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# COMPOUND NUCLEUS CROSS-SECTION CALCULATIONS FOR α-PARTICLES IN PARABOLIC APPROXIMATION

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The analysis of nuclear reaction experiments induced by D+T neutrons requires the knowledge of $T_l(E_i)$ coefficients for each open channel $i$ of a given reaction. Within the statistical theory of nuclear reactions these coefficients are calculated on the basis of two nuclear models: a rectangular threedimensional well and an optical model. Both calculations can be carried out only

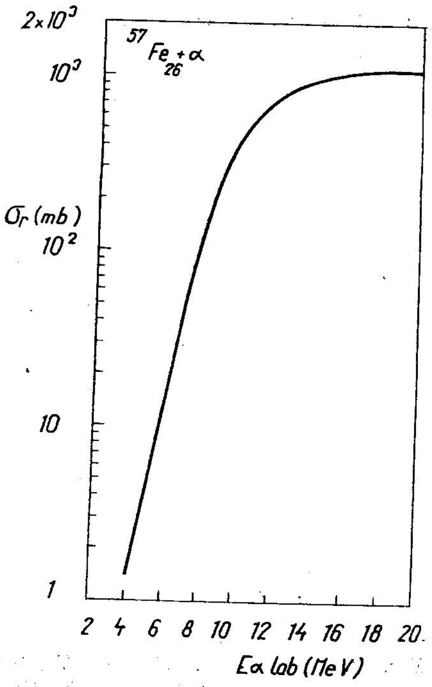


Fig. 1. Cross-section of the $^{57}Fe_{26} + \alpha$ reaction in the parabolic approximation.

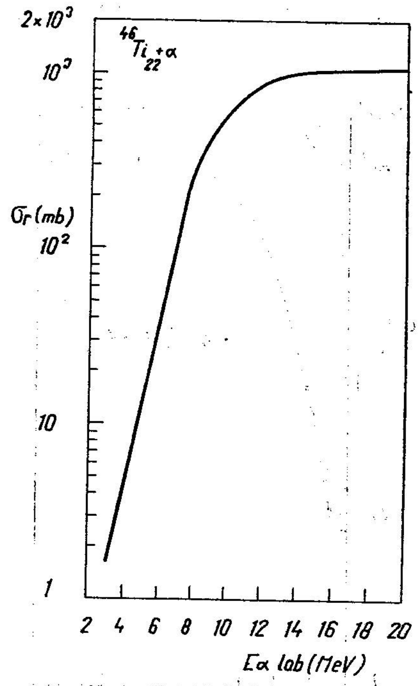


Fig. 2. Cross-section of the $^{46}Ti_{22} + \alpha$ reaction in the parabolic approximation.

numerically and they require a lot of machine time. The calculations of $T_l(E_l)$ coefficients based on the optical model of the nucleus are generaly considered to be the most accurate, resp. they are in excellent agreement with experimental data. There exist many approximate methods of calculations of $T_l(E_l)$ which are based on the two above mentioned nuclear models or which use some semiempirical formulae. Systematic tables of $T_l(E_l)$ coefficients for neutrons only [1, 2] and protons [3] are available at present. Systematic tables of $T_l(E_l)$ for $\alpha$-particles do not exist although some partial calculations based on the two models have been published [4, 5, 6].

One of the approximate methods of calculation of $T_l(E_\alpha)$ is that using the parabolic approximation of the real part of the optical potential [7] as a nuclear potential. The results of this approach are very close to the results based on optical model calculations, especially at higher energies (depending on $Z$). It seems to be convenient to program the calculations of the $T_l(E_\alpha)$ coefficients within this approach as this method is quick and uses the same parameters as the optical model.

In the following the method of compound nucleus cross-section calculations based on calculations of $T_l(E_\alpha)$ coefficients will be briefly described.

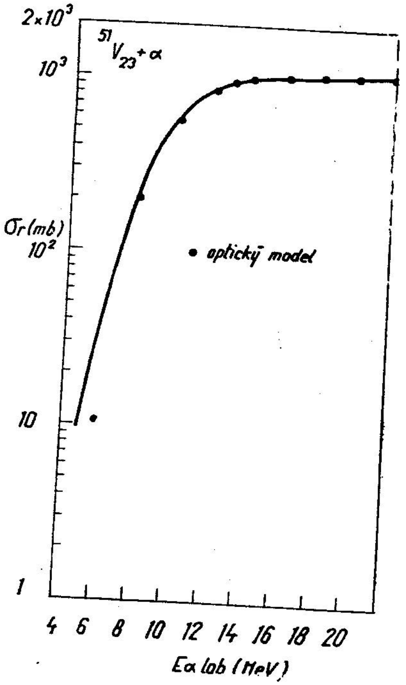


Fig. 3. Cross-section of the $^{51}V_{23} + \alpha$ reaction in the parabolic approximation. (full circles represent $\sigma_r$ calculated on the basis of the optical model [8]).



Within the statistical theory of nuclear reactions the compound nucleus cross-section is given by the relation [5]

$$\sigma_{CN} \doteq \sigma_r = \pi \lambda\!\!\!^{-2} \sum_{l=0}^{\infty} (2l + 1)\, T_l(E), \tag{1}$$

where $\lambda\!\!\!^{-}$ and $E$ are the Broglie wave length of the incident particle and its energy in the CM system. As shown by Hill and Wheeler [7], the $T_l(E_\alpha)$ coefficients in the parabolic approximation are given by

$$T_l(E_\alpha) = \left\{1 + \exp\left[\frac{2\pi(B_l - E_\alpha)}{\hbar\omega_l}\right]\right\}^{-1}, \tag{2}$$

where $B_l$ is the height of the potential barrier for the angular momentum $l$ — the maximum of the real part of the optical potential $V_l(r)$ given by

$$V_l(r) = \frac{2Ze^2}{r} + \frac{l(l+1)\hbar^2}{2\mu_\alpha r^2} - 1100 \exp\left[-\frac{r - 1.17\, A^{1/3}}{0.574}\right], \tag{3}$$

where $\mu_\alpha$ is the reduced mass of the $\alpha$-particle and $A$ is the mass number of the target nucleus. The quantity $\hbar\omega_l$ in Eq. (2) is determined by the curvature of the top of the barrier and the reduced mass of the $\alpha$-particle and is given by

$$\hbar\omega_l = \left|\frac{\hbar^2}{\mu_\alpha} \cdot \frac{d^2 V_l}{dr^2}\right|^{1/2},$$

where $d^2V_l/dr^2$ is evaluated for the value $r$, where $V_l(r)$ has the maximum. $\omega_l$ represents the vibrational frequency of the harmonic oscillator having the potential of the same form but with the reverse sign from that describing the barrier.

The program for $T_l(E_\alpha)$ calculations has been written in Algol 4 language [9]. The results of calculations are the quantities $\sigma_{CN}^{(\alpha)}(E_\alpha)$, which are necessary for the statistical calculations of the nuclear reactions. Carried out by this program, calculations were checked with the data published by Huizenga and Igo [8]. Some of the results of our calculations are plotted in Figs. 1, 2 and 3. The results of Huizenga and Igo 8] are plotted — for the sake of comparison — in Fig. 3.

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