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Measurements of the $^6He + p$ Resonant Scattering

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Abstract. Measurements of the p(^{6}He,p) elastic scattering excitation function have been performed in the RIBRAS system using a ^{6}He secondary beam and a CH_2 polyethylene thick target. The motivation is to observe states of the compound nucleus ^{7}Li in the excitation energy range of $E^{^7Li}_{exc} = 10.8 - 11.8$MeV, where the isobaric analog state of ^{7}He ground state lies. Excitation functions have been obtained at three laboratory angles $\theta_{lab} = 0°$, 20°, and 25° which correspond to $\theta_{c.m} = 180°$, 140°, and 130°.

Keywords: nuclear reactions, exotic nuclei, elastic scattering
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INTRODUCTION

We performed measurements of the excitation function of the p(^{6}He,p) scattering to observe states of the compound nucleus ^{7}Li. This type of measurement can provide information about the structure of the compound nucleus ^{7}Li in a region of excitation energy for the ^{7}Li in which we observed the excited state at 11.24MeV $J^\pi = \frac{3}{2}^-$ $T = \frac{3}{2}$ which is an Isobarig Analog State (IAS) of the ground state of ^{7}He (see figure 1). This state was observed by Rogachev et al. [2] in the p(^{6}He,n) reaction.

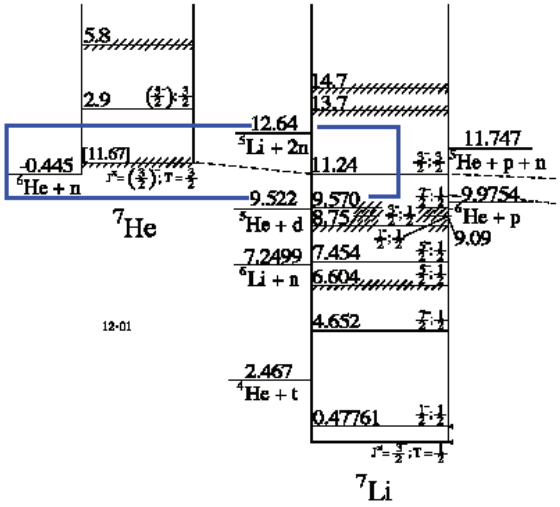

FIGURE 1. Level scheme of ^{7}He and ^{7}Li [1]

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EXPERIMENTAL SETUP

The experiment has been performed at São Paulo Pelletron Laboratory of the University of São Paulo(see Fig. 2) using the double solenoid RIBRAS system[3]. We obtained the secondary ^{6}He beam from the production reaction ^{9}Be(^{7}Li,^{6}He). We used an absorber of polyethylene(CH_2) in the mid-scattering chamber in order to improve the secondary beam purity by an additional $B\rho$ selection in the second solenoid. In the scattering chamber we used a polyethylene(CH_2) with thickness of $12mg/cm^2$(see Fig. 3) which is sufficient to stop the $E_{lab} = 11.5$MeV ^{6}He beam particles. Two detectors were mounted in the scattering chamber at 0° and 20° as we can see in Fig. 4. The measurement at 25° was performed in a different run.

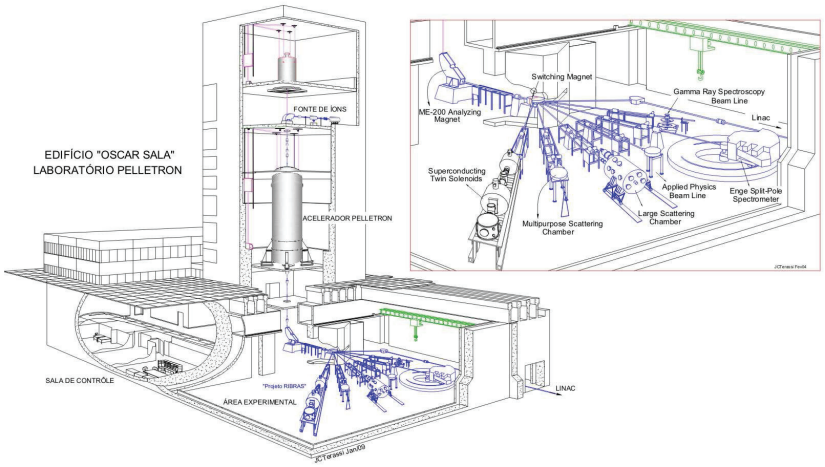

FIGURE 2. Scheme of the São Paulo Pelletron Laboratory

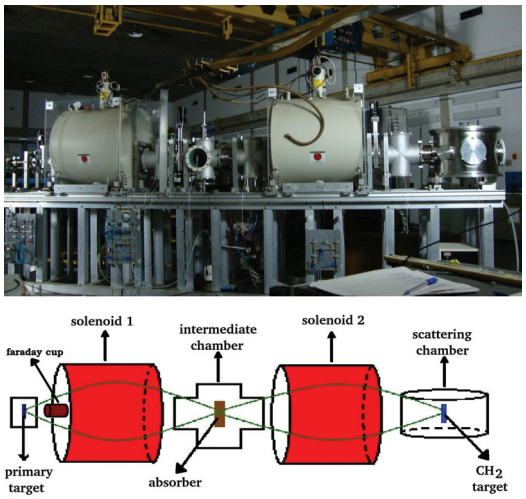

FIGURE 3. (above)Photo of the RIBRAS system. (below)Scheme of the RIBRAS system.

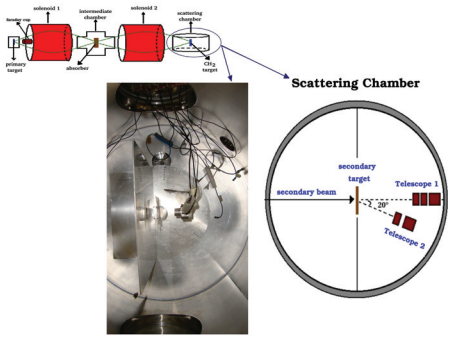

FIGURE 4. Picture inside of the scattering chamber. The scheme is showing the two detectors mounted at 0° and 20° degrees.

TABLE 1. Parameters of the Breit-Wigner obtained from the best fit.

θ_{lab}	γ_p^2	Γ(keV)	E_r(MeV)
0°	0.052 ± 0.004	254 ± 24	11.11 ± 0.02
20°	0.011 ± 0.001	262 ± 25	11.28 ± 0.02
25°	0.036 ± 0.001	256 ± 27	11.11 ± 0.03

THICK TARGET METHOD

This technique consists in using polyethylene sheets with a thickness sufficient to stop the secondary beam of ^{6}He, but that are transparent to the recoil light particles as protons, deuterons, tritons and α particles produced in reactions with polyethylene CH_2 target. The recoil particles are identified by a telescope placed behind the target at an angle θ_{lab}, and their energy is directly related to the energy of the elastic collision ^{6}He+p. In this way a measure of the range of recoil protons provides directly a measure of the excitation function of the compound system ^{6}He+p (see Fig. 5) [4, 5].

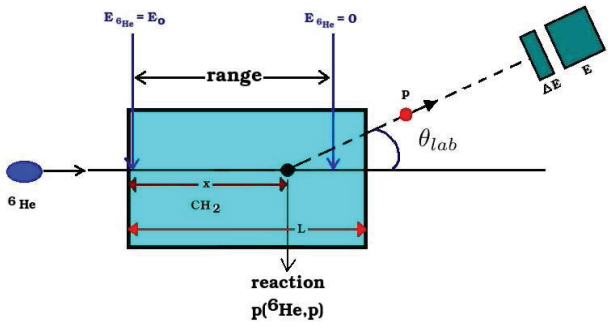

FIGURE 5. Illustration of the thick target method. In our case we used a polyethylene foil of a thickness of $12 mg/cm^2$.

RESULTS

We can see in Fig. 6 biparametric spectra for θ_{lab} =0°, 20°, and 25°. From the energy of the protons one can obtain, by kinematical and energy loss calculations, the energy of the ^{6}He+p collison. The collision energy in the C.M. system is related to the excitation energy of the ^{7}Li by the relation $E_{exc}(^7Li) = E_{c.m.} + Q_{fusion}$. The measured excitation functions as a function of the ^{7}Li excitation energy are plotted in figure 6 (right). We observe the presence of a peak in the position expected to be the 11.24MeV state of ^{7}Li. The excitation functions have been fitted by a Breit-Wigner function using the code XFIT developed by G. Amadio[6] and in table 1 we present the parameters obtained. As we can see the total width Γ and energy position of the resonant E_r is in agreement with the literature [1].

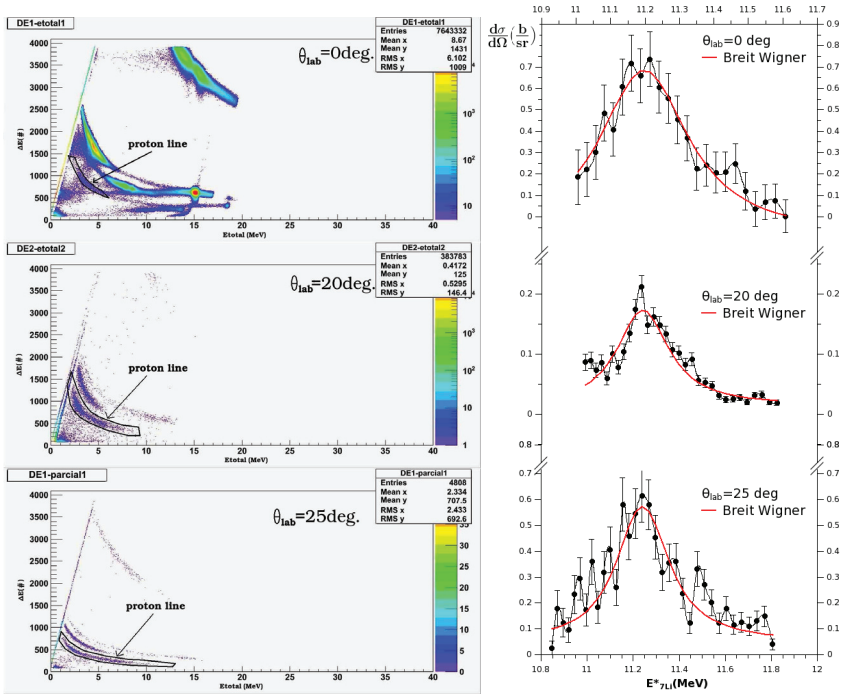

FIGURE 6. (left) Biparametric spectra for θ_{lab} =0°, 20°, and 25°. Excitation functions (right). The red line corresponds to the best fit using a Breit-Wigner function.

CONCLUSIONS

We present p(^{6}He,p) elastic scattering excitation functions at θ_{lab} =0°, 20°, and 25°. We clearly see a peak in the position corresponding to the state 11.24MeV $J^{\pi} = 3/2^{-}$ $T = 3/2$ of the ^{7}Li nucleus. The fit with a Breit-Wigner function gives results for the position and total width which are in agreement with the literature.

ACKNOWLEDGMENTS

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