The transition rates for ^{232}Th using the two component particle-hole state density with different corrections

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Abstract

The particle-hole state densities have been calculated for ^{232}Th in the case of incident neutron with $T = T_Z$, $T = T_Z + 1$ and $T = T_Z + 2$. The finite well depth, surface effect, isospin and Pauli correction are considered in the calculation of the state densities and then the transition rates. The isospin correction function (f_{iso}) has been examined for different exciton configurations and at different excitation energies up to 100 MeV. The present results are indicated that the included corrections have more affected on transition rates behavior for $(\lambda_{\pi+}, \lambda_{\nu+}, \lambda_{\pi\nu}$ and $\lambda_{\nu\pi})$ above 30MeV excitation energy.

Key words

transition rates, state density, Surface effect.

Article info

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معدلات الانتقال للنظير ^{232}Th باستخدام كثافة المستوي جسيم- فجوة ثنائي التركيب مع تصحيحات مختلفة

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الخلاصة

تم حساب كثافة المستوي جسيم- فجوة للنظير ^{232}Th في حالة سقوط نيترون عند:

$$T = T_Z, T = T_Z + 1, T = T_Z + 2$$

تم اعتماد التصحيحات التالية: جهد البئر المحدد، تأثير القشرة، احادي البرم و تصحيح باولي في حساب كثافات المستوي ومن ثم معدلات الانتقال. تم فحص تصحيح دالة أحادي البرم (f_{iso}) لعدة أشكال مختلفة للاكسايتون وعند طاقات تهيج مختلفة تصل إلى 100 مليون الكترون فولت. أن النتائج الحالية قد بينت أن التصحيحات المضافة لها تأثير كبير على تصرف معدلات الانتقال $(\lambda_{\pi+}, \lambda_{\nu+}, \lambda_{\pi\nu}, \lambda_{\nu\pi})$ فوق طاقة التهيج 30 مليون الكترون فولت.

Introduction

The exciton model, at first proposed by Griffin [1] to describe the equilibration of the composite nucleus. This model neglects all the required corrections that needed to be added to the state density formula. Thus, the effect of the surface, isospin and the finite well depth are all now considered. For isospin conserved calculations, state density for particle-hole configurations with isospin correction function is needed. The isospin dependence of nuclear state density becomes important since 1977 where Jensen [2] derived some expressions for isospin dependence state density, then Kalbach[3] derived additional expressions for the two-component particle-hole state density with $T = T_Z$, $T = T_Z + 1$ and $T = T_Z + 2$, where T is the total isospin, and $T_Z = (N - Z)/2$ is its Z component for nucleus with neutrons N greater than protons Z. In order to get a complete corrected state density, additional factors were included in the state density formula one of these recommended factors is the isospin correction function $f(p_\pi, h_\pi, p_\nu, h_\nu)$. The presence of the nuclear surface will strongly affect the target-projectile interactions, since, as the incident energy increased, the mean free path of the projectile in the nucleus will decrease, and the first interaction will be localized in the nuclear surface. In order to include the surface effect in our calculations, we must first examine the finite well depth correction which contains the surface effect. Běták and Dobeš [4] derived the finite well depth correction function, which eliminate the states with holes below the bottom of the well, but they did not include the surface effect in their calculation; they assumed that the depth of the nuclear potential well V is constant and equals to 38 MeV. Kalbach, [3] included the surface effect and used the effective well depth of the surface region. She assumed that V is not constant, but it has a different value and depends on the number of the holes. Many calculations have been performed to evaluate the effective potential well; some of these estimations assumed that the effective potential well depends only on the projectile energy but does not depend on the type of the incident particle [3]. Other calculations included the effect of the type of the incident particle and its energy [5], also the inclusion of the effect for the type of the target nucleus was suggested in [6, 7].

The aim of the present work is to investigate the effect of the finite well depth correction function $f(p_\pi, h_\pi, p_\nu, h_\nu, V_{eff}, E)$ which includes the surface effect in addition to the isospin correction function $f(p_\pi, h_\pi, p_\nu, h_\nu, T, T_Z)$, in calculation of the state density and then the transition rates for n- ^{232}Th reactions.

Theory

The state density with including the isospin correction function for the states with $T = T_Z$, $T = T_Z + 1$ and $T = T_Z + 2$ can be written as [7],

$$\omega(p_\pi,h_\pi,p_\nu,h_\nu,E,T=T_z,T_z)=\omega(p_\pi,h_\pi,p_\nu,h_\nu,E)$$
$$-\left[Y_1(p_\pi-1,h_\pi,p_\nu+1,h_\nu,E_1)+Y_2(p_\pi-1,h_\pi,p_\nu,h_\nu-1,E_1)+Y_3(p_\pi,h_\pi+1,p_\nu,h_\nu-1,E_1)\right]$$
$$\omega(p_\pi,h_\pi,p_\nu,h_\nu,E_1) \qquad (1)$$

$$\omega(p_\pi,h_\pi,p_\nu,h_\nu,E,T=T_z+1,T_z)=X_1(p_\pi-1,h_\pi,p_\nu+1,h_\nu,E_1)\omega(p_\pi-1,h_\pi,p_\nu+1,h_\nu,E_1)$$
$$+X_2(p_\pi,h_\pi,p_\nu,h_\nu,E_1)\omega(p_\pi,h_\pi,p_\nu,h_\nu,E_1)+X_3(p_\pi,h_\pi+1,p_\nu,h_\nu-1,E_1)\omega(p_\pi,h_\pi+1,p_\nu,h_\nu-1,E_1)$$
$$-\left\{X_1(p_\pi-1,h_\pi,p_\nu+1,h_\nu,E_1)\frac{p_\pi}{p_\nu+1}\frac{g_\nu}{g_\pi}\times\left[Y_1(p_\pi-2,h_\pi,p_\nu+2,h_\nu,E_2)\right.\right.$$
$$\left.+Y_2(p_\pi-2,h_\pi,p_\nu+1,h_\nu-1,E_2)+Y_3(p_\pi-1,h_\pi+1,p_\nu+1,h_\nu-1,E_2)\right]$$
$$+X_2(p_\pi,h_\pi,p_\nu,h_\nu,E_1)\left[Y_1(p_\pi-1,h_\pi,p_\nu+1,h_\nu,E_2)+Y_2(p_\pi-1,h_\pi,p_\nu,h_\nu-1,E_2)\right.$$
$$\left.+Y_3(p_\pi,h_\pi+1,p_\nu+1,h_\nu-1,E_2)\right]+X_3(p_\pi,h_\pi+1,p_\nu,h_\nu-1,E_1)\frac{h_\nu}{h_\pi+1}\frac{g_\pi}{g_\nu}$$
$$\left.\times\left[Y_1(p_\pi-1,h_\pi+1,p_\nu+1,h_\nu-1,E_2)+Y_2(p_\pi-1,h_\pi+1,p_\nu,h_\nu-2,E_2)+Y_3(p_\pi,h_\pi+2,p_\nu,h_\nu-2,E_2)\right]\right\}$$
$$\times\omega(p_\pi,h_\pi,p_\nu,h_\nu,E_2) \qquad (2)$$

$$\omega(p_\pi,h_\pi,p_\nu,h_\nu,E,T=T_z+2,T_z)=X_{11}(p_\pi-2,h_\pi,p_\nu+2,h_\nu,E_2)\omega(p_\pi-2,h_\pi,p_\nu+2,h_\nu,E_2)$$
$$+2X_{12}(p_\pi-1,h_\pi,p_\nu+1,h_\nu,E_2)\omega(p_\pi-1,h_\pi,p_\nu+1,h_\nu,E_2)$$
$$+2X_{13}(p_\pi-1,h_\pi+1,p_\nu+1,h_\nu-1,E_2)\omega(p_\pi-1,h_\pi+1,p_\nu+1,h_\nu-1,E_2)$$
$$+X_{22}(p_\pi,h_\pi,p_\nu,h_\nu,E_2)\omega(p_\pi,h_\pi,p_\nu,h_\nu,E_2)+2X_{23}(p_\pi,h_\pi+1,p_\nu,h_\nu-1,E_2)\omega(p_\pi,h_\pi+1,p_\nu,h_\nu-1,E_2)$$
$$+X_{33}(p_\pi,h_\pi+2,p_\nu,h_\nu-2,E_2)\omega(p_\pi,h_\pi+2,p_\nu,h_\nu-2,E_2)-\{\ X_{11}(p_\pi-2,h_\pi,p_\nu+2,h_\nu,E_2)$$
$$\times\frac{p_\pi}{p_\nu+1}\frac{p_\pi-1}{p_\nu+2}\left(\frac{g_\nu}{g_\pi}\right)^2\times[\ Y_1(p_\pi-3,h_\pi,p_\nu+3,h_\nu-2,E_3)+Y_2(p_\pi-3,h_\pi,p_\nu+2,h_\nu-1,E_3)$$
$$+Y_3(p_\pi-2,h_\pi+1,p_\nu+2,h_\nu-1,E_3)\ ]+2X_{12}(p_\pi-1,h_\pi,p_\nu+1,h_\nu,E_2)\frac{p_\pi}{p_\nu+1}\left(\frac{g_\nu}{g_\pi}\right)$$
$$\times[\ Y_1(p_\pi-2,h_\pi,p_\nu+2,h_\nu,E_3)+Y_2(p_\pi-2,h_\pi,p_\nu+1,h_\nu-1,E_3)+Y_3(p_\pi-1,h_\pi+1,p_\nu+1,h_\nu-1,E_3)\ ]$$
$$-2X_{13}(p_\pi-1,h_\pi+1,p_\nu+1,h_\nu-1,E_2)\frac{p_\pi}{p_\nu+1}\frac{h_\nu}{h_\pi+1}\times[\ Y_1(p_\pi-2,h_\pi+1,p_\nu+2,h_\nu-1,E_3)$$
$$+Y_2(p_\pi-2,h_\pi+1,p_\nu+1,h_\nu-2,E_3)+Y_3(p_\pi-1,h_\pi+2,p_\nu+1,h_\nu-2,E_3)\ ]+X_{22}(p_\pi,h_\pi,p_\nu,h_\nu,E_2)$$
$$\times[\ Y_1(p_\pi-1,h_\pi,p_\nu+1,h_\nu,E_3)+Y_2(p_\pi-1,h_\pi,p_\nu,h_\nu-1,E_3)+Y_3(p_\pi,h_\pi+1,p_\nu,h_\nu-1,E_3)\ ]$$
$$+2X_{23}(p_\pi,h_\pi+1,p_\nu,h_\nu-1,E_2)\frac{h_\nu}{h_\pi+1}\left(\frac{g_\pi}{g_\nu}\right)\times[\ Y_1(p_\pi-1,h_\pi+1,p_\nu+1,h_\nu-1,E_3)$$
$$+Y_2(p_\pi-1,h_\pi+1,p_\nu,h_\nu-2,E_3)+Y_3(p_\pi,h_\pi+2,p_\nu,h_\nu-2,E_3)\ ]+X_{33}(p_\pi,h_\pi+2,p_\nu,h_\nu-2,E_2)$$
$$\times\frac{h_\nu}{h_\pi+1}\frac{h_\nu-1}{h_\pi+2}\left(\frac{g_\nu}{g_\pi}\right)^2\times[\ Y_1(p_\pi-1,h_\pi+2,p_\nu+1,h_\nu-2,E_3)+Y_2(p_\pi-1,h_\pi+2,p_\nu,h_\nu-3,E_3)$$
$$+Y_3(p_\pi,h_\pi+3,p_\nu,h_\nu-3,E_3)\ ]\}\omega(p_\pi,h_\pi,p_\nu,h_\nu,E_3) \qquad (3)$$

where the three Y functions,

$$Y_1(p_\pi,h_\pi,p_\nu,h_\nu,E_i)=\frac{p_\pi+1}{p_\pi+h_\pi+2(T_e+i)}\frac{g_\nu}{g_\pi} \qquad (4)$$

$$Y_2(p_\pi,h_\pi,p_\nu,h_\nu,E_i)=\frac{2(T_e+i)}{p_\nu+h_\pi+2(T_e+i)}\frac{(p_\pi+1)(h_\nu+1)(n-1)(n-2)}{g_\pi g_\nu[E-A(p_\pi,h_\pi,p_\nu,h_\nu)]^2} \qquad (5)$$

$$Y_3(p_\pi,h_\pi,p_\nu,h_\nu,E_i)=\frac{h_\nu+1}{p_\nu+h_\nu+2(T_e+i)}\frac{g_\pi}{g_\nu} \qquad (6)$$

where T_e is the isospin of the target nucleus,
$g_\pi=Z/13$ and $g_\nu=N/13$.
The three X functions for single isospin flip are given by:

$$X_1(p_\pi,h_\pi,p_\nu,h_\nu,E_1)=\frac{p_\nu}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_1)} \qquad (7)$$

$$X_2(p_\pi,h_\pi,p_\nu,h_\nu,E_1)=\frac{B(p_\pi,h_\nu,E_1)}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_1)} \quad (8)$$

$$X_3(p_\pi,h_\pi,p_\nu,h_\nu,E_1)=\frac{h_\pi}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_1)} \quad (9)$$

and those for double isospin flips,

$$X_{11}(p_\pi,h_\pi,p_\nu,h_\nu,E_2)=\frac{p_\nu}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_2)}\ \frac{p_\nu-1}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_2)-1} \quad (10)$$

$$X_{12}(p_\pi,h_\pi,p_\nu,h_\nu,E_2)=\frac{p_\nu}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_2)}\ \frac{B(p_\pi,h_\nu,E_2)}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_2)-1} \quad (11)$$

$$X_{13}(p_\pi,h_\pi,p_\nu,h_\nu,E_2)=\frac{p_\nu}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_2)}\ \frac{h_\pi}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_2)-1} \quad (12)$$

$$X_{22}(p_\pi,h_\pi,p_\nu,h_\nu,E_2)=\frac{B(p_\pi,h_\nu,E_2)}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_2)}\ \frac{B(p_\pi,h_\nu,E_2)-1}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_2)-1} \quad (13)$$

$$X_{23}(p_\pi,h_\pi,p_\nu,h_\nu,E_2)=\frac{B(p_\pi,h_\nu,E_2)}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_2)}\ \frac{h_\pi}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_2)-1} \quad (14)$$

$$X_{33}(p_\pi,h_\pi,p_\nu,h_\nu,E_2)=\frac{h_\pi}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_2)}\quad \frac{h_\pi-1}{C(p_\pi,h_\pi,p_\nu,h_\nu,E_2)-1} \quad (15)$$

The total number of isospin flip possibilities is:

$$C(p_\pi,h_\pi,p_\nu,h_\nu,E_i)=B(p_\pi,h_\nu,E_i)+p_\nu+h_\pi \quad (16)$$

where $i = 1, 2, 3, \ldots\ldots$

$$B(p_\pi,h_\nu,E_i)=2(T_e+i)-(p_\pi+h_\nu)f_2(p_\pi,h_\pi,p_\nu,h_\nu,E_i)+\frac{p_\pi h_\nu}{2T_e}\left[f_2(p_\pi,h_\pi,p_\nu,h_\nu,E_i)\right]^2 \quad (17)$$

and

$$f_2(p_\pi,h_\pi,p_\nu,h_\nu,E_i)=1-\left[\frac{E_i-A(p_\pi,h_\pi,p_\nu,h_\nu,E_i)-2(T_e+i)/g_a}{E_i-A(p_\pi,h_\pi,p_\nu,h_\nu)}\right]^{n-1} \quad (18)$$

which represents the function of the n-excitons in full configuration with an excitation energy between zero and $2(T_e+i)/g_a$.

with the average single particle state density $g_a=(g_\pi+g_\nu)/2$.

The effective excitation energy is given by:

$$E_i=E-E_{sym}\left(|T_z|+i,T_z\right) \quad (19)$$

where the symmetry energy term is given by [7]:

$$E_{sym}(T,T_z) = \left[\frac{112MeV}{A} - \frac{133MeV}{A^{4/3}}\right]\left(T^2 - T_z^2\right) \quad (20)$$

The other correction that required to be added to the state density formula is the finite well depth correction function which is given by [3]:

$$f(p,h,E,V) = 1 + \sum_{i=1}^{h}(-1)^i \binom{h}{i}\left[\frac{E - iV_{eff}}{E}\right]^{n-1} \Theta(E - iV) \quad (21)$$

With the effective potential well V_{eff} given by [6]:

$$V_{eff} = 22 + 16\frac{E_p^4}{E_p^4 + (\frac{450}{A^{1/3}})^4} MeV \qquad \text{for h} = 1 \text{ and incident proton}$$

$$V_{eff} = 12 + 26\frac{E_p^4}{E_p^4 + (\frac{245}{A^{1/3}})^4} MeV \qquad \text{for h} = 1 \text{ and incident neutron}$$

$$V_{eff} = E_f = 38MeV \qquad \text{for h} > 1 \quad (22)$$

where E_p is the incident particle energy. The complete state density formula with all required corrections is then given by

$$\omega(p_\pi,h_\pi,p_\nu,h_\nu,E,T) = \frac{g_\pi^{n_\pi} g_\nu^{n_\nu}\left[E - A(p_\pi,h_\pi,p_\nu,h_\nu,E,T)\right]^{n-1}}{p_\pi! h_\pi! p_\nu! h_\nu! (n-1)!} f(p_\pi,h_\pi,p_\nu,h_\nu,V_{eff},E) f(p_\pi,h_\pi,p_\nu,h_\nu,T,T_z) \quad (23)$$

The energy dependent Pauli correction is given by [7]:

$$A(p_\pi,h_\pi,p_\nu,h_\nu,E,T) = E_{th}(p_\pi,h_\pi,p_\nu,h_\nu) - \frac{p_\pi^2 + h_\pi^2 + n_\pi}{4g_\pi} - \frac{p_\nu^2 + h_\nu^2 + n_\nu}{4g_\nu}$$
$$+ \frac{\left[\left(p_\pi - \frac{2}{m}\right)\left(p_\pi - \frac{3}{m}\right) + \frac{1}{m}\right]\Theta\left(p_\pi - \frac{1}{2}\right)}{g_\pi G_\pi(p_\pi,h_\pi,p_\nu,h_\nu,E)} + \frac{\left[\left(h_\pi - \frac{2}{m}\right)\left(h_\pi - \frac{3}{m}\right) + \frac{1}{m}\right]\Theta\left(h_\pi - \frac{1}{2}\right)}{g_\pi G_\pi(p_\pi,h_\pi,p_\nu,h_\nu,E)}$$
$$+ \frac{\left[\left(p_\nu - \frac{2}{m}\right)\left(p_\nu - \frac{3}{m}\right) + \frac{1}{m}\right]\Theta\left(p_\nu - \frac{1}{2}\right)}{g_\nu G_\nu(p_\pi,h_\pi,p_\nu,h_\nu,E)} + \frac{\left[\left(h_\nu - \frac{2}{m}\right)\left(h_\nu - \frac{3}{m}\right) + \frac{1}{m}\right]\Theta\left(h_\nu - \frac{1}{2}\right)}{g_\nu G_\nu(p_\pi,h_\pi,p_\nu,h_\nu,E)} \quad (24)$$

m is the active exciton classes and the threshold energy is given by:

$$E_{th}(p_\pi,h_\pi,p_\nu,h_\nu) = \frac{\max(p_\pi,h_\pi)}{g_\pi} + \frac{\max(p_\nu,h_\nu)}{g_\nu} \quad (25)$$

The function G has the form

$$G_\pi(p_\pi,h_\pi,p_\nu,h_\nu) = 9.35 + \frac{(5.7 - 0.6m)mg_\pi(E - E_{th}(p_\pi,h_\pi,p_\nu,h_\nu))}{n} \quad (26)$$

The possible transitions that carry the system from one class of particle-hole configuration to another, are the creation of particle-hole pair or the conversion of a proton pair into neutron pair and *vice versa*. The complete formula of the transition rates with the recommended corrections listed above is given by [7]:

$$\lambda_{\pi+}(p_\pi,h_\pi,p_\nu,h_\nu,E,T)=\frac{2\pi}{\hbar}\frac{(p_\pi+1)(h_\pi+1)}{2}\frac{\omega(p_\pi+1,h_\pi+1,p_\nu,h_\nu,E,T)}{\omega(p_\pi,h_\pi,p_\nu,h_\nu,E,T)}(n_\pi g_\pi M^2_{\pi\pi}+2n_\nu g_\nu M^2_{\pi\nu})$$
$$\times f(p_\pi,h_\pi,p_\nu,h_\nu,V_{eff},E)f_{iso}(p_\pi,h_\pi,p_\nu,h_\nu,T,T_z) \qquad (27)$$

$\lambda_{\nu+}$ is the same as $\lambda_{\pi+}$ but with interchanging π with ν.

$$\lambda_{\pi\nu}(p_\pi,h_\pi,p_\nu,h_\nu,E,T)=\frac{2\pi}{\hbar}M^2_{\pi\nu}\frac{p_\pi h_\pi}{n}g_\nu^2\left(\frac{E-A_{\pi\nu}(p_\pi,h_\pi,p_\nu,h_\nu,E,T)}{E-A(p_\pi,h_\pi,p_\nu,h_\nu,E,T)}\right)^{n-1}$$
$$\times\left\{2\left[E-A_{\pi\nu}(p_\pi,h_\pi,p_\nu,h_\nu,E,T)\right]-n\left|A(p_\pi,h_\pi,p_\nu,h_\nu,E,T)-A(p_\pi-1,h_\pi-1,p_\nu+1,h_\nu+1,E,T)\right|\right\}$$
$$\times f(p_\pi,h_\pi,p_\nu,h_\nu,V_{eff},E)f_{iso}(p_\pi,h_\pi,p_\nu,h_\nu,T,T_z) \qquad (28)$$

$$A_{\pi\nu}(p_\pi,h_\pi,p_\nu,h_\nu,E,T)=\max(A(p_\pi,h_\pi,p_\nu,h_\nu,E,T),A(p_\pi-1,h_\pi-1,p_\nu+1,h_\nu+1,E,T) \qquad (29)$$

$$A_{\nu\pi}(p_\pi,h_\pi,p_\nu,h_\nu,E,T)=\max(A(p_\pi,h_\pi,p_\nu,h_\nu,E,T),A(p_\pi+1,h_\pi+1,p_\nu-1,h_\nu-1,E,T) \qquad (30)$$

M^2 is the two-body interaction squared matrix element, in this work, we adopted two formulas of this matrix; the first is Kalbach's result, which can be used only at low excitation energy [6], actually not higher than 60 MeV ,

$$M^2=\frac{1}{A^3}\left[\frac{8.1\times10^5}{\left(\frac{E}{n}+14.4\right)^3}\right] \qquad (31)$$

The other expression is parameterized for high excitation energy [6]:

$$M^2=\frac{1}{A^3}\left[6.8+\frac{4.2\times10^5}{\left(\frac{E}{n}+10.7\right)^3}\right] \qquad (32)$$

The two-component matrix elements are given in terms of an average M^2, by

$$M^2_{\nu\nu}=M^2_{\pi\pi}=M^2 \qquad (33)$$

$$M^2_{\pi\nu}=M^2_{\nu\pi}=R\pi\nu M^2 \qquad (34)$$

$$R_{\pi\nu}=1.5 \qquad (35)$$

The above transition rates are the complete expressions which include the isospin finite depth and the surface effects.

Results, discussions and conclusions

The particle-hole state densities have been calculated for ^{232}Th in the case of incident neutrons with $T = T_Z$, $T = T_Z + 1$ and $T = T_Z + 2$. The results are shown in Figs. 1 and 2 respectively, with different configurations. In both figures, one can note the downward shift for the value of the state density in case of states with $T \rangle T_Z$, for clearness the results are multiplied by 0.1 and 0.01. The value of the state density starts to increase rapidly at low excitation energies, while for higher energies, it continues increasing but gradually. The state density calculations are important for calculating the transition rates but before doing this one must see the behavior of the isospin correction function with $T = T_Z$, which was shown in Fig. 3 with multiple configurations and in all cases, the value of this function is unity at energies lower than 30 MeV, so it doesn't affect the transition rates or the state density behavior, as the energy increase higher and higher, function starts to affect the transition rates value.The behavior of the transition rates as a function of excitation energy for n=3 are shown in Figs. 4, 5 and 6 for creation of proton particle-hole pair $\lambda_{\pi+}$, neutron particle-hole pair $\lambda_{\nu+}$ and conversion of proton into neutron and vice versa $\lambda_{\pi\nu}$ and $\lambda_{\nu\pi}$. The finite well depth, surface effect, isospin and Pauli corrections are included. In these figures, two types of squared matrix elements are included; the solid curve gives the results for the transition rates calculated using the matrix element given by Eq. (32) while the dashed curve gives the results using Eq. (31). The two curves give the same results at energies lower than 30MeV, then they start to deviate to give a different behavior. The transition rates calculated using Eq. (31), dashed curve, at high energies become so small compared to the transitions calculated with Eq. (32).

Figs. (7-9) illustrate comparisons of the transition rates $\lambda_{\pi+}$, $\lambda_{\nu+}$ and $\lambda_{\nu\pi}$ in case of n=3, T=T_z and incident neutron on ^{58}Fe and ^{232}Th, in these figures one can see the effect of the mass of a nuclei on the transmission of particles and holes. In case of creation a proton particle hole pair $\lambda_{\pi+}$, in heavy nuclei these transitions are slightly lower than those for light once while for $\lambda_{\nu+}$ the behavior is different and the heavy nuclei will have the higher transitions. For the case of conversion of a neutron particle hole pair into a proton particle hole pair, the transitions for this case will be high in the light nuclei compared with the heavy one.

Fig. 10 shows a comparison between the transition rates of creation of a proton particle-hole pair in case of no correction was added, with isospin correction only and with all required corrections for (1,1,1,0) and (0,0,2,1) configurations using the two body squared matrix element calculated using Eq. (32) which give correct results at high energies, The behavior of these curves explains that these corrections will reduce the number of transitions per unit time at energies higher than 60 MeV but lower than this these corrections do not affect the transitions. Adding all the required corrections will reduce the transitions.

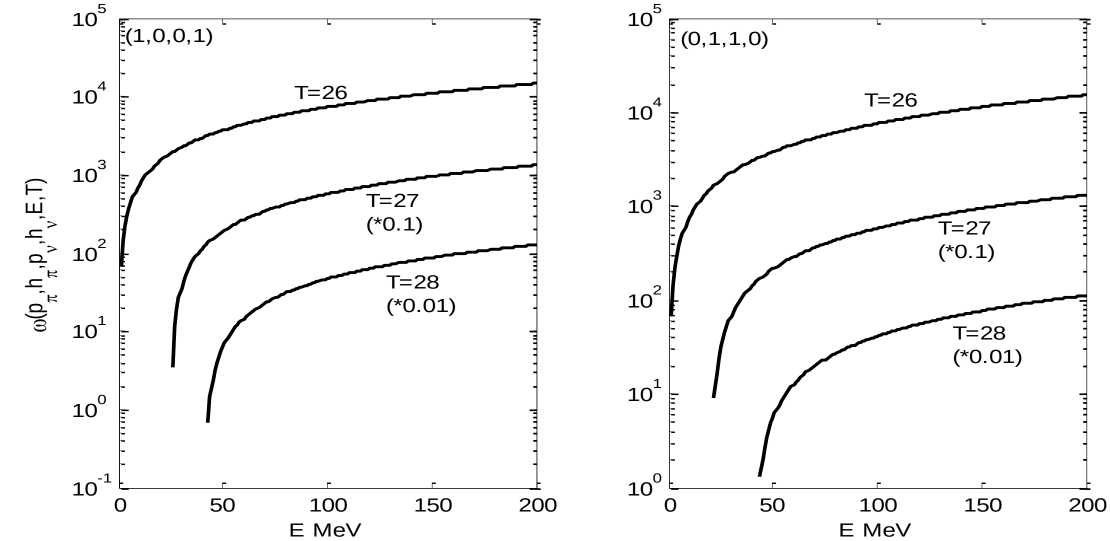

Fig. 1. The isospin dependent state density as a function of excitation energy in ^{232}Th for n=2.

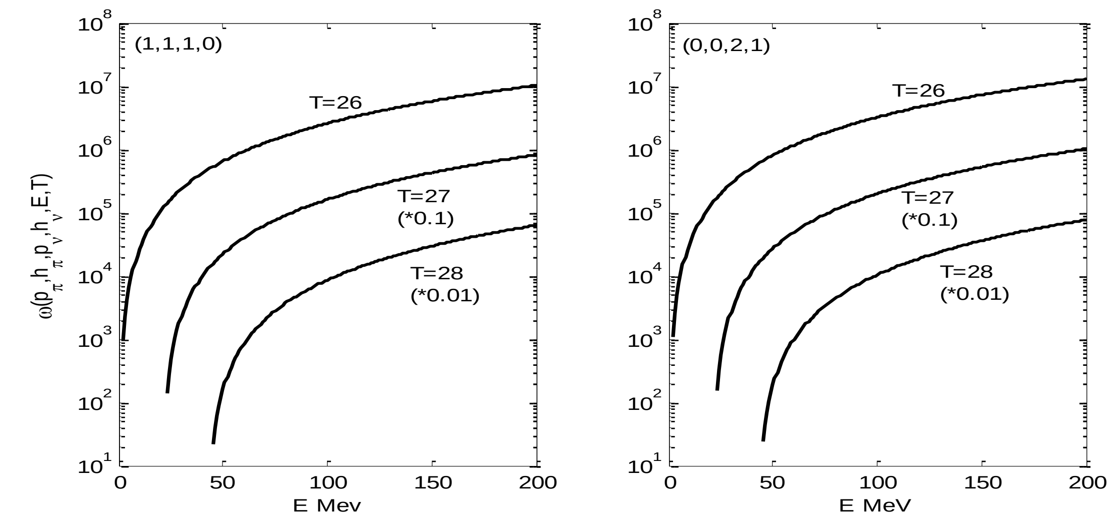

Fig. 2. The isospin dependent state density as a function of excitation energy in ^{232}Th for n=3.

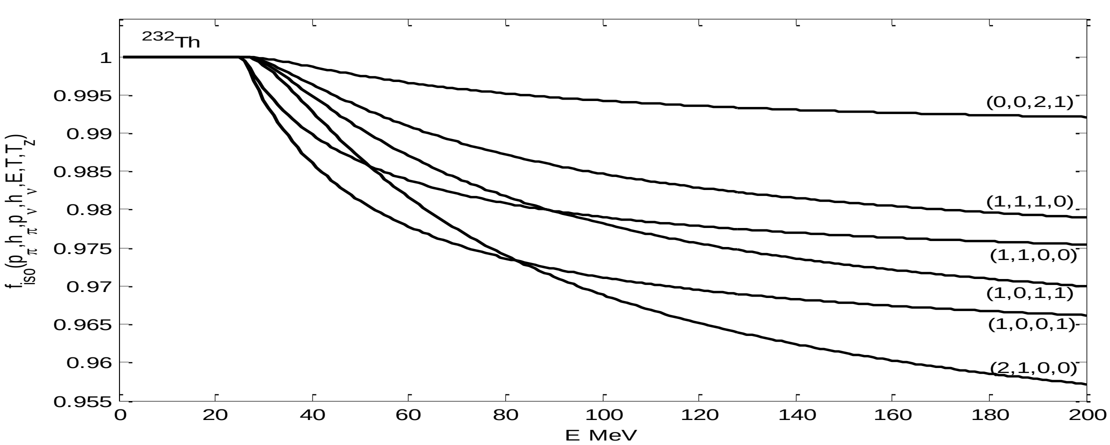

Fig. 3. The isospin correction functions as a function of excitation energy.

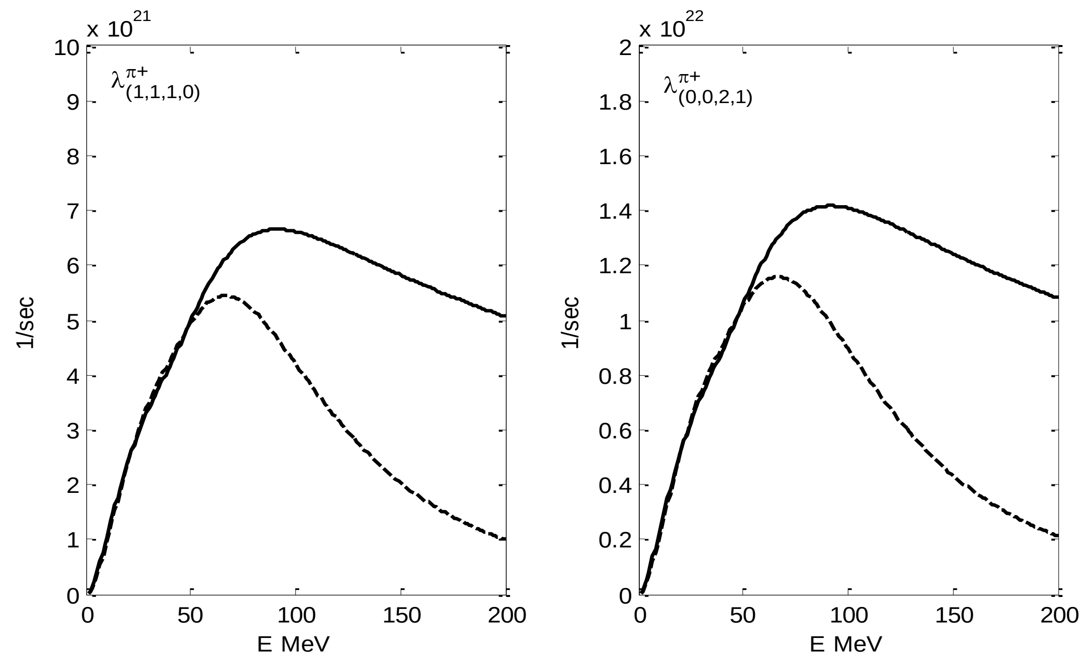

Fig. 4. The transition rates for creation of a proton particle-hole pair as a function of excitation energy in ^{232}Th for n=3 and incident neutron, the solid curve calculated using the matrix element taken from Eq. (32) while the dashed curve was calculated using Eq. (31).

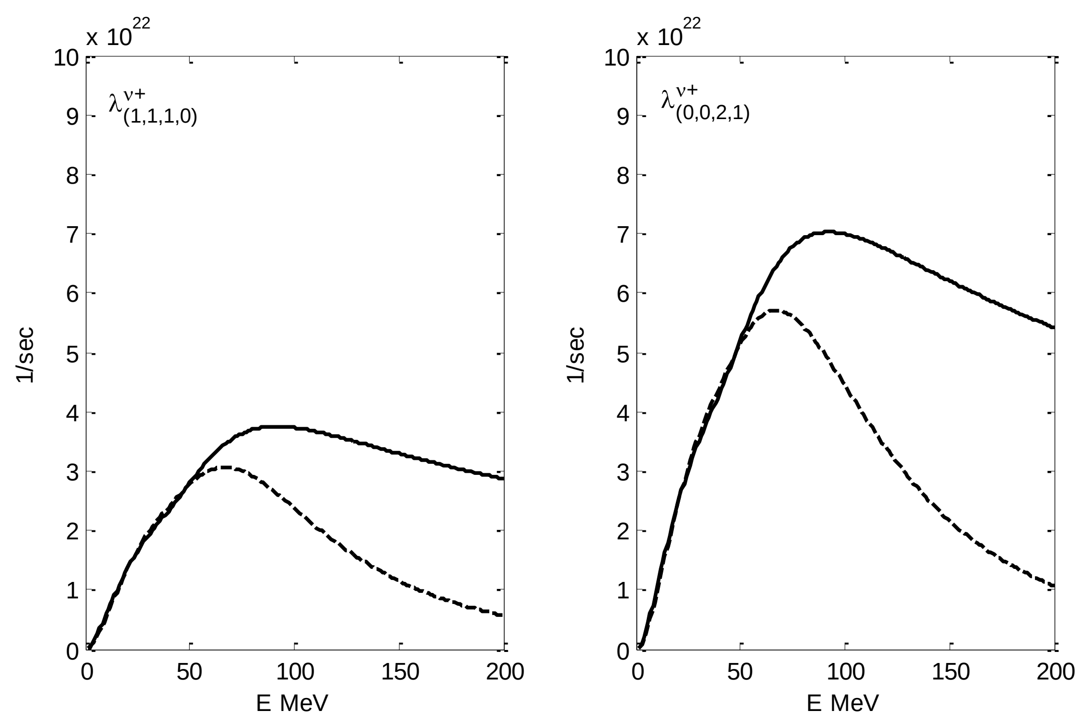

Fig. 5. The transition rates for creation of a neutron particle-hole pair as a function of excitation energy in ^{232}Th for n=3 and incident neutron, the solid curve calculated using the matrix element taken from Eq. (32) while the dashed curve was calculated using Eq. (31).

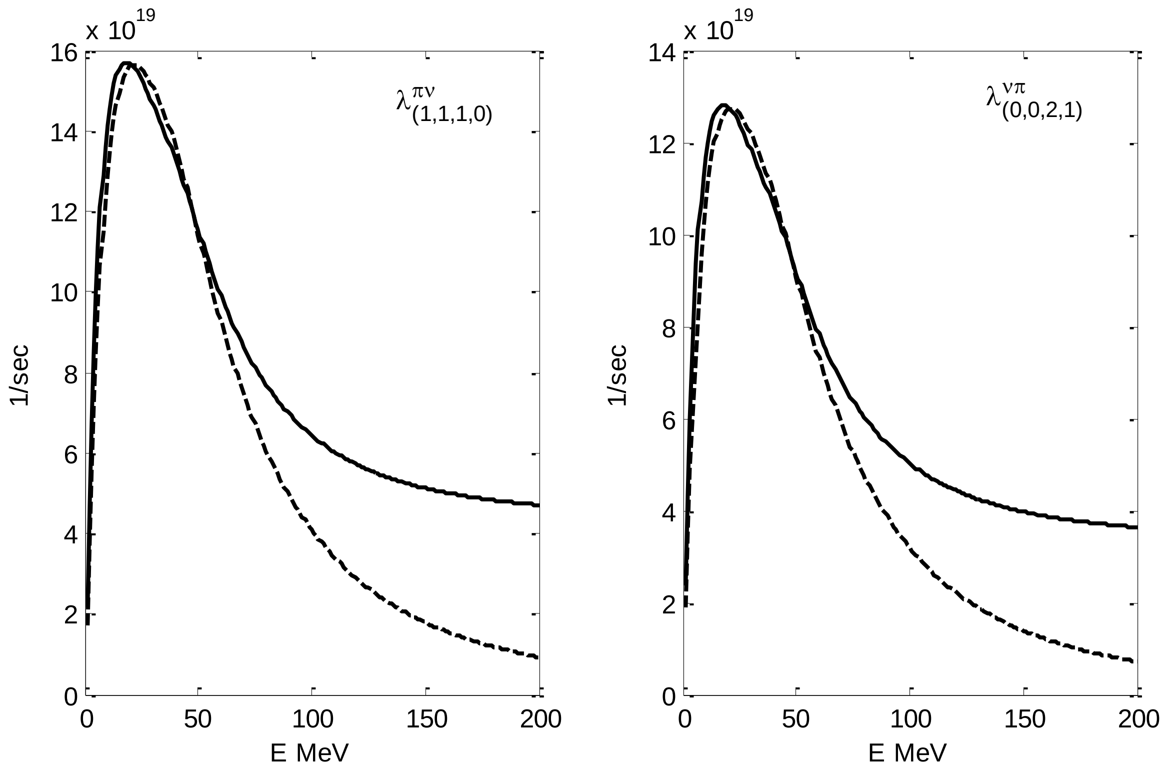

Fig. 6. The transition rates for conversion of a neutron into a proton and vise versa as a function of excitation energy in ^{232}Th for n=3 and incident neutron, the solid curve calculated using the matrix element taken from Eq. (32) while the dashed curve was calculated using Eq. (31).

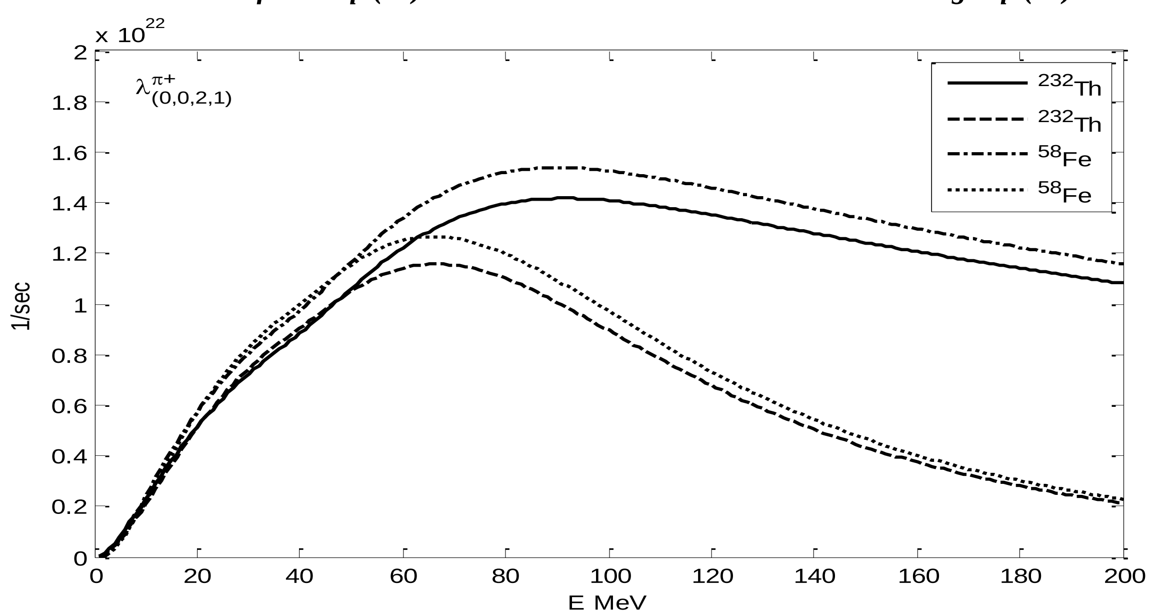

Fig. 7. The transition rates for creation of a proton particle-hole pair as a function of excitation energy in ^{232}Th and ^{58}Fe, the solid and dashed dotted curves calculated using the matrix element taken from Eq. (32) while the dashed and dotted curves were calculated using Eq. (31).

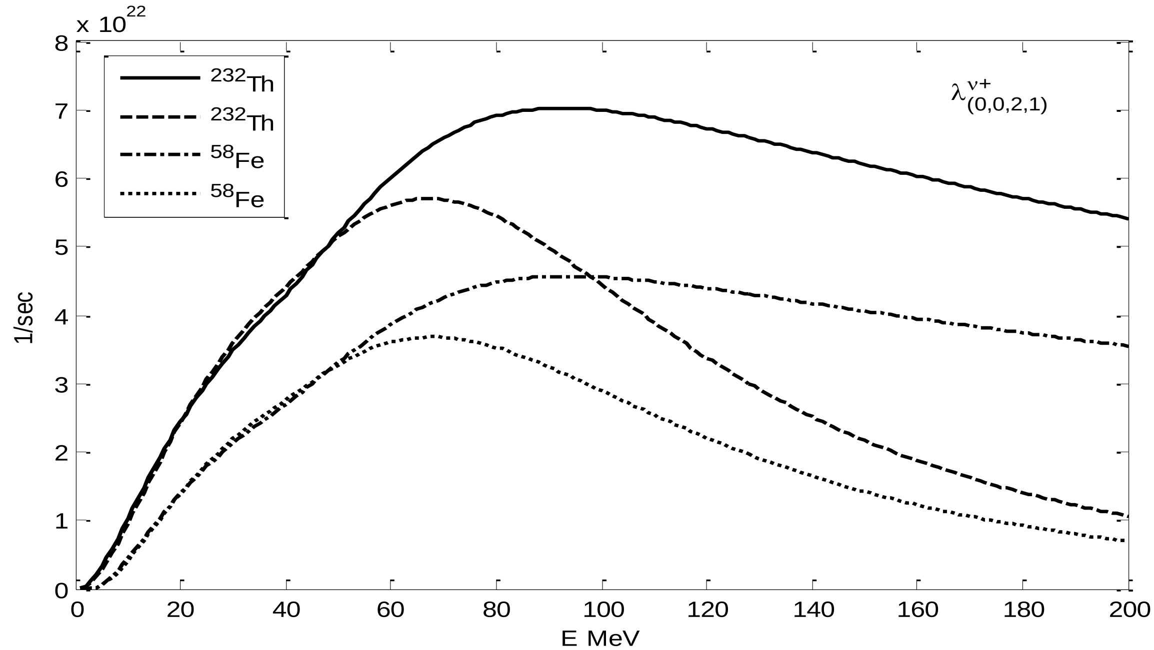

Fig. 8. The transition rates for creation of a neutron particle-hole pair as a function of excitation energy in ^{232}Th and ^{58}Fe, the solid and dashed dotted curves calculated using the matrix element taken from Eq. (32) while the dashed and dotted curves were calculated using Eq. (31).

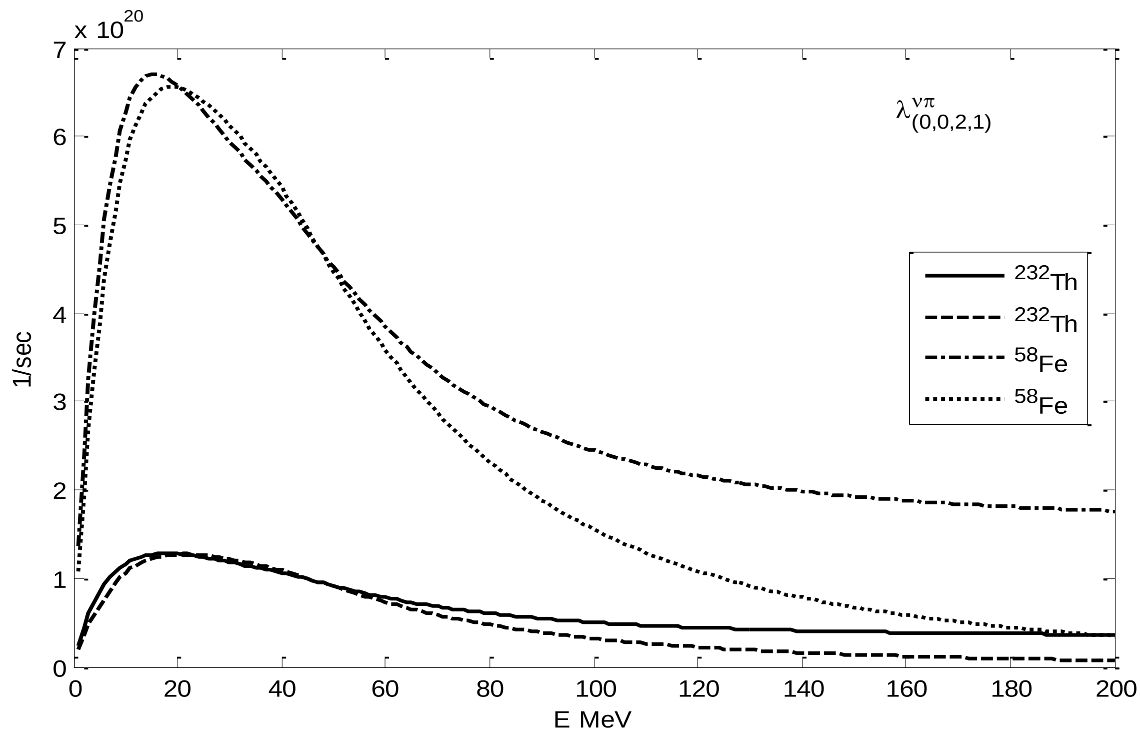

Fig. 9. The transition rates for conversion of a neutron particle-hole pair into a proton particle-hole pair as a function of excitation energy in ^{232}Th and ^{58}Fe, the solid and dashed dotted curves calculated using the matrix element taken from Eq. (32) while the dashed and dotted curves were calculated using Eq. (31).

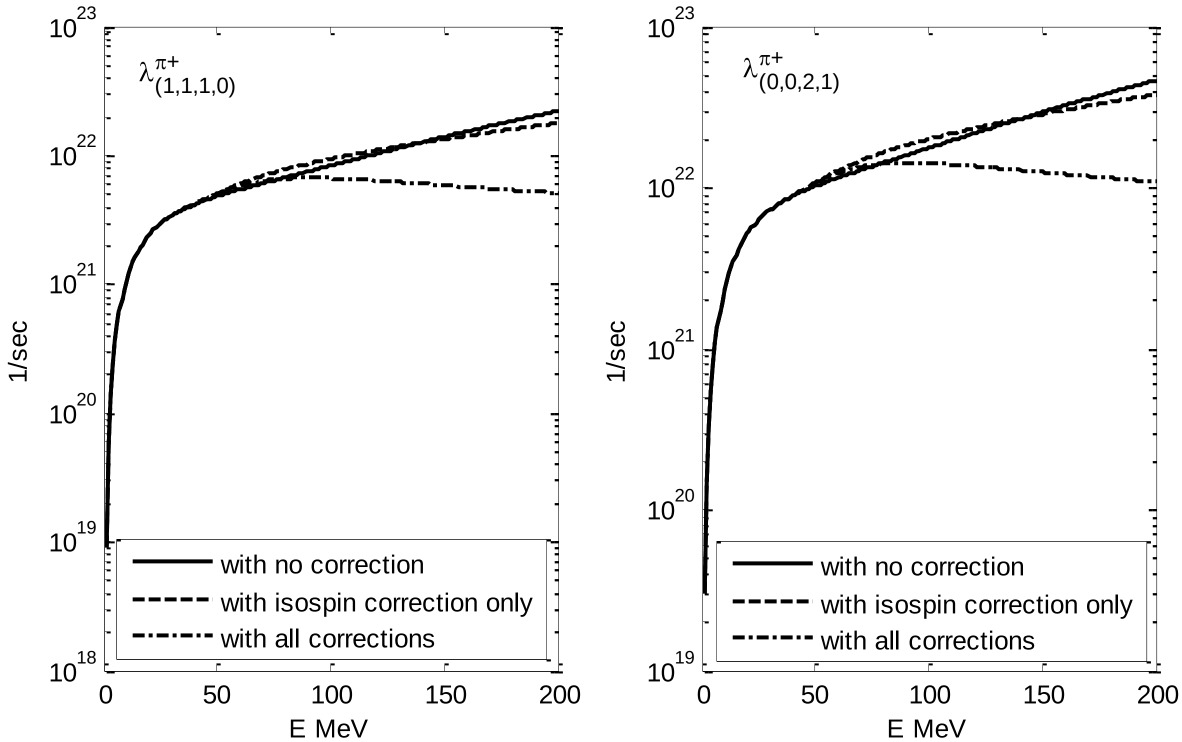

Fig. 10. The transition rates for creation of a proton particle-hole pair as a function of excitation energy in ^{232}Th for n=3 and incident neutron, with and without inclusion the recommended corrections in case of $T=T_z$.

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