The ^{6}He Optical Potential at energies around the Coulomb barrier

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Abstract. We present an Optical Model (OM) study of ^{6}He on ^{208}Pb elastic scattering data, measured at laboratory energies around the Coulomb barrier (E_{lab}=14, 16, 18, 22, and 27 MeV) [1]. For the projectile-target bare interaction, we use the microscopic São Paulo Potential (SPP). This bare interaction is supplemented with a Coulomb Dipole Polarization (CDP) potential, as well as a diffuse complex Woods-Saxon potential. Four-body Continuum-Discretized-Coupled-Channels (CDCC) calculations have been performed in order to support the optical model analysis. We have also studied the α channel, which is the dominant reaction process. In the analysis of this channel, we compare the angular and energy distributions of the α particles measured at 22 MeV, with Distorted Wave Born Approximation (DWBA) calculations.

Keywords: Nuclear reaction ^{6}He+^{208}Pb, halo nucleus, Coulomb dipole polarizability, Coulomb barrier, threshold anomaly, optical model and DWBA calculations.
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OPTICAL MODEL CALCULATIONS

We have performed OM calculations, in which the ^{6}He + ^{208}Pb potential is parametrized according to the following expression,

$$U_{TOT}(r) = V_{Coul}(r) + V_{SPP}(r) + U_{Pol}(r), \tag{1}$$

where $V_{SPP}(r)$ is a nuclear microscopic bare potential [2], $V_{Coul}(r)$ represents the Coulomb interaction, and $U_{pol}(r)$ contains the effects of reaction channels on the elastic scattering, given by the equation,

$$U_{Pol}(r) = U_{CDP}(r) + V_L(r) + iW_L(r). \tag{2}$$

Here $U_{CDP}(r)$ represents the dynamic CDP potential derived in Ref. [3], which depends only on the B(E1) distribution of the ^{6}He projectile, and $V_L(r)$ and $W_L(r)$ are the real and imaginary parts of the phenomenological Woods-Saxon potential. The parameters of

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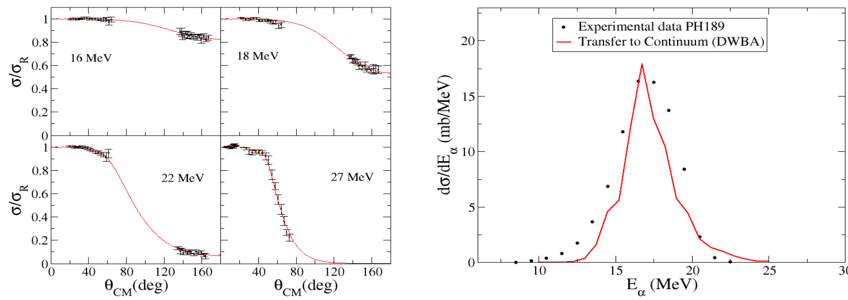
these terms are obtained by means of a χ^2 fit of the elastic data. In order to obtain satisfactory fits, a large value of the diffuseness of the real and imaginary parts is required ($a_r \sim a_i \sim 1$ fm). This is in agreement with the results found in [1].

CDCC calculations [4], based on a 3-body model of ^{6}He (α + n + n), have also been performed. The local equivalent potential derived from these calculations have a long range, which is consistent with the large diffuseness parameters found in the OM analysis.

The energy dependence of the strengths of the real and imaginary parts of the optical potential show a correlation consistent with dispersion relations [5].



(a) (b)

FIGURE 1. (a) Elastic scattering angular distribution and calculations. The solid lines represent the optical model calculations using the Eq. 1. (b) Energy distribution of α particles. Transfer to the continuum calculations (solid line) are compared with the experimental data.

STUDY OF α CHANNEL

We have also analyzed the α production channel. The experimental data show that this channel is the main reaction process [6]. We study this channel by means of Distorted Wave Born Approximation (DWBA) calculations, assuming that the α particles are produced by transferring the two valence neutrons to bound and unbound states of the target. In this transfer mechanism, the continuum states are discretized and divided into a set of energy packages (bins). Comparing with the experimental data, we conclude that the α particles are produced mainly by a two-neutron transfer mechanism to very excited states of the target.

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