, special attention has been directed to nuclear reactions, in which both the energies of the projectile and the outgoing particles are well below the Coulomb barrier [1-5]. The most striking feature of these reactions is the tendency of the angular distribution towards backward peaking. There are strong evidences that a direct interaction mechanism such as stripping takes place even in this low energy range. Coulomb stripping was first treated by Ter-Martirosian [1] and Biedenharn et al. [2] in the case of deuteron stripping, assuming zero-range neutron—proton interactions. Dar et al. [3] have modified this theory by assuming finite-range interaction and applying some reasonable approximations. Lately, El-Nadi and Rhian [4], and Buttle and Goldfarb [5] have developed the Coulomb stripping theory in the general case of arbitrary cluster transfer.

On the other hand the two-nucleon stripping mechanisms considered by El-Nadi [6], News [7] and Glendenning [8] seem to give reliable fitting with the experimental data, when the projectile energy is above the Coulomb barrier.

The aim of the present work is to consider the two-nucleon stripping processes, when the energy of the projectile is well below the Coulomb barrier. An approximate treatment will be considered in which the projectile is assumed to be partially polarized so that the centre of mass coordinate may be replaced by the coordinate of the outgoing particle. This is the assumption introduced for (d, p) reactions by Dar et al. [3]. Using this approximation, a general
expression is derived in Section 2 for the two-nucleon stripping from a heavy projectile. In Section 3, an alternative method is given for the derivation of the differential cross-section for (t, p) reactions. In Section 4, a special case is considered in which the energy of the outgoing particle is above the Coulomb barrier, while that of the incident particle is below the barrier.

The results of this section could be applied to (He\(^3\), n) reactions. Results and discussions are given in Section 5, where the results of the present calculations are compared with the experimental results of SCHWARTZ et al. [9] on N\(^{14}\)(t, p)N\(^{16}\) and DUGGAN et al. [10] on Be\(^9\)(He\(^3\), n)C.

2. General consideration

Let us consider the reaction

\[ A + T \rightarrow C + R, \]

where A represents the projectile consisting of two nucleons (1) and (2) bound to a cluster (C) with relative angular momenta \( l_1 \) and \( l_2 \), respectively. R refers to the residual nucleus formed from the two nucleons bound to the target (T) with relative angular momenta \( l_{n1} \) and \( l_{n2} \), respectively.

The transition matrix element for the two-nucleon stripping process may be given to a first approximation by [4]

\[ T_{fi} = \langle \Phi_f^{-}\rangle |\{V_{1c}+V_{2c}\}| \psi_i^{(+)}\rangle. \quad (2.1) \]

From Fig. 1, it can be seen that:

\[ \varrho = r_2 + \frac{1}{2} r_{12}, \]

\[ R = r_c + \frac{2 m_n}{m_A} r_2 + \frac{m_n}{m_A} r_{12}. \]

When the charge of the cluster (C) is larger than that of the nucleons (1) and (2), the projectile (A) can be expected to be partially polarized by the target Coulomb field so that the cluster (C) will be on the farther side of the target (T) while the nucleons (1) and (2) will be nearer.* Assuming also the mass

* For the case of (He\(^3\), n), one may assume that the two protons will be symmetrical with respect to the line joining the target nucleus and the neutron, so that, in this case, the replacement (2.2) may also be justified. The neutron in this case may, however, be nearer to the target nucleus.