ASYMPTOTIC NORMALIZATIONCOEFFICIENTS FOR $^{24}Mg+p\rightarrow^{25}Al$ AND THEIR APPLICATION TO NUCLEAR ASTROPHYSICS

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ABSTRACT

Nowadays in the world a lot of attention is drawn again to obtaining reliable information about the structure of the low-lying nuclear states (Spectroscopic factor, asymptotic normalization coefficient (ANC)). In addition to important information on the structure of nuclei, the ANC values are widely used to calculate the cross sections (S factors) and rates of reactions of radiative nucleon capture in stellar medium. The aim of this dissertation work, is to determine the ANC value for the single-particle bound state of $^{25}Al\rightarrow^{24}Mg+p$ from the analysis of the experimental differential cross section of the proton transfer $^{24}Mg(^{3}He,d)^{25}Al$ reaction. This value is important for estimating the astrophysical S-factor for radiative capture of the proton by the ^{24}Mg nucleus, which is the first link in the MgAl chain of the $^{24}Mg(p,\gamma)^{25}A1(\beta^{+})^{25}Mg(p,\gamma)^{26}A1(\beta^{+})^{26}Mg$ cycle.

Keywords: SF – spectroscopic factor, ANC – asymptotic normalization coefficient, DWBA – Distorted-Wave Born Approximation, DCS - differential cross section

The angular distributions of the $^{24}Mg(^{3}He,d)^{25}Al$ one proton transfer reaction leading to the ground state of ^{25}Al were measured at helium energies of 25, 33.3 MeV and they used to extract the spectroscopic factors of $^{24}Mg+p\rightarrow^{25}Al$ with the Distorted-Wave Born Approximation (DWBA) analysis [1].In the present work,theanalysis of the differential cross sections of the above mentionedproton transfer $^{24}Mg(^{3}He,d)^{25}Al$ reaction has been performed within the modified DWBA [3] to obtain the “indirectly determined” values of the asymptotic normalization coefficient ($C^{2}_{p^{24}Mg}$) for

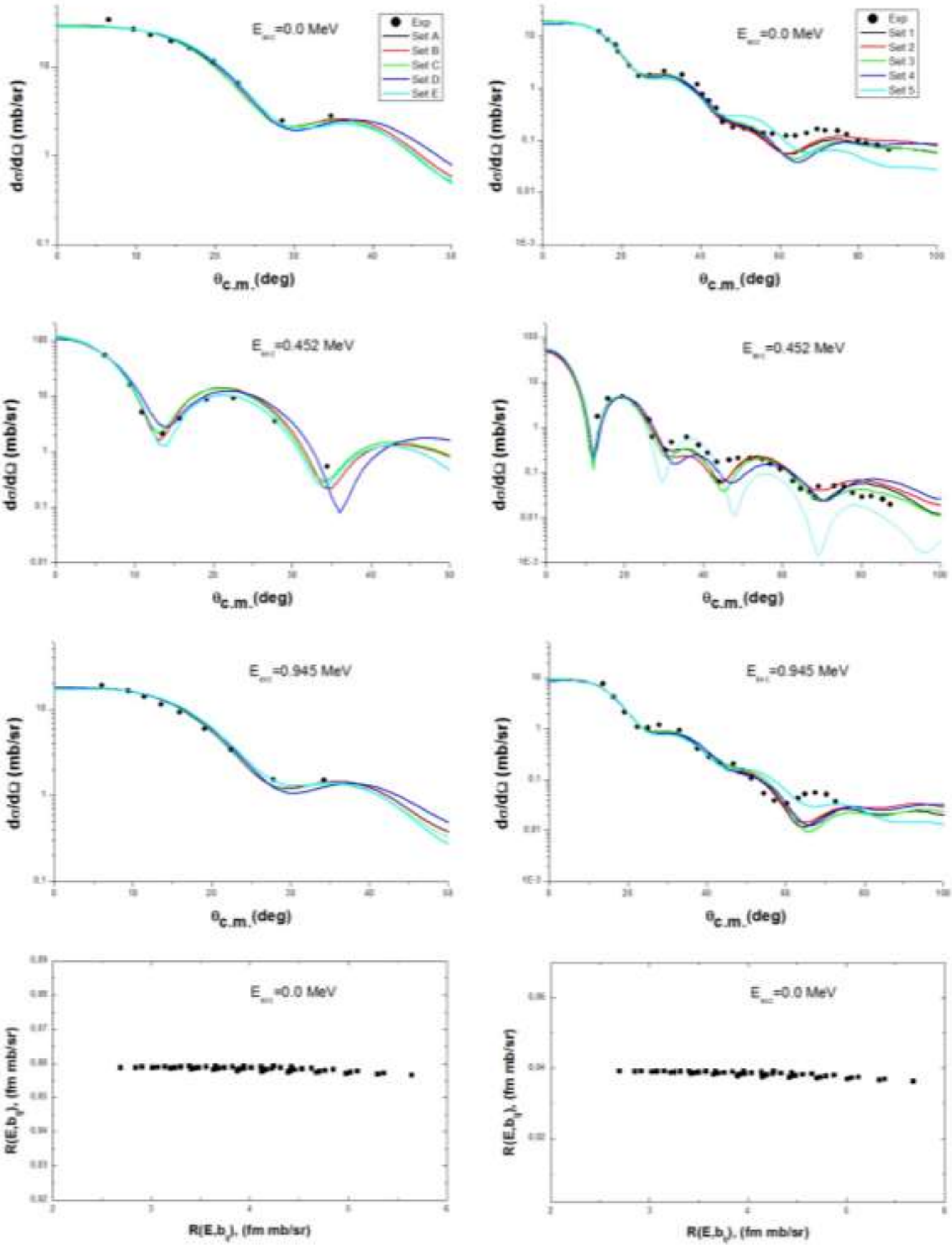
^{24}Mg+p→^{25}Al(0.0 MeV). To determine the absolute values of the ANCs in ^{25}Al, the ANC for ^{3}He→d+p was used the value of the asymptotic normalization coefficient, $C_{dp}^{2} = 4.28 \pm 0.50$ fm, recommended in Ref. [2]. All calculations were carried out with the code DWUCK5 [4].

We have changed the geometric parameters r_0 and a of the Woods-Saxon potential, used for calculation of the bound (^{24}Mg+p) state wave functions, in wide physically acceptable ranges ($r_0 = 1.0 \div 1.40$ fm and $a = 0.5 \div 0.8$ fm) with respect to their "standart" values ($r_0 = 1.25$ fm and $a = 0.65$ fm). Such variation of the r_0 and a results in changing the single-particle ANCs ($b_{p^{24}Mg} = b_{p^{24}Mg}\ (r_0, a)$.

It was shown that the neutron transfer ^{24}Mg(^{3}He,d)^{25}Al reaction at the projectile energy $E_{\ ^{3}He} = 25$ and 33.3 MeV was peripheral and the weighted mean value of the extracted ANCs were found to be $C_{p^{24}Mg}^{2} = 4.6 \pm 0.21$ fm^{-1} for ^{24}Mg+p→^{25}Al(0.0 MeV). The uncertainty involves the error arising because of a change of the $R(E\ \ ,\theta;\ b_{d\,p}, b_{p\ ^{6}Li})$ function at variation of the free parameter $b_{p^{24}Mg}$, where $b_{p^{24}Mg} = b_{p^{24}Mg}\ (r_0, a)$ in which r_0 and a are the geometry parameters of the Woods-Saxon potential adopted, the uncertainty of the ANC for ^{3}He→d+p and the experimental errors for the differential cross section. The different optical potentials also were used in the calculation for estimation of the values of ANC for ^{24}Mg+p→^{25}Al(0.0 MeV) and their uncertainty.

The weighted mean value of the extracted values of the asymptotic normalization coefficients was used for calculation of the astrophysical S factor of the ^{24}Mg(p,γ)^{25}Al reaction leading to the ground state of ^{25}Al at low energies, including E=0.

25 MeV
33.3 MeV



a) b)

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