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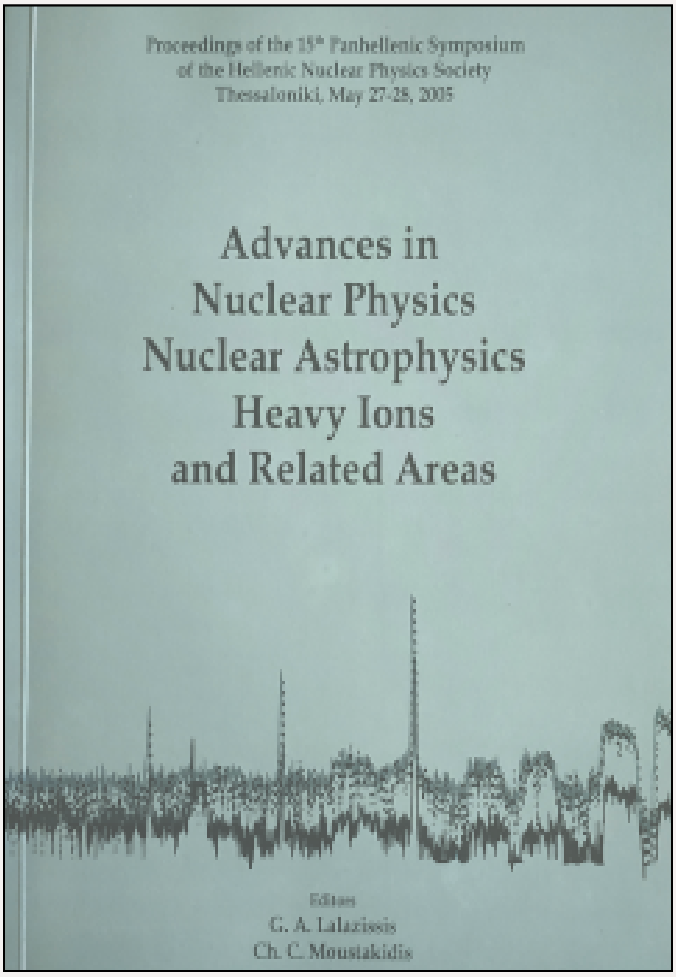

6Li+28Si reaction cross sections at sub-barrier energies

Pakou A.	Department of Physics, The University of Ioannina
Musumarra A.	Dipartimento di Metodologie Fisiche e Chimiche per l'Ingegneria dell'Università di Catania
Pierroutsakou D.	INFN Sezione di Napoli
Alamanos N.	CEA-Saclay, DAPNIA-SPhN, Gif-sur-Yvette
Assimakopoulos P.	Department of Physics, The University of Ioannina
Divis N.	National Research Center Demokritos
Doukelis G.	Technical Educational Institute of Athens
Harissopulos S.	National Research Center Demokritos
Kalyva G.	National Research Center Demokritos
Lagoyannis A.	National Research Center Demokritos
Mertzimekis T.	Department of Physics, The University of Ioannina
Nicolis N.	Department of Physics, The University of Ioannina
Papaxristodoulou C.	Department of Physics, The University of Ioannina
Perdikakis G.	National Research Center Demokritos
Roubos D.	Department of Physics, The University of Ioannina
Russek K.	Technical Educational Institute of Athens
Spyrou A.	National Research Center Demokritos
Zarkadas Ch.	National Research Center Demokritos

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A. Pakou[1], A. Musumarra[2], D. Pierroutsakou[3] N. Alamanos[4], P. A. Assimakopoulos[1], N. Divis[5], G. Doukelis[6], S. Harissopulos[5], G. Kalyva[5], A. Lagoyannis[5], T. J. Mertzimekis[1], N. G. Nicolis[1], C. Papaxristodoulou[1], G. Perdikakis[5], D. Roubos[1], K. Russek[6], A. Spyrou[5] and Ch. Zarkadas[5]

[1] Department of Physics, The University of Ioannina, 45110 Ioannina, GREECE

[2] Dipartimento di Metodologie Fisiche e Chimiche per l'Ingegneria dell'Universita di Catania, ITALY

[3] INFN Sezione di Napoli, I-80125, Napoli, ITALY

[4]CEA-Saclay, DAPNIA-SPhN, Gif-sur-Yvette, FRANCE

[5]National Research Center Demokritos, 15110 Athens, GREECE

[6]Technical Educational Institute of Athens, 12210 Athens, GREECE

[7] Department of Nuclear Reactions, The Andrzej Sołtan Institute for Nuclear Studies, Hoża 69, 00-681 Warsaw, POLAND

Abstract

Total reaction cross sections at near barrier energies (9-13 MeV) were measured for the system ^{6}Li+^{28}Si adopting a new technique. The results will be discussed in terms of the threshold anomaly at barrier.

Reaction cross sections are of fundamental interest in Nuclear Physics. They are an effective tool for providing measurements on the size of nuclei and therefore for revealing unusual features such as extended halos or neutron skins. On the other hand they also complement elastic scattering data for obtaining information on the nuclear potential. Absorption processes affect the elastic scattering probability by removing flux, therefore measured values of reaction cross sections can put the appropriate constrains on the amount of absorption (imaginary potential), included in the theoretical analysis of elastic scattering [1,2].

In a previous work [3,4] the study of the ^{6}Li+^{28}Si elastic scattering was undertaken at near-barrier energies to resolve the existence or not of a threshold anomaly for weakly bound systems. Our results were analysed in a theoretical framework within the double folding model [5] by using the BDM3Y1 interaction developed by Khoa et al. [6] and the code ECIS [7]. Into the same

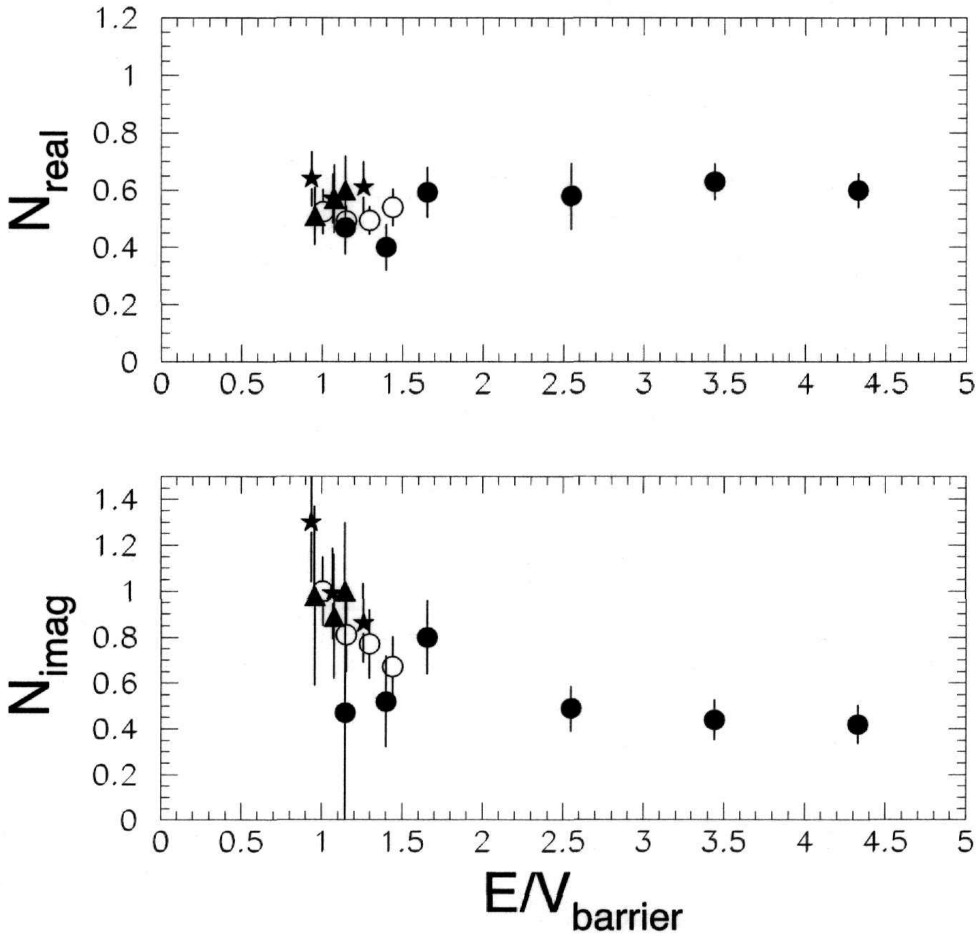

Fig. 1. Normalization factors of the real and imaginary potential as a function of the ratio of lithium bombarding energy over the barrier. Solid circles correspond to data for the $^{6}Li+^{28}Si$ system, open circles to the $^{6}Li+^{58}Ni$, triangles to the $^{6}Li+^{118}Sn$ system and stars to the $^{6}Li+^{208}Pb$ system. The adopted barriers in the laboratory, were the BDM3Y1 potential barriers obtained in the present calculations equal to 7.83, 13.9, 20.95 and 31 MeV for the above systems respectively.

framework previous data on heavier targets were also analysed. The results are displayed in Fig. 1. In principle, the data concerning the imaginary potential present an increasing trend approaching the barrier, which contrasts the behaviour of stable projectiles as well as the behavior of ^{7}Li on all targets. On the other hand our data on silicon do not firmly favour this trend. Since at these energies the Coulomb potential is comparable with the nuclear potential the fits do not give data with a big confidence. Therefore in order to corroborate these results, we have undertaken total reaction cross section measurements at near barrier energies, employing a technique similar to the one adopted in ref. [8] where a Si detector is used both as a target and as a

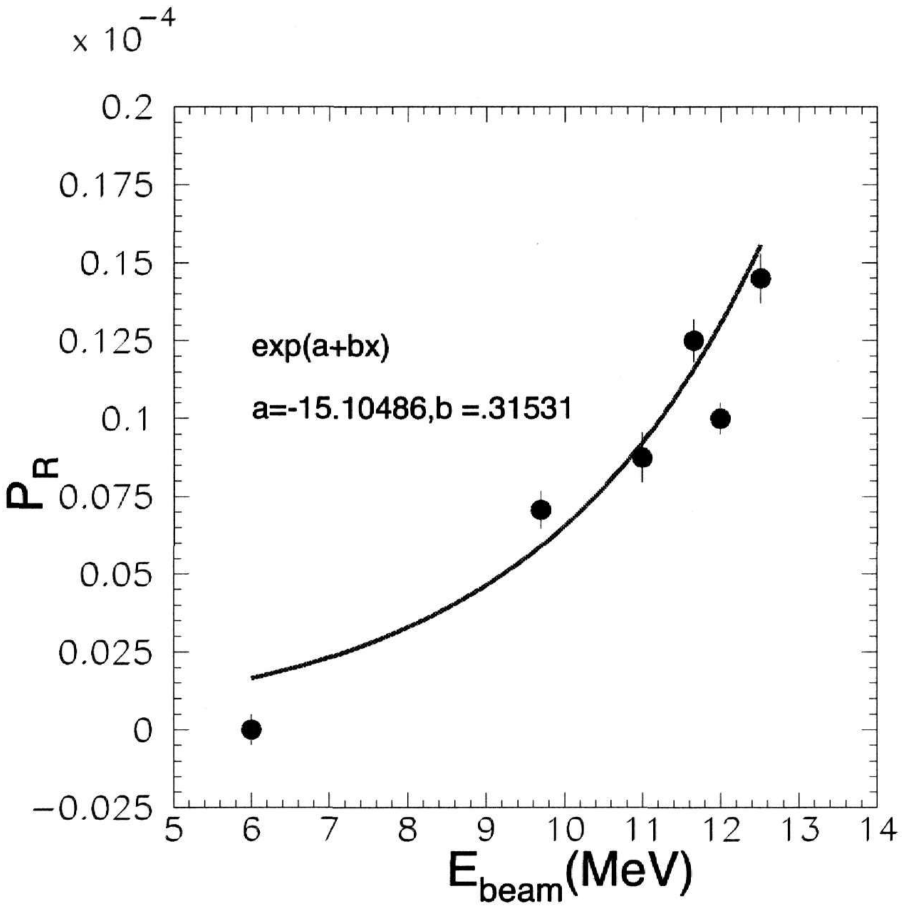

Fig. 2. Measured reaction probabilities as a function of energy. The line is the best fit to the data.

detector.

A $^{6}Li^{+2}$ beam was delivered by the TN11/25 HVEC 5.5 MV Tandem accelerator of the National Research Center of Greece-DEMOKRITOS at five bombarding energies, namely 9.7, 11.0, 11.65, 12 and 12.5 MeV. Beam currents were of the order of 10^3 pps, produced by using several collimators and a 6.05 μm tantalum degrader. The beam impinged on a telescope set at 0 degrees, which was used both as a target and a detector. The telescope consisted of two parts; a ΔE silicon detector 50 μm thick, and an E detector 2000 μm thick. The thickness of the ΔE detector, was chosen such as to stop the beam and the scattered beam particles, but allow the reaction products to go through and stop in the second stage of the telescope. A reaction probability was thus

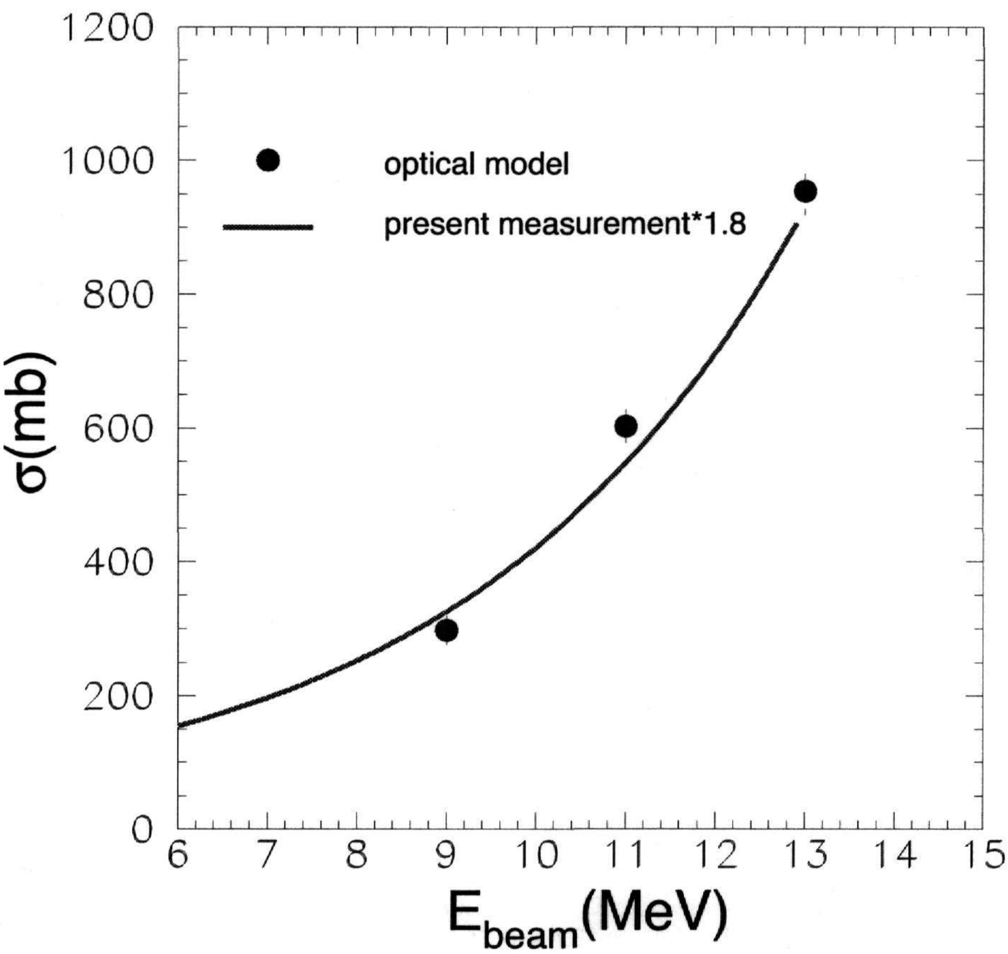

Fig. 3. Present total reaction cross sections, represented with the solid line. Previous data obtained via an elastic scattering are designated with filled circles.

formed by dividing the reaction events detected in the E detector over the total number of beam particles stopped in the first stage of the telescope. The efficiency of the system was determined via a Monte Carlo simulation where angular distributions and energy spectra of the emitted particles, mainly protons and alphas, were taken from our previous work [3,4]. The results of the reaction probabilities as a function of energy, are shown in Fig. 2.

The probabilities are connected with total reaction cross sections, σ_R(E), according to the relation

$$\sigma_R = \frac{\int_0^{E_{max}} \sigma_R(E)(dR/dE)dE}{\int_0^{R_{max}} dR} = -\frac{mln(1 - P_R(E))}{N_A R_{max}} \quad (1)$$

where m is the target mass number, P_R is the reaction probability, N_A is the Avogadro's number and R_{max} is the range of Li ions in silicon. The above quantity is an integrated cross section. Therefore the reaction cross sections, σ_R(E), have to be unfolded from the integral. For high energy measurements, such a procedure can be obtained by using the parametrization of Kox et al [9]. At the low velocities of the present experiment these relations do not hold and the unfolding procedure has to be done performing an energy excitation function of reaction cross section measurements. Preliminary results of reaction probabilities at 5 energies are shown in Fig. 2. These data and an additional point at 6 MeV assumed to have zero cross section, are fitted by an exponetial function. This mapping of the reaction probability as a function of energy, allows us to deduce reaction cross sections σ_R(E), applying the following recursion relations.

$$\sigma_{R(E_n)} = \frac{1}{dE}(A_n - A_{n-1})\frac{dE_n}{dx}.10^4 mb \tag{2}$$

where

$$A_n = \frac{-mln(1 - P_R(E_n))}{N_A} \tag{3}$$

The results are shown in Fig. 3 with the solid line. The estimated error is 20% and it is due to statistics and the systematic error introduced by the efficiency calculation. Our results are compared with three previous values obtained via elastic scattering measurements [3] and show good consistency. This outcome confirms a rather decreasing trend for the imaginary potential at barrier which contradicts the behaviour of ^{6}Li on heavier targets and resembles the ^{7}Li potential trend. It has to be noted that in order to obtain an increasing imaginary potential, the cross section at 9 MeV should have to be multiplied at least by a factor of 2. It has to be pointed out however, that more data around 9 MeV have to be obtained in order to fix the zero cross section point and draw final conclusions.

In summary, we have presented preliminary total reaction cross sections measurements, for ^{6}Li+^{28}Si at near barrier energies. The results support previous optical model values extracted via elastic scattering, while are consistent with a rather decreasing trend of the imaginary potential. This contrasts the behaviour of ^{6}Li on heavier targets and is similar to the one exhibited by ^{7}Li. To draw however firm conclusions, we need more data points at lower energies and also data on ^{7}Li.

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