Spectroscopic factor for $^{25}Mg \rightarrow ^{24}Mg+n$ through the "experimental" ANC from analysis of the peripheral transfer reactions.

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Usually the differential cross sections (DCSs) of nucleon transfer reactions are analyzed within the DWBA for determination of spectroscopic factors (SFs). Even when the error bars in the experimental differential cross section are small, the uncertainty of the SF resulting from normalization of the calculated DCS is often large, regardless of whether it agrees with the shell-model prediction. One of the main reasons for this fault is the strong dependence of the extracted SF on the model single-particle potential parameters.

The purpose of the work is to demonstrate the possibility to clarify the value of the SF (indirectly determined) for the B→A+n/p configuration using the experimental data on the peripheral and non-peripheral transfer reactions. Here it is shown by the combine analysis of the peripheral **$^{25}Mg(d,t)^{24}Mg$** and the non-peripheral **$^{24}Mg(d,p)^{25}Mg$** reactions.

The analysis is fulfilled within the framework of the MDWBA method (see [1] and references therein). The experimental differential cross section (DCS) of the peripheral transfer reaction A(x,y)B in this method parameterizes through the Asymptotic Normalization Coefficient (ANC):

$$\frac{d\sigma}{d\Omega} = C_B^2 R_{lj}(E,\theta;b_{lj}) \qquad 1)$$

$$R_{lj}(E,\theta;b_{lj}) = \left(\frac{C_x}{b_x}\right)^2 \frac{\sigma^{DW}(E,\theta;b_{lj})}{b_{lj}^2} \qquad 2)$$

Here B=A+a, x=y+a, a – transferred particle, *l* (*j*) – is its orbital (total) angular momentum;

$C_{B/x}$ – ANC, which determines the amplitude of the tail of the corresponding overlap integral $I_{lj}(r)$:

b_{lj} – single-particle ANC which determines the amplitude of the tail of the wave function $\varphi_{lj}(r)$.

The analyzes of the reaction $^{25}Mg(d,t)^{24}Mg$

This reaction is analyzed at E_d = 14.5 [2], 14.8 [3] and 18 [4] MeV.

The suitability for the analysis of optical potentials was selected according to the quality of description (according to the χ2 criterion) of differential cross sections of both the reaction under consideration and elastic scattering at the corresponding relative energy of interacting particles in the input and output channels. For the deuteron channel, we used the global parameters from [5,6], for the triton channel - from [7,8], and for the proton channel from work [9].

The proton transfer **$^{25}Mg(d,t)^{24}Mg$** reaction is peripheral at analyzed energies as follows from the behavior of the function *R*(*b*):

$$R(E,\theta;b)=R(b)=const$$

which is constant at variation the geometric parameters of the neutron bound state potential

For example, in figure 1 shown the dependence of the function R(b) from single-particle ANC b in the region of the main maximum of the angular distribution at energies 14.5 and 18 MeV.

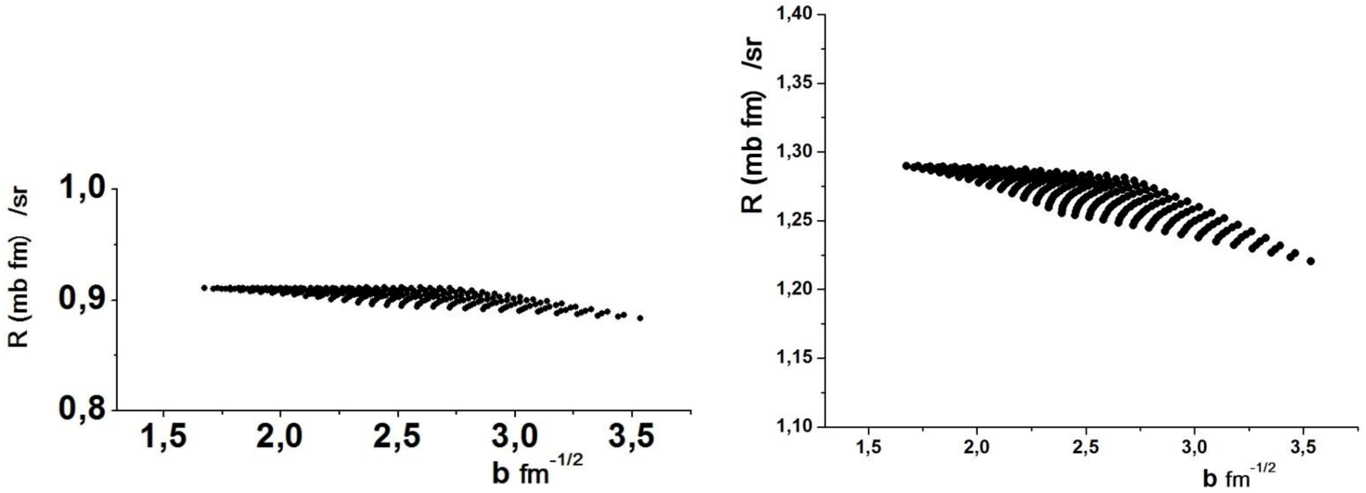

Figure 1. Dependence of the function $R(b)$ from b

In figure 2 presented the experimental and calculated in MDWBA differential cross section for the reaction ^{25}**Mg(d,t)**^{24}**Mg** at 14.5, 14.8 and 18 MeV, respectively

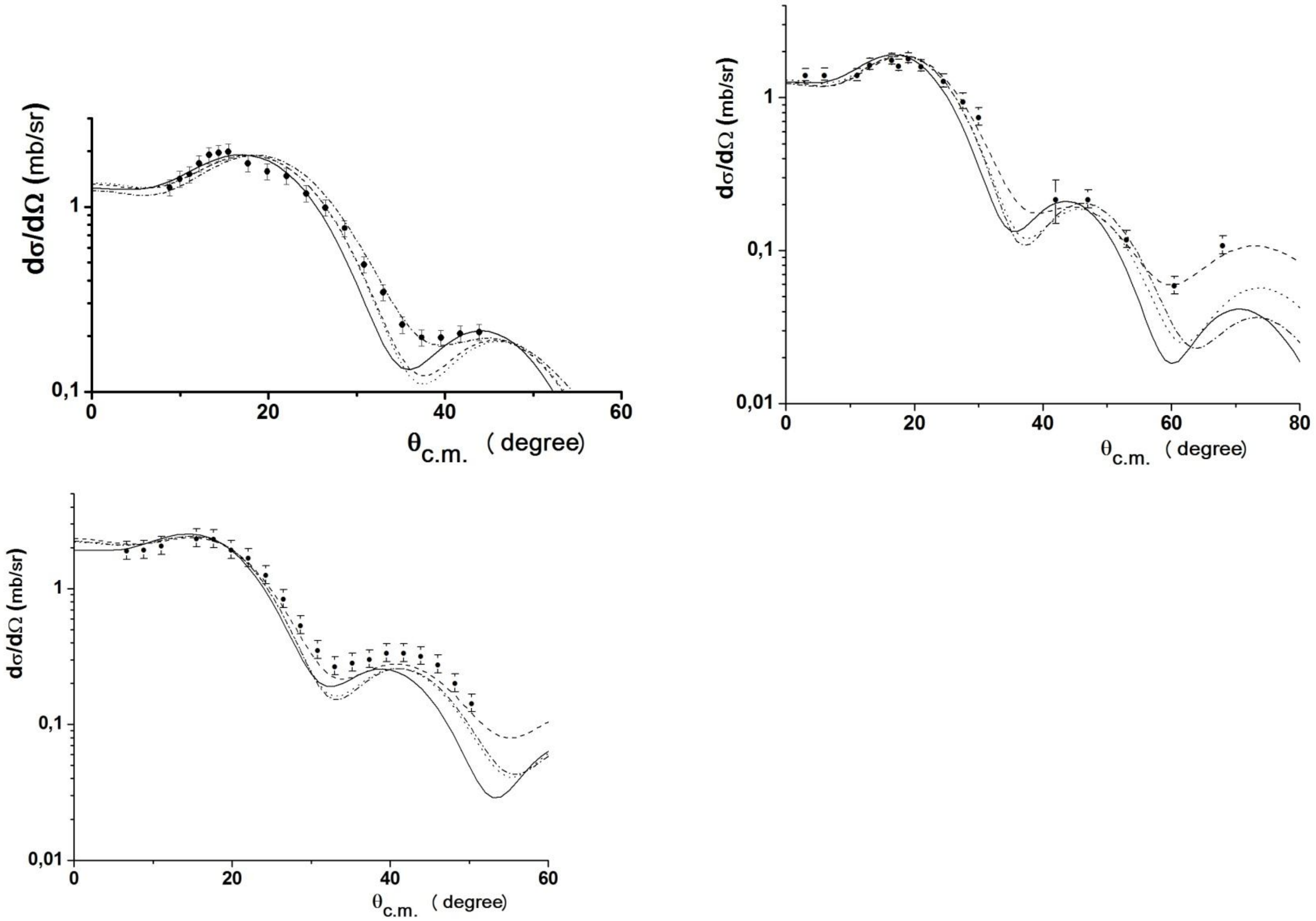

Figure 2. Calculated and experimental angular distributions for the reaction ^{25}**Mg(d,t)**^{24}**Mg.** The experimental points are taken from [2-4], respectively.

The phenomenological values of ANC C^2 for the bound state of $^{25}Mg \to {}^{24}Mg+n$, obtained from the analysis of experimental data on the reaction ^{25}**Mg(d,t)**^{24}**Mg** a are shown in Table 1.

Table 1.

E MeV	l,j	χ^2/n	C^2_{lj} Fm^{-1}	Z
14.5	2, 5/2	0.36	1.70±0.21	0.28
		0.37	1.67±0.20	0.27
		0.62	1.63±0.21	0.27
14.8	2, 5/2	0.21	1.59±0.20	0.26
		0.23	1.67±0.20	0.28
		0.31	1.69±0.21	0.28
18	2, 5/2	0.22	1.83±0.24	0.30
		0.37	1.94±0.24	0.32
		0.37	1.91±0.23	0.32

Averaged over the selected OP pairs, the values of the ANC square for the bound state ^{25}**Mg**$\to$^{24}**Mg+n** are C^2=1.66±0.12 fm^{-1}, and the spectroscopic factor Z = 0.27 ± 0.02 at E_d = 14.5 MeV; C^2=1.65±0.12 fm^{-1}, and Z = 0.27 ± 0.02 at E_d = 14.8 MeV; and C^2=1.89±0.14 fm^{-1}, and Z = 0.31 ± 0.02 at E_d = 18 MeV.

The analyzes of the reaction ^{24}Mg(d,p)^{25}Mg

This reaction is analyzed at E_d = 13.6 [10] and 14.5[2] MeV.

The study of the behavior of the test function $R(b)$ with selected optical potentials in the region of the main maximum of the angular distribution at both energies indicates a strong non-peripherality of the neutron transfer process in this reaction and, therefore, the incorrectness of the ANC extraction for the configuration {^{25}**Mg=**^{24}**Mg+n**} from the analysis. The figure 3 shows the curves (areas) of the values of the test function R (b), calculated at the main maximum of the angular distribution at both values of the energy with fixed pairs of OP in the input and output channels, which give the best description according to the $\chi 2$ criterion. It is seen that the dependence of the R values on b differs significantly from the constant.

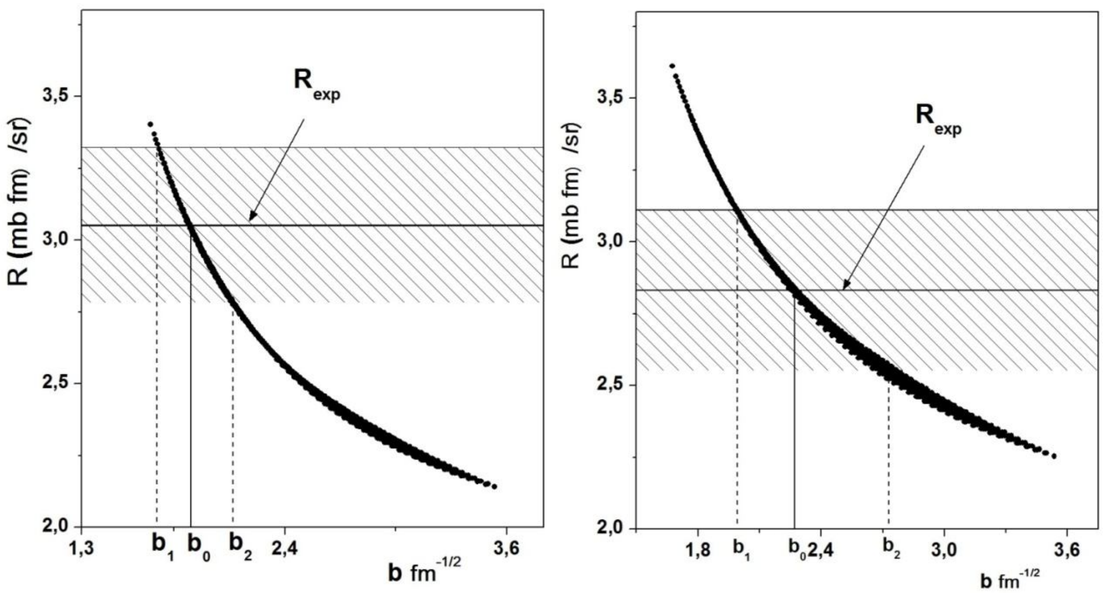

Figure 3. Graphical determination of the value b=b_0 and the corresponding SF value from the analysis of the reaction ^{24}**Mg(d,p)**^{25}**Mg**

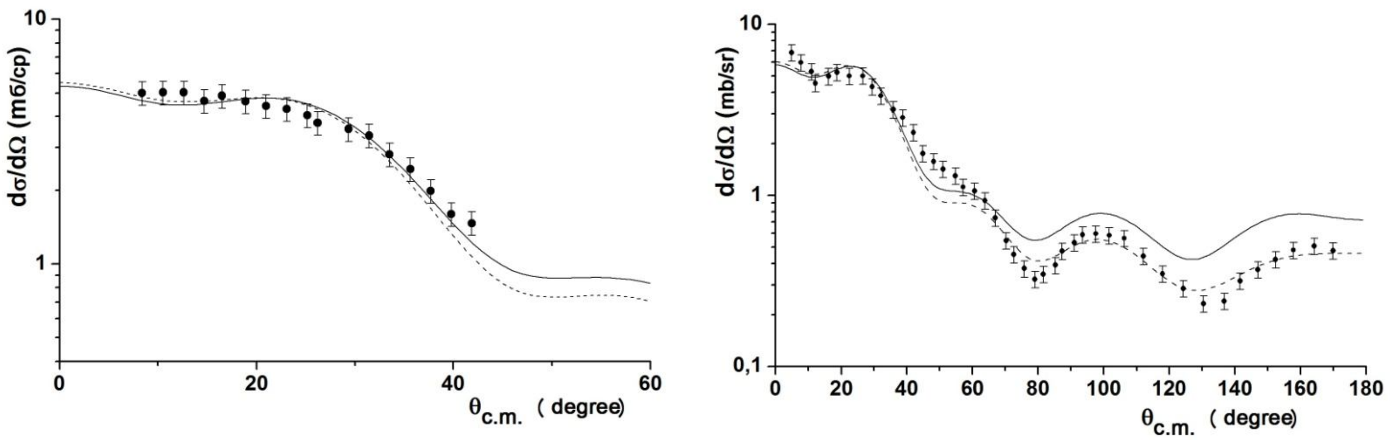

Figure 4. Calculated and experimental angular distributions for the reaction ^{25}**Mg(d,t)**^{24}**Mg.** The experimental points are taken from [10,2], respectively.

In figure4 presented the experimental and calculated in MDWBA differential cross section for the reaction ^{24}**Mg(d,p)**^{25}**Mg** at 13.6 and 14.5 MeV, respectively. The description in the region of the first (main) maximum of the angular distribution in both cases is generally satisfactory.

As shown in [1], the square of ANC is uniquely related to the SF Z by the relation C^2 = Zb^2, and the SF value for the bound state ^{25}Mg→^{24}Mg+n can be obtained. The error in determining the SF includes the dependence of the values of R on the optical parameters, and this dependence is quite significant due to the non-peripheral nature of the reaction and the large contribution of the inner part of the overlap integral.

The results of calculating the spectroscopic factor based on the expressions $R(b;[r_0,a]) = R_{\exp}$ and $C^2=Zb^2$ are illustrated in figure 3. The summed SF value for the bound state ^{25}Mg→^{24}Mg+n is $Z = 0.41^{+0.13}_{-0.11}$.

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