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THE SYSTEMATICS RESEARCH ON (p, n) AND (p,2n) REACTIONS EXCITATION FUNCTION

YINQUN MA , YOUXIANG ZHUANG

CNDC,Beijing ,P.R.China

1 Introduction

On the basis of Planck formula of black body radiation and experimental excitation functions of (p,n) and(p,2n) reactions, an empirical systematics formula is presented, which includes two adjustable parameters , incident proton energies from threshold to 150 MeV, target masses from 44 to 243, and reproduces excitation functions of (p,n) and (p,2n) reactions well.

2 Establishment of systematics empirical formula

The Planck radiation formula of black body is as follows:

$$M(\nu) = \frac{C_0 \nu^3}{e^{C_1 \nu / T} - 1} \tag{1}$$

we have : $M(\nu) \Leftrightarrow \sigma(E)$, $\nu \Leftrightarrow E$, $C_1/T \Leftrightarrow \beta_0$

thus a preliminary formula of reaction cross section is obtained:

$$\sigma(E) = \frac{C_0 E^3}{e^{\beta_0 E} - 1} \tag{2}$$

Because there exits a threshold E_{th} for a certain reaction ,$\sigma(E)=0$,when E$\le E_{th}$; we replace E with (E $-E_{th}$) in formula (2)

$$\sigma(E) = \frac{C_0 (E - E_{th})^3}{e^{\beta_0 (E - E_{th})} - 1} \tag{3}$$

It can describe the curves of (p,xn) reaction excitation functions roughly, at E<30MeV.

In order to raise the values of curves at E>30MeV, we put some β functions into formula (3).

For (p,n) reaction, we have:

$$\sigma_{p,n} = \frac{C_0 (E - E_{th})^3}{e^{\beta_0 (E - E_{th})} - 1} \prod_{i=1}^{6} \beta_i \tag{4}$$

where,

$$\beta_1 = \frac{1}{1 + \left(\frac{C_2}{E - E_{th}}\right)^2}$$

For (p,2n) reaction we have:

$$\sigma_{p,2n}(E) = \sigma_1(E) + \sigma_2(E)\delta_{E.C_3} \tag{5}$$

where, $\delta_{E,C_5} = \begin{cases} 0 & , \quad E = C_5 \\ 1 & , \quad E \neq C_5 \end{cases}$, $\sigma_1(E) = \dfrac{C_0(E - E_{th})^3}{e^{\beta_0(E-E_{th})} - 1}\beta_1\beta_2\beta_3$,

$\sigma_2(E) = \sigma_1(C_5)(C_5/E)^{C_6}\beta_4$, $\beta_2 = e^{(E/C_1)^{C_3}}$

where c_0, c_2 and C_0, c_3 are adjustable parameters(also the so- called local parameters). Are there systematics behavior of parameters c_0, c_2 and c_0, c_3? The answer is certainly yes. Using the minimum deviation, the systematic formulas of parameters c_0, c_2 and c_0, c_3 are as follows:

for (p,n) reaction we have:

$$C_0 = (-0.009556 + 0.1665\frac{N-Z}{A})(1 - 0.3e^{-1800(\frac{N-Z}{A} - 0.185)^2}) \tag{7}$$

$$C_2 = \frac{0.000412A^{2.1484} - (A/100)^{2.9888} + (A/150)^{6.7} + (A/200)^{24}}{1 + 0.4e^{10(67-A)}} \tag{8}$$

For (p,2n) reaction ,we have:

$$C_0 = \begin{cases} 0.002635e^{(20.485X + (\frac{0.06514}{X})^{20} - (\frac{0.08}{X})^{5})} & X < 0.19796 \\ 2.476935 - 11.7X & X \geq 0.019796 \end{cases} \tag{9}$$

$$C_3 = \begin{cases} 0.6057e^{(3.5|X-0.1323| + 132|X-0.1323|^{1.579})} & X < 0.2055 \\ (260.7769 - 1253.8X) & \\ (1 - \dfrac{5.65X}{1 + 0.0000001e^{1000000(0.20775-X)}}) & X \geq 0.2055 \end{cases} \tag{10}$$

where $X = \frac{N-Z}{A}$.

The values of c_0, c_2 and c_0, c_3 extracted from the above systematics are called regional parameters .

Using the regional parameters c_0, c_2 the excitation function of the (p,n) reaction can be predicted . when 50<A<120, the comparison with the existing measured excitation functions shows that the agreements between the predicted and measured curves are very good (see Fig. 2); while for A<51 and A>120 nuclei , agreement between the excitation function predicted by the systematics and the existing measured excitation functions is not satisfactory. For (p,2n) reaction, agreement between the excitation function predicted by the systematics and the existing measured excitation functions is very satisfactory(see Fig. 1).

3 Figures

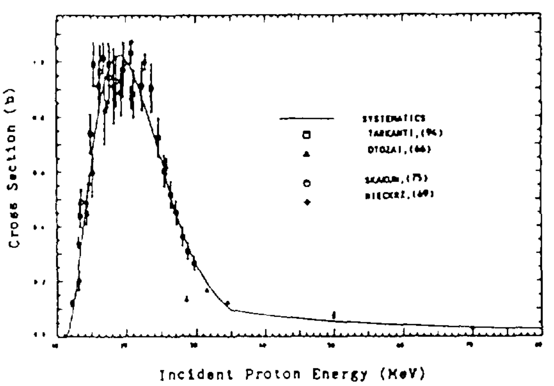

Fig. 1 $^{112}Cd(p,2n)^{111}In$ reaction

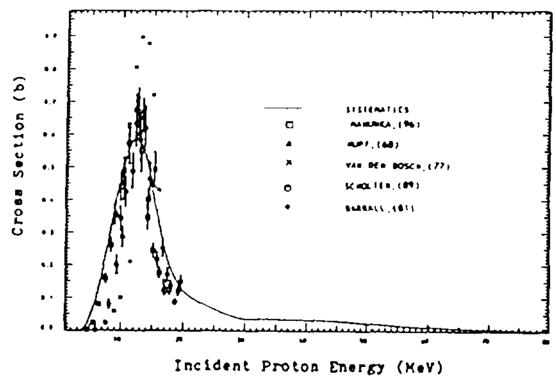

Fig. 2 $^{123}Te(p,n)^{123}I$ reaction