Evaluation of Transmission Coefficients in Nuclear Processes

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1. AIMS OF THE WORK

Evaluation of transmission coefficients in nuclear reactions using a quantum mechanical approach

2. MOTIVATION

Transmission coefficients (TC) were evaluated for charged and neutral particles

TC = Probability of a micro-particle to pass a potential barrier -> 0 <= TC < 1

a) Important for nuclear reactions and time of life of nuclear states

b) In many programs TC are calculated applying approximations (ex. Gamow)

3. METHODS

Quantum-mechanical approach based on **Reflection Factor U_l**

Logarithmic derivative D_l is a function of U_l and internal wave functions / U_l depends of ingoing and outgoing functions / Internal wave function is unknown and in our calculations is considered a plane wave / Ingoing and outgoing functions are pondered sum of regular and irregular functions for charged and neutral particles

Neutral particles – Bessel functions / Charged particles – regular and irregular Coulomb functions

Functions -> have an Integral form with Complex Functions

4. RESULTS

TC for neutrons, protons, and alpha particles. Results used for the evaluations of (n,α) cross sections for medium and heavy nuclei like ^{147}Sm, ^{64}Z, ^{144}Nd and other nuclei were calculated.

They were used also in the evaluations of Widths Fluctuations Correction Factor

5. CONCLUSIONS

Evaluated TC for neutrons and alpha particles described well experimental cross sections

(n,α) data / Necessary to evaluate in the future energy dependences of WFC factor

TRANSMISSION COEFFICENTS T

$$T(l,E) = 1 - \left|U_l(E)\right|^2$$

INNER WAVE FUNCTION AS A SUM OF IN AND OUT- GOING FUNCTIONS

$$U_l = \left\{ \frac{D_l - R\left[\frac{1}{W_l^-}\frac{dW_l^-}{dr}\right]}{D_l - R\left[\frac{1}{W_l^+}\frac{dW_l^+}{dr}\right]} \frac{W_l^-}{W_l^+} \right\}_R$$

REFLECTION FACTOR

$$W_l(r) \sim W_l^-(r) - U_l W_l^+(r)$$

$$D_l = R\left[\frac{1}{W_l}\frac{dW_l}{dr}\right]_R$$

LOGARTHMIC DERIVATIVE

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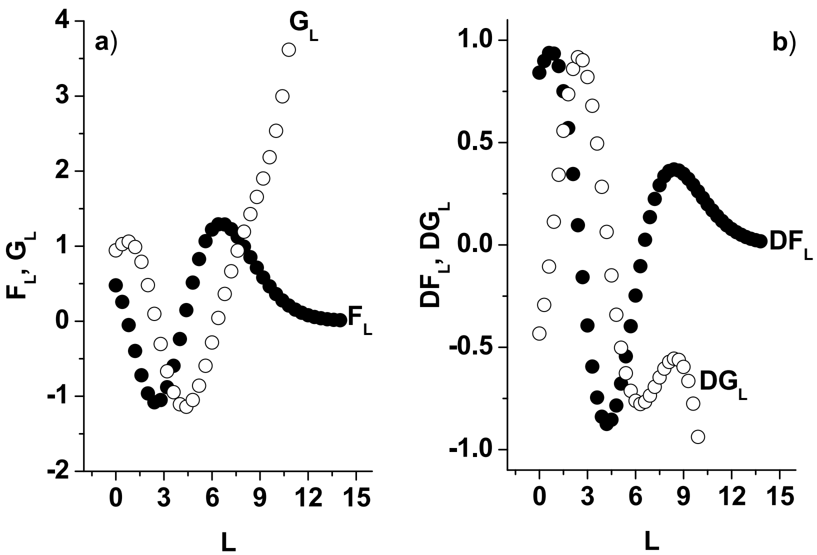
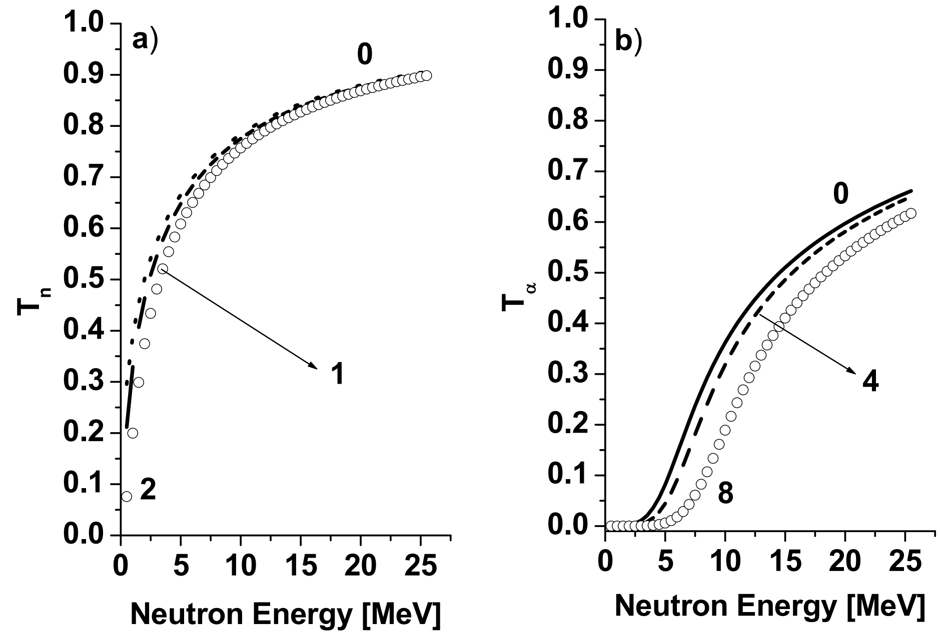


Dependence by orbital momentum *l* of a) Regular and irregular Coulomb functions (F_l, G_l) b) Derivatives of regular and irregular Coulomb functions (DF_l, DG_l)

$$F_l - iG_l = \frac{e^{-\pi\rho}\rho^{l+1}}{(2l+1)!\,c_l(\eta)} \int_{-1}^{-i\infty} e^{-i\rho t}(1-t)^{l-i\eta}(1+t)^{l+i\eta}\,dt,$$

$$c_l(\eta) = \frac{2^l e^{-\frac{\pi\eta}{2}} \left|\Gamma(l+1+i\eta)\right|}{\Gamma(2l+2)}$$

TRANSMISSION COEFFICIENTS



$^{143}Nd(n,\alpha)^{140}Ce$.

Orbital momentum:

a) Neutrons, $l_n = 0,1,2$; Alphas, $l_a = 0,4,8$

TC are positives and lower than 1