DWBA CALCULATION OF THE CROSS SECTION
OF THE $^{12}$C ($^6$Li, d) $^{18}$O* [O$_2^-$, 6.05 MeV] REACTION*

By

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Exact finite range DWBA calculation performed for the reaction $^{12}$C ($^6$Li, d) $^{18}$O* [6.05] reproduces satisfactorily the 18 MeV experimental cross section and yields a value of 0.17 for the product of the spectroscopic factors. A comparison of the results with two approximate descriptions shows that the finite range effects induce more oscillations in the angular distribution and depress the maxima at medium and backward angles. A finite range correction calculation with 1.5 fm for the finite range parameter is acceptable for describing the experimental data.

1. Introduction

Alpha-particle transfer reactions represent important tools for studying alpha-clusterization in nuclei. The ($^6$Li, d) reaction is one of the best for this purpose since there is a large alpha-deuteron clusterization in the $^6$Li ground state. Moreover, the two clusters move almost exclusively with $l = 0$ orbital momentum in this case. This property offers a chance that zero-range (ZR) approximation can be applied in the DWBA calculation which is generally used in describing the direct alpha-transfer processes. Of course, reliable spectroscopic information can only be extracted from the measured cross section if the reaction mechanism is predominantly direct alpha-transfer and this mechanism is described with a sufficient accuracy. In the theoretical description the crucial points may be the type of the form factor used, the optical-model potentials applied in the entrance and exit channels, and the approximations made in the calculation of the DWBA amplitude.

In the DWBA description of the alpha-transfer, a phenomenological alpha-cluster form factor is generally used which is typically a bound state wave function in a Saxon—Woods (SW) potential with the depth adjusted to reproduce the separation energy of the alpha-particle. The use of the pheno-

* Dedicated to Prof. R. GÁSPÁR on his 60th birthday
menological form factor is not justified in every case; indeed, earlier investigations [1--4] have shown that in some cases the use of microscopical form factor is necessary in order to give a good account for the experiment. The alpha-transfer reaction leading to the first excited state \( [O_2^+, 6.05 \text{ MeV} \] of the nucleus \( ^{16}\text{O} \) is however the most probable candidate which can be described by using a simple phenomenological form factor. In this case the microscopical form factor and the phenomenological one exhibit very similar structure [4] as a result of the large alpha-clusterization of the final (4-particle — 4-hole) state.

It is the purpose of this investigation to test the applicability of the ZR approximation which is widely used in DWBA calculations mainly because it allows a substantial saving in computation. The accuracy of this approximation in the \((\text{Li}, d)\) reaction at 18 MeV bombarding energy has not been cleared up yet in detail [5] and strongly depends on what region gives the dominant contribution to the radial integrals. This region is determined by the optical potentials as well as the shape of the form factor.

In the present investigation DWBA calculations are compared with the experiment of BETHE et al at 18 MeV projectile energy [6]. In order to examine the importance of the finite range (FR) effects, calculations have been carried out and the results are compared together in the ZR and FR approximations and also with taking into account FR corrections (FRC) in local energy approximation [7, 8].

2. Optical potentials, form factors and differential cross sections

To calculate the differential cross sections, the single particle transfer options (with and without FRC) of the code DWUCK [9] and the exact finite range (EFR) computer code LOLA [10] have been used.

Entrance channel optical potential parameters have been taken from the analysis of the elastic scattering of 20 MeV \(^6\text{Li} \) particles on \(^{12}\text{C} \) target by MEIER—EWERT et al [11]. Due to the shallow real well depth, this potential incorporates somewhat the effect of the Pauli principle between the two composite nuclei which is a well-known characteristic feature of the low energy nucleus-nucleus optical potentials [12].

Exit channel optical parameters are those of NEWMAN et al [13] reproducing elastic scattering of 34.4 MeV deuterons on \(^{16}\text{O} \). Since the energy in the present case is considerably lower the strength of the imaginary potential has been somewhat reduced. The values of the optical parameters used are listed in Table I.

The \(^{16}\text{O} \) form factor has been taken to be the normalized eigenfunction with node number \( N = 4 \) (excluding the origin) in a SW well with radius