A NEW OUTLOOK ON THE SQUARE-WELL POTENTIALAPPROACH FOR ASTROPHYSICAL FUSION REACTION

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Introduction:

Estimation of the fusion cross section of heavy ions, which are important from the point of view of astrophysics, can be performed within the framework of the simplest model - a rectangular potential well with a complex potential. This is one of the first models for nuclear reactions in astrophysics. In a recent work [R.Ogura, K Hagino, C.A. Bertulani Phys. Rev. C99, 065808, 2019], the example of a shallow potential for the $^{16}O+^{16}O$ fusion reaction was considered. Despite the presence of artifacts associated with the absence of a diffuse edge, the results show a good reproduction of the experimental data compared to the Woods-Saxon potential. The aim of this work is to search for a possible systematics for such a model in describing the fusion cross section for the available experimental data.

Model:

A rectangular complex potential with a positive value of the real part and a negative value of the imaginary part *(V-iW)* is considered. *K* is the wave number inside the rectangular potential:

$$K=\sqrt{2\mu(E-V+iW)/\hbar^2}$$

μ – reduced mass. For the transmission coefficient we have [G. Michaud, L. Scherk, and E. Vogt, Phys. Rev. C 1, 864 1970]:

$$T_l=\frac{4P_l\operatorname{Im}(f_l)}{(1-S_l\operatorname{Re}(f_l)+P_l\operatorname{Im}(f_l))^2+(P_l\operatorname{Re}(f_l)+S_l\operatorname{Im}(f_l))^2}$$

f_l – logarithmic derivative of the wave function,

$$P_l=\frac{kR}{F_l^2+G_l^2} \qquad S_l=kR\frac{F_lF_l'+G_lG_l'}{F_l^2+G_l^2}$$

k – wave number of a free particle, and $f_l=i/KR$. Fusion cross-section is:

$$\sigma_{fus}=\frac{\pi}{k^2}\sum_l(2l+1)T_l$$

So, we have three parameters *R, V, W.*

Results:

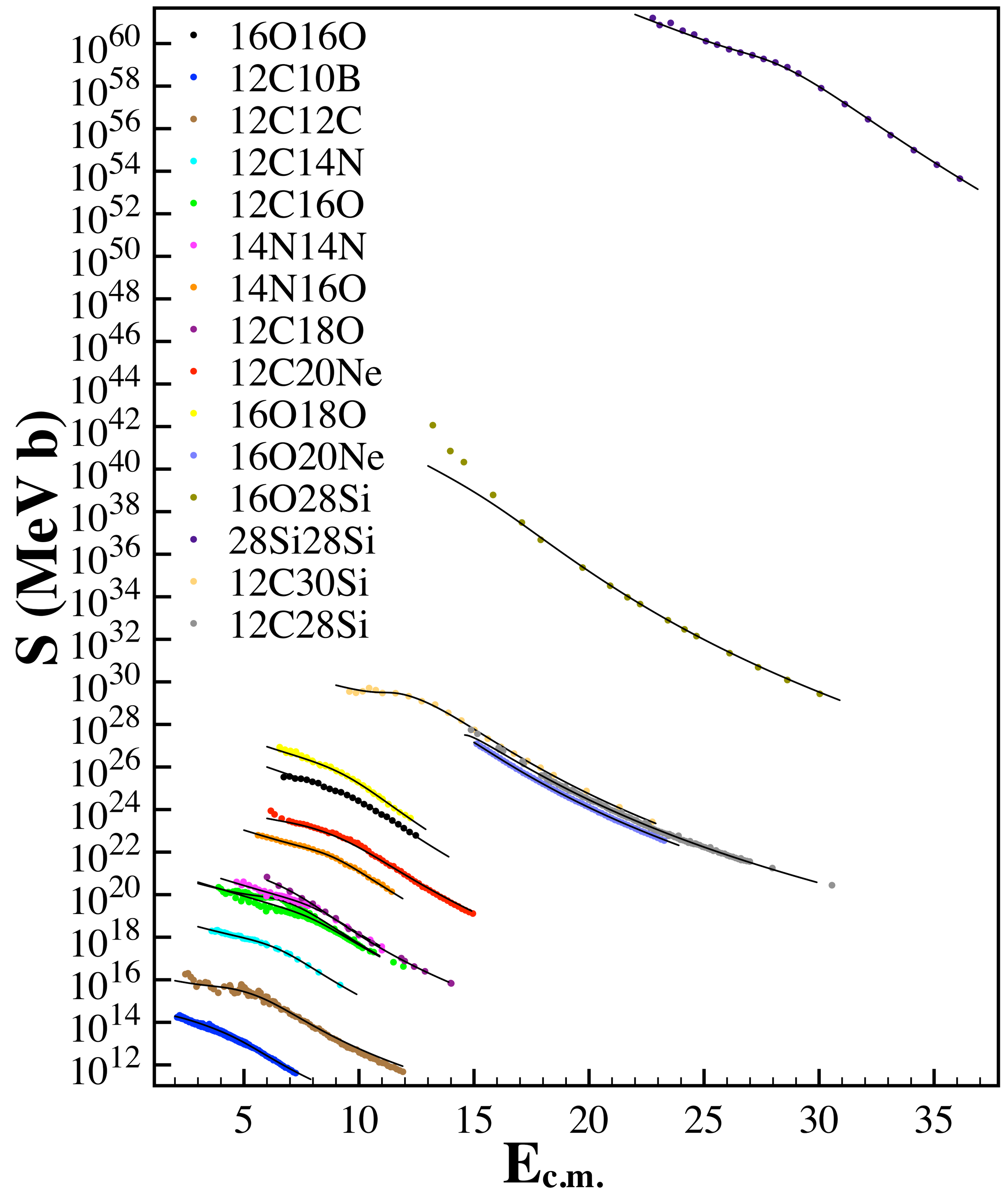

Fig. 1. (Top) Experimental values for fusion reactions (points) and fitting for a rectangular well model (solid line). Experimental data from NNDC.

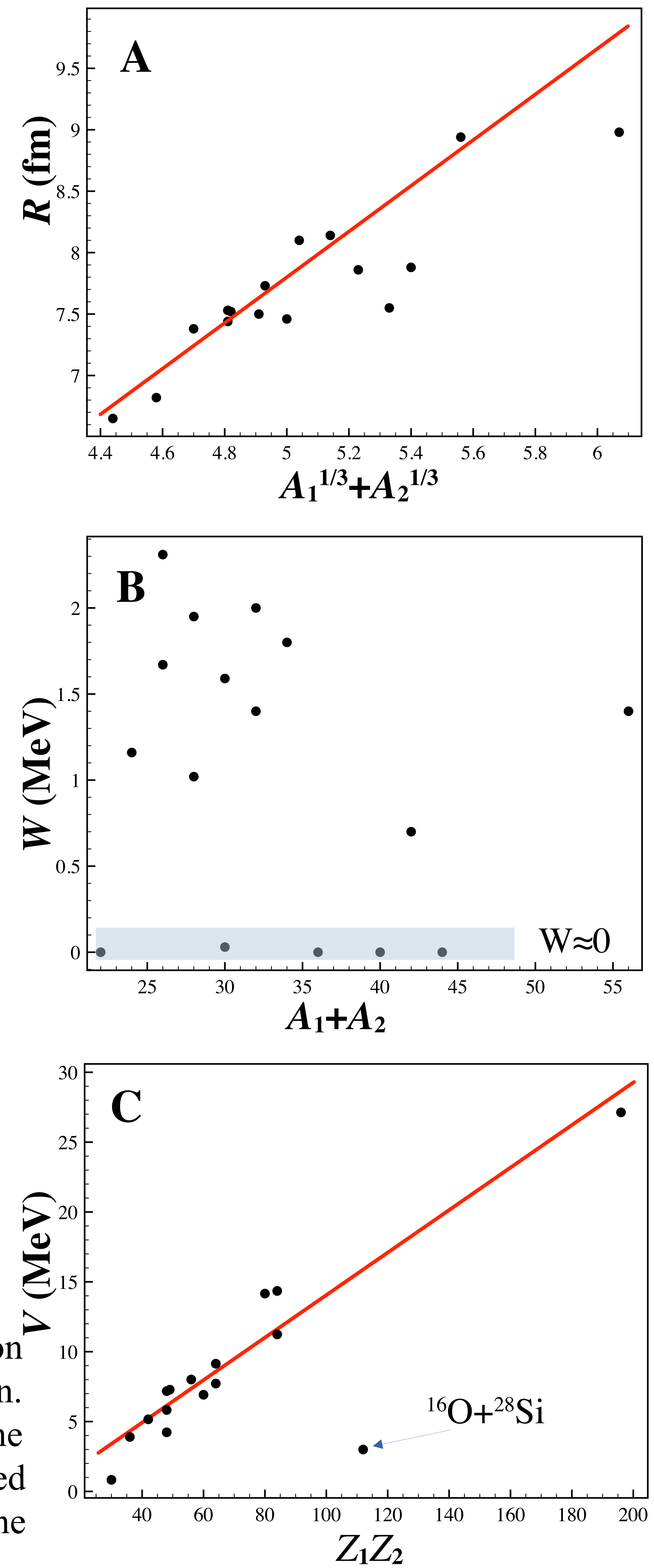

Fig. 2. (Right) Model parameters: A is the radius, B is the imaginary part of the potential, C is the real part of the potential. For A and C linear approximations are shown.

Conclusion:

As can be seen from Fig. 1, within the framework of the model, it is possible to achieve a good description of the cross section for all considered nuclei. The dependence for the radius and the real part of the potential is well described by a linear function. Thus, the main contribution to the positive part of the potential comes from the Coulomb interaction, and the depth of the potential well is almost independent of the nuclei involved in the reaction. The chaotic behavior of the *W* value can be reduced by introducing restrictions on the parameters *R* and *V* during the fitting procedure. In this case, *W* is close to 1.47 MeV. The considered approach can be useful for the systematics of data on fusion reactions in nuclear astrophysics.