ELASTIC SCATTERING OF ^{6}He ON HEAVY TARGETS AT COULOMB BARRIER ENERGIES*

A.M. Sánchez-Benítez, I. Martel

Departamento de Física Aplicada, EPS La Rábida, Universidad de Huelva
21819 Palos de la Frontera, Huelva, Spain

and J. Gómez-Camacho

Departamento de Física Atom. Molec. y Nucl. Facultad de Física
Universidad de Sevilla, Apdo. 1065, 41080 Sevilla, Spain

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Elastic cross sections for the scattering of ^{6}He projectiles by ^{208}Pb at 27 MeV have been studied. The data have been analyzed within the framework of the Optical Model using Saxon–Woods phenomenological form factors for both the real and imaginary parts of the nuclear potential. The elastic scattering data suggests the presence of a long range absorption mechanisms which might be related to the halo structure of ^{6}He.

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1. Introduction

The ^{6}He nucleus is known to be composed of an alpha particle core and a two-neutron halo which extends for unusually large distances [1]. It is also a weakly bound system, with a binding energy of 0.973 MeV [2].

The Optical Model (OM) has been successfully used in the description of the elastic scattering of stable nuclei. In this framework, the nucleus–nucleus interaction is usually described by the monopole Coulomb potential plus an Optical Potential (OP) that is complex and energy-dependent. The OP geometry has to be physically sensible in order to assess the validity of the model. Although it has been shown that the OM is valid for the treatment of elastic scattering with stable nuclei, its validity in the case of weakly bound nuclei, as in the case of ^{6}He, remains an open question.

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In this work we perform an OM analysis of recent experimental data on the elastic scattering of ^{6}He by ^{208}Pb at 27 MeV (Lab), and discuss the main characteristics of the resulting OM potential. The analysis presented here is preliminary, and the final results will be presented elsewhere [3]. In our analysis we use a fix Coulomb radius of $r_0^{\rm C} = 1.2$ fm. For the nuclear potential we have chosen Saxon–Woods radial form factors for both the real and imaginary parts. The value of the reduced nuclear radius was kept fixed at $r_0 = 1.301$ fm while the strengths of the real and imaginary parts of OP have been optimized in order to reproduce the data.

2. Analysis and results

As the starting point of our analysis we have considered the values of the OP parameters obtained from the elastic scattering ^{6}Li + ^{208}Pb [4, 5] and are given in the first row of Table I.

TABLE I

Values of the OM parameters for ^{6}He + ^{208}Pb and the associated χ^2_ν values ($N_{\rm F}$ is the number of degrees of freedom). See text.

	V_0 (MeV)	W_0 (MeV)	$a_r = a_i$ (fm)	χ^2_ν
^{6}Li potential	6	14.24	0.819	6.88 ($N_{\rm F} = 86$)
Fit V_0, W_0	10 ± 3	31 ± 3	0.819	2.93 ($N_{\rm F} = 84$)

The second row of Table I was obtained with an optimization of the strength of the OP performed with the code ECIS [6]. Here both real and imaginary diffuseness were fixed to the same constant value, and only the potential depths were adjusted in order to fit experimental data. It should be noted that the depths of the real parts for the two calculations are sizeable, being larger in the latter case. If we compare the depths of the imaginary and the real parts, we can observe that the ratio is appreciably greater for the ^{6}He. This result indicates a larger removal of flux from the elastic channel in the case of ^{6}He.

Analysis of previous measurements of the scattering of ^{6}He by a ^{209}Bi target around [7] and well below [8] the Coulomb barrier indicate the existence of mechanisms that remove elastic flux at very large distances. We have studied the value of the diffuseness of the absorptive part, a_i, with the purpose of getting information about the spatial range in which the absorption mechanisms take place. In this case we performed several constrained fits, fixing the value of a_i, and allowing to vary freely the real and imaginary potential depths. Changing the value of the diffuseness of the real potential did not reduce significantly the χ^2 values, so it was kept fixed at $a_r = 0.819\,\text{fm}$ in every fit.

In Fig. 1 it is depicted the variation of the χ^2 per degree of freedom *versus* a_i, and the optimized parameters corresponding to the minimum are shown in Table II. One should note that the value of the diffuseness needed to fit the experimental distribution is extremely large: $a_i = 1.4 \pm 0.4\,\text{fm}$. It is also a noticeable result that the quality of the fit improves when we allow a_i to vary, and it is rather independent of the value of the real part of the OP. This means that the elastic scattering is strongly dependent on the shape of the imaginary part of the OP. These results are in agreement with those in Refs. [7, 8] for the scattering of ^{6}He by ^{209}Bi.

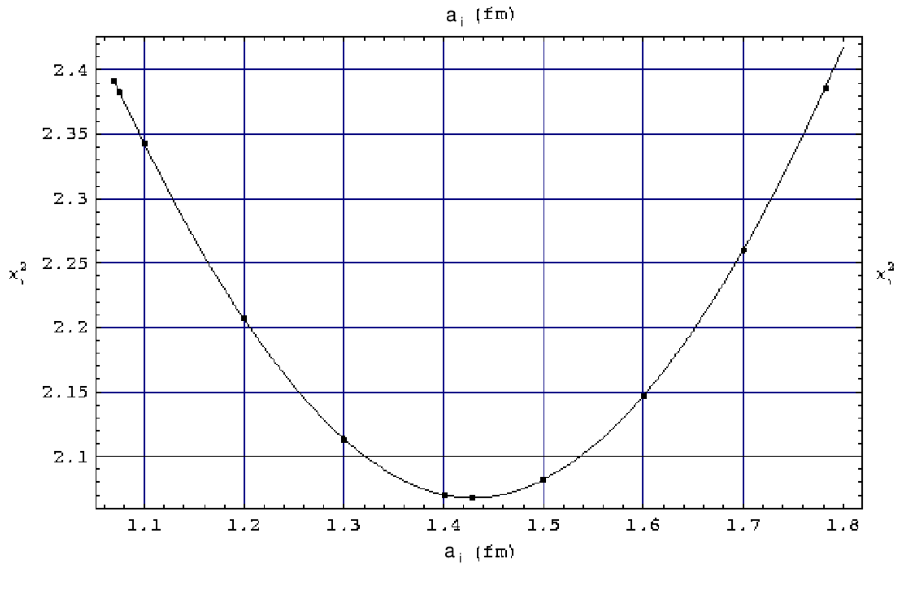

Fig. 1. Aspect of the minimum of χ^2_ν with respect to the diffuseness of the absorptive term of the OP, a_i. The value at the minimum is $a_i = 1.4 \pm 0.4\,\text{fm}$.

Our results suggest the existence of absorption mechanisms at very large distances for ^{6}He. The origin of this mechanism may be related to the dipole Coulomb polarizability [9], which was already found in the scattering other weakly bound nuclei by heavy targets [10].

TABLE II

Values of V_0, W_0 and a_i at the minimum of χ^2_ν obtained from the constrained fits with respect to a_i.

V_0 (MeV)	W_0 (MeV)	a_r (fm)	a_i (fm)	χ^2_ν ($N_\mathrm{F} = 83$)
8.1 ± 0.7	5.2 ± 0.8	0.819	1.4 ± 0.4	2.07

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