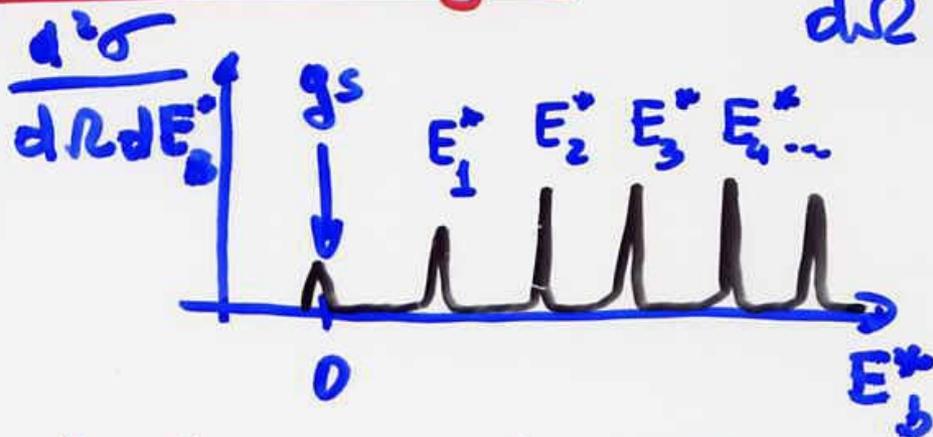


1
ESPALHAMENTO - $\sigma_{\text{REAÇÃO}} A(a, b) B \Rightarrow \sigma_{ab}$

OBSERVÁVEIS:

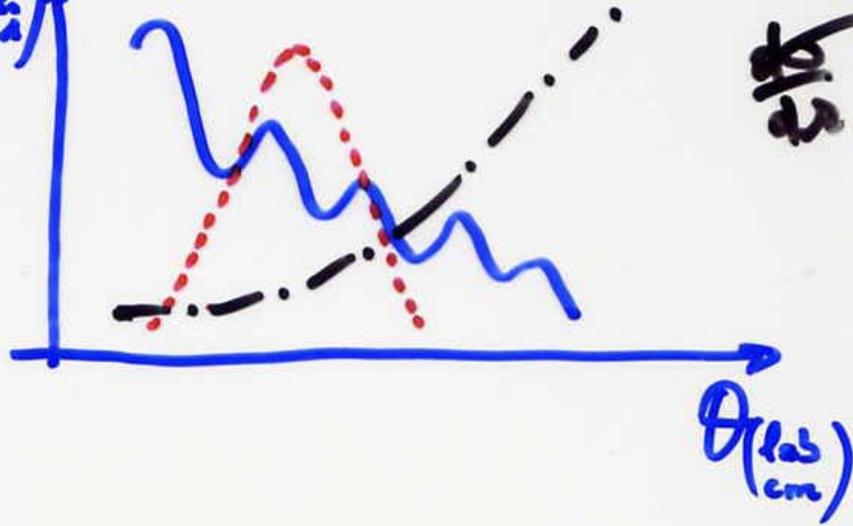
- RELAÇÃO das INTENSIDADES : $\frac{d\sigma}{d\Omega}(\theta_{\text{esp}})$
seção de choque diferencial

- Espectro de Energias : $\frac{d^2\sigma}{d\Omega dE_B^*}(E_B^*)$



- Distribuição Angular : $\frac{d\sigma}{d\Omega}(\theta_{esp}, E)$

$\frac{d\sigma}{d\Omega}(E_i)$

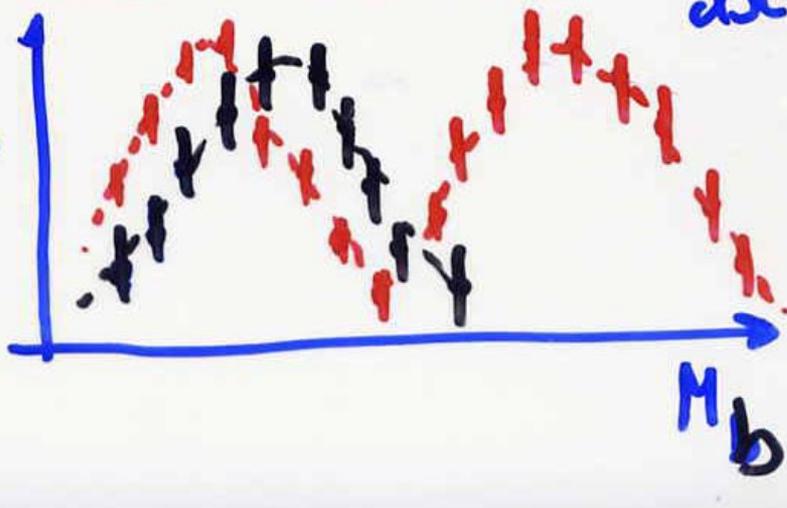


$\frac{d\sigma}{d\Omega}$



- Distribuição de MASSA

$\frac{d^2\sigma}{d\Omega dM_b}$



$\frac{d^2\sigma}{d\Omega dM_b}$

$E_{bon}, \theta,$

$M_b(M_B)$

A + a
CANAL DE ENTRADA

b + B
CANAL de SAIDA

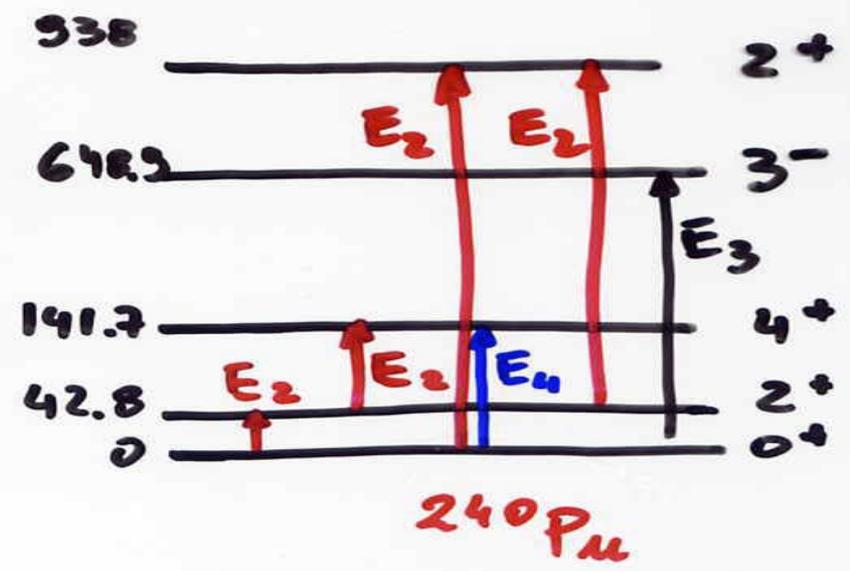
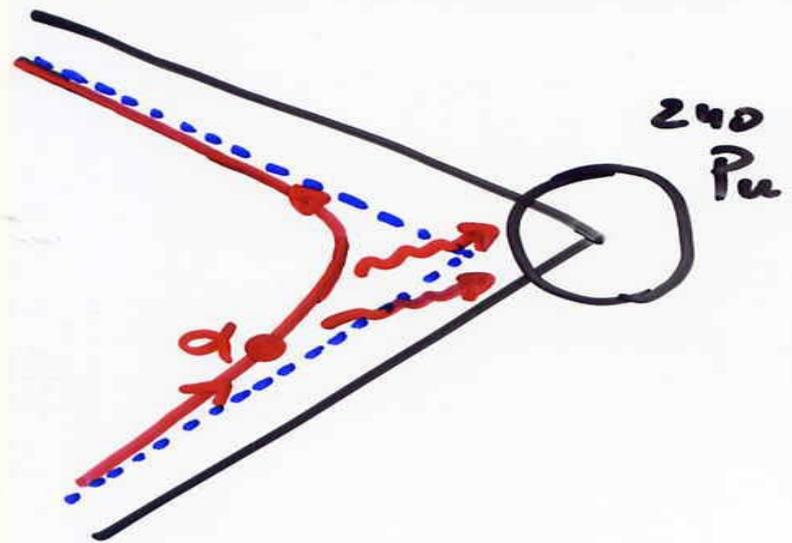
E_B^* ? , \vec{S}_B , \vec{L}_B
CANAL DE REAÇÃO

$$\vec{S}_e = \vec{I}_A + \vec{I}_a$$

spin do CANAL

$$\vec{I}_e = \vec{S}_e + \vec{l} = \vec{I}_s = \vec{S}_s + \vec{l}_s$$

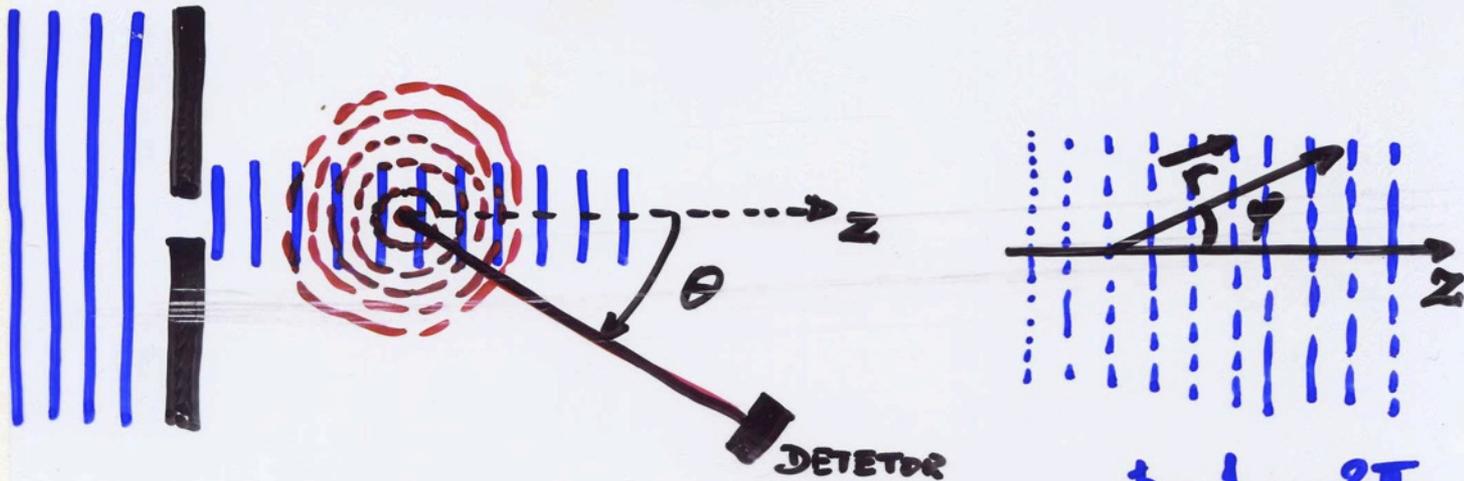
"CANAL" se refere a todas as rns quânticos
b + B ≡ CANAL de REAÇÃO



240Pu

3

ESPALHAMENTO



$$k = \frac{1}{\lambda} = \frac{2\pi}{\lambda}$$

$$\vec{k} \cdot \vec{r} = kr \cos \varphi$$

onda plana: $\exp(i\vec{k} \cdot \vec{r})$

- Decomposição em ondas parciais esféricas:

$$\psi_{\text{inc}} = A e^{ikz} = A \sum_{l=0}^{\infty} i^l (2l+1) j_l(kr) P_l(\cos\theta)$$

NORMALIZAÇÃO

FUNÇÃO DE BESSEL RADIAL

Polinômio de LEGENDE

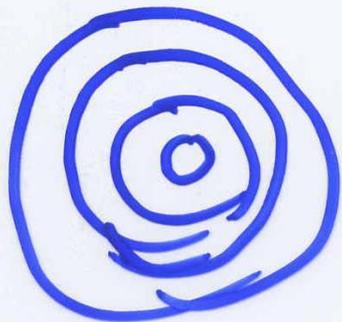
— + —

$$l\hbar = p b \Rightarrow b = l \frac{\hbar}{p} = l \frac{\lambda}{2\pi} = l\lambda$$

$l \equiv \text{inteiro} \therefore 0\hbar - 1\hbar$ ou $\hbar < l < 2\hbar$

$$\text{area} = \pi \lambda^2$$

$$\text{area} = 3\pi \lambda^2$$



$$l \Rightarrow \sigma_l = \pi [(l+1)\lambda^2] - \pi l\lambda^2$$

$$\sigma_l = (2l+1)\pi \lambda^2$$

$$\sigma = \sum_{l=0}^{R/\lambda} (2l+1)\pi \lambda^2 = \pi (R+\lambda)^2$$

4

ASSINTOTICAMENTE $kr \gg l$ (Pouca do Núcleo)

$$j_l(kr) \equiv \frac{\sin(kr - \frac{1}{2}l\pi)}{kr}$$

$$= i \frac{e^{-i(kr - l\pi/2)} - e^{+i(kr - l\pi/2)}}{2kr}$$

$$\psi_{inc} = \frac{A}{2kr} \sum_{l=0}^{\infty} i^{l+1} (2l+1) \left[e^{-i(\dots)} - e^{+i(\dots)} \right] P_l(\cos\theta)$$

The diagram shows a bracket under the term $\left[e^{-i(\dots)} - e^{+i(\dots)} \right]$ in the equation above. An arrow points from the left side of the bracket to the text "onda esférica inc". Another arrow points from the right side of the bracket to the text "onda esf. saindo". A larger bracket underneath both of these labels is labeled "onda plana".

Para a ONDA EMERGENTE

O ESPALHAMENTO AFETA:

A FASE

A AMPLITUDE ↓

∴ menos partículas

∴ A onda espalhada

$$\psi_{\text{esp}} = \frac{A}{2kr} \sum_{l=0}^{\infty} i^{l+1} (2l+1) (1-\eta_l) e^{i(kr - l\pi/2)} P_l(\cos\theta)$$

$$= \frac{A}{2kr} \frac{e^{ikr}}{r} \sum_{l=0}^{\infty} (2l+1) i (1-\eta_l) P_l(\cos\theta)$$

como o $k_{\text{esp}} \equiv k_{\text{incid}} \Rightarrow \psi_{\text{esp}} \equiv$ espalh. ELASTICO

$$\frac{d\sigma}{d\Omega} = \frac{1}{4k^2} \left| \sum_{l=0}^{\infty} (2l+1) i (1-\eta_l) P_l(\cos\theta) \right|^2$$

pois $j_{\text{inc}} = \frac{\hbar k}{m} |A|^2 =$

5

FINALMENTE

$$\sigma_{\text{esp}} = \sum_{l=0}^{\infty} \pi \lambda^2 (2l+1) |1 - \eta_l|^2$$

SE O ÚNICO PROCESSO FOR ESPAL. ELÁSTICO

$$|\eta_l| = 1 \iff \eta_l = e^{2i\delta_l}$$

↑
defasagem da l-
onda parcial

$$\Rightarrow |1 - \eta_l|^2 = 4 \sin^2 \delta_l$$

$$\sigma_{\text{esp}} = \sum_{l=0}^{\infty} 4\pi \lambda^2 (2l+1) \sin^2 \delta_l$$

SE EXISTIR OUTROS PROCESSOS (INEL, REAÇÃO)

$$|\eta_l| < 1$$

$$\sigma_R = \sum_{l=0}^{\infty} \pi k^2 (2l+1) (1 - |\eta_l|^2)$$

$$\sigma_{\text{TOTAL}} = \sigma_{\text{esp}} + \sigma_R$$

$$= \sum_{l=0}^{\infty} 2\pi k^2 (2l+1) (1 - \text{Re} \eta_l)$$

$$\underline{|\eta_l|^2 = 1} \Rightarrow \underline{\sigma_R = 0}$$

6

MODELO OPTICO

É LUZ INCIDINDO EM UMA ESFERA OPACA

$$U(r) = V(r) + iW(r)$$

$$U(r) = -V_0 - iW_0 \quad r < R$$

$$U(r) = 0 \quad r > R$$

respon.
ESPALHAMENTO
= shell model pot

respon.
ABSORÇÃO

onda espalhada $\rightarrow \frac{e^{ikr}}{r}$

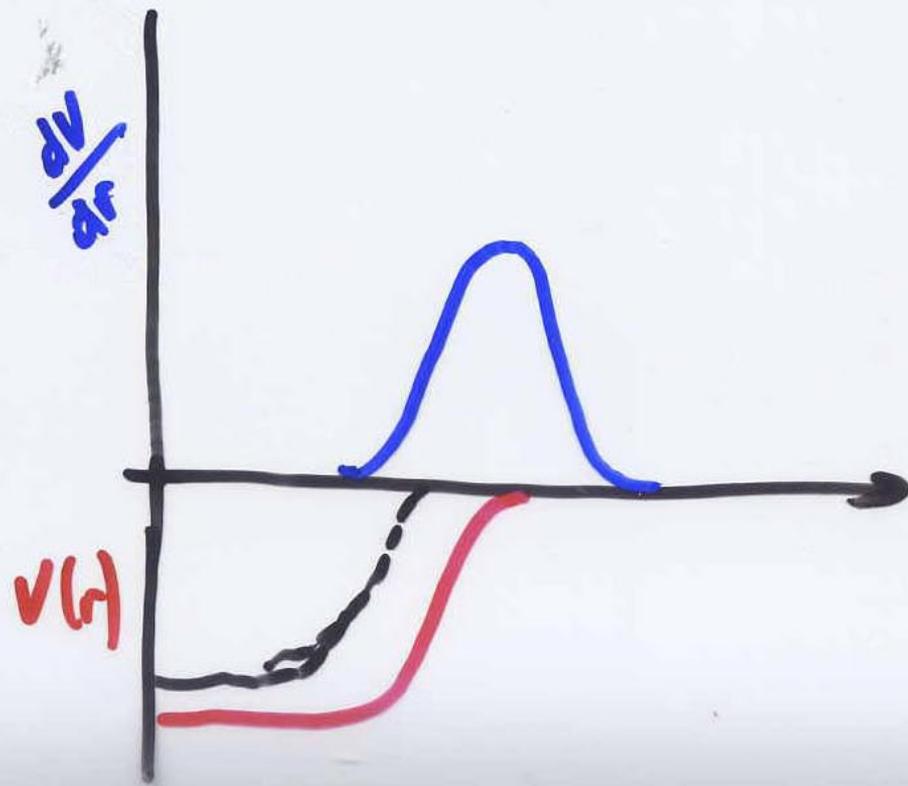
$$V(r) = \frac{-V_0}{1 + e^{(r-R)/a}}$$

$$k = \sqrt{\frac{2m(E + V_0 - iW)}{\hbar^2}}$$

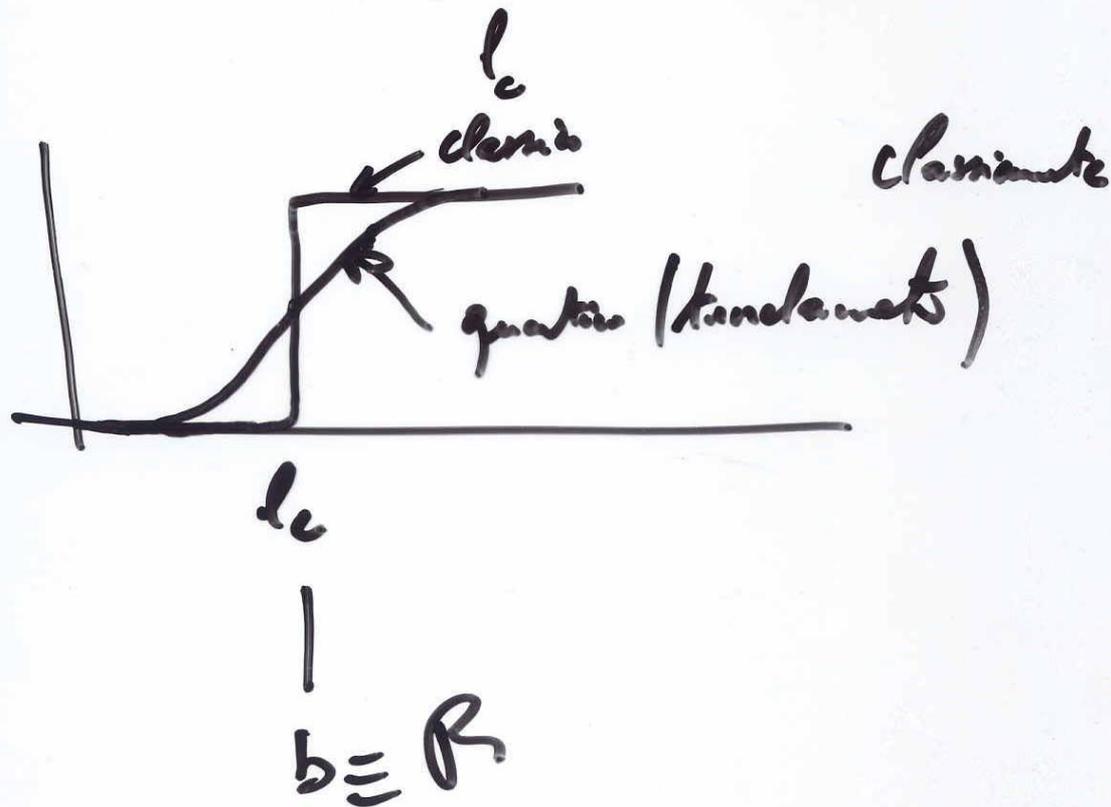
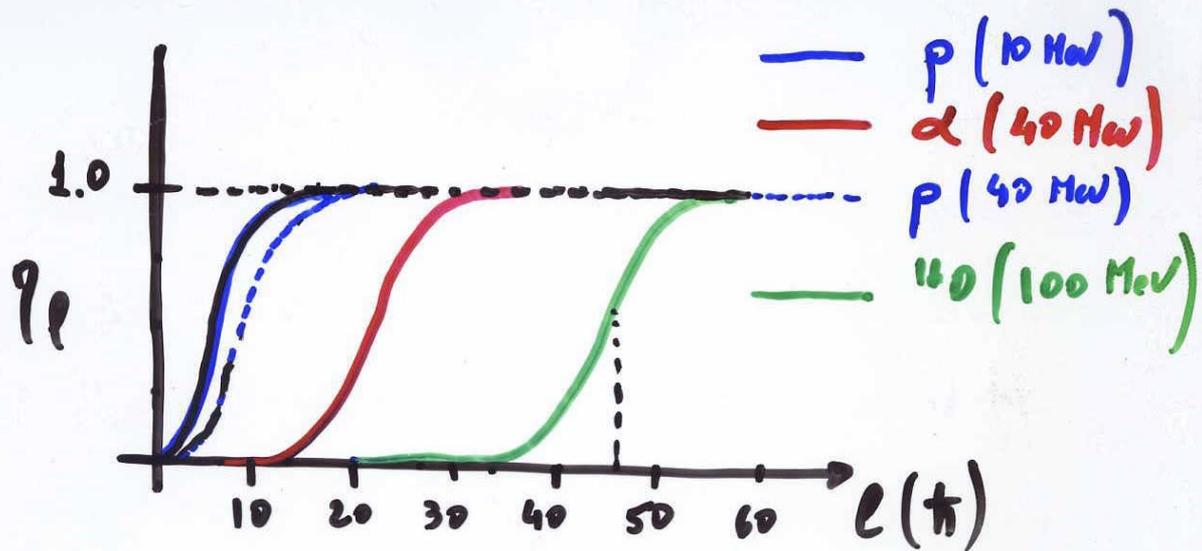
$$|V_0| \sim 40 \text{ MeV}$$

$$|W| \sim 10 \text{ MeV}$$

$$W(r) = \frac{-W_0}{1 + e^{(r-R)/a}} \quad \text{ou} \quad \frac{dV}{dr}$$



7



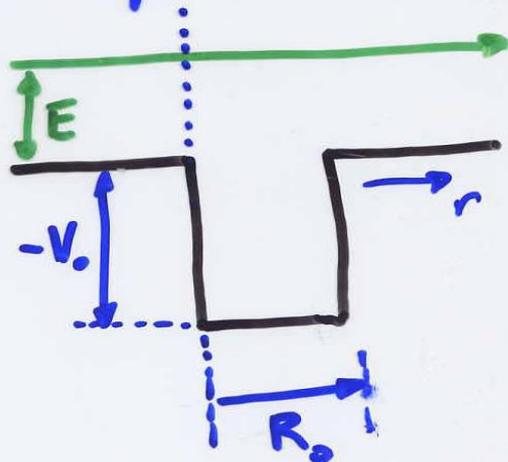
9

EXEMPLO SIMPLES

Espalhamento de ondas \underline{s} ($l=0$) por um potencial retangular esféricamente simétrico e atrativo. Por exemplo: FEIXE DE NEUTRONS LENTOS \therefore Pot. retangular \iff aprox. pot. mu

Para ONDA \underline{s} existe apenas 1 defasagem

Dado E
 $-V_0$
 R_0



Como $V(r)$ não depende de θ e ϕ
 $l=0; \Theta(\theta) \Phi(\phi) = 1 \implies \Psi$ é igual à solução R(r)

A equação de Schrödinger

$$\frac{d^2 u}{dr^2} + \frac{2m}{\hbar^2} \left[E - V(r) - \frac{l(l+1)\hbar^2}{2mr^2} \right] u = 0$$

$$u(r) = r R(r)$$

$$u'' + \frac{2m}{\hbar^2} [E - V(r)] u \equiv u'' + k^2 u = 0$$

onde $k^2 = \frac{2m}{\hbar^2} [E - V] \Rightarrow k = \frac{1}{\hbar} \sqrt{2m(E - V)}$

Para $V \equiv Cte$

$$\hookrightarrow u = \alpha e^{ikr} + \beta e^{-ikr}$$

(α, β) determinados pelas condições de contorno

$\rightarrow r < R_0$ \equiv região i onde $V(r) = -V_0$

$$k_i = \frac{1}{\hbar} \sqrt{2m(E - V_0)}$$

$$u_i = \alpha (\cos k_i r + i \sin k_i r) + \beta (\cos k_i r - i \sin k_i r)$$

Para $r=0 \Rightarrow u_i = 0$ para $\psi = \frac{u}{r}$ \vec{n} divergir

$$\alpha + \beta = 0 \iff \alpha = -\beta$$

$$u_i = A \sin k_i r \text{ com } 2\alpha i = A$$

$\rightarrow r > R_0 \equiv$ região a ψ_{total}

$$u_T = r \psi_T = \frac{1}{2kr} \sum_{l=0}^{\infty} (2l+1) i^{l+1} [e^{-i(\dots)} - \eta_l e^{i(\dots)}] P_l(\cos \theta)$$

10

Para $l=0$

$$\psi_0 = \exp(2i\delta_0)$$

$$u_T = \frac{1}{2k_a} [e^{-ik_a r} - e^{2i\delta_0} e^{ik_a r}] = \frac{1}{k_a} e^{i\delta_0} \sin(k_a r)$$

$$= \frac{e^{i\delta_0}}{k_a} \sin k_a \left(r + \frac{\delta_0}{k_a} \right)$$

$$\text{com } k_a = \frac{1}{\hbar} \sqrt{2mE}$$

Para $r = R_0$ \Rightarrow condições de continuidade

$$\frac{1}{k_a} e^{i\delta_0} \sin(k_a R_0 + \delta_0) = A \sin k_i R_0$$

/ derivada

$$e^{i\delta_0} \cos(k_a R_0 + \delta_0) = A k_i \cos k_i R_0$$





$$\delta_0 = -k_a R_0 + a n c \operatorname{tg} \left\{ \left(\frac{k_a}{k_i} \right) \operatorname{tg} k_i R_0 \right\}$$

Para $l=0$

$$u_{\text{enf}} r \psi_e = \frac{i}{2k_a} \left[e^{-ik_a r} - e^{ik_a r} \right] = \frac{1}{k_a} \sin k_a r$$



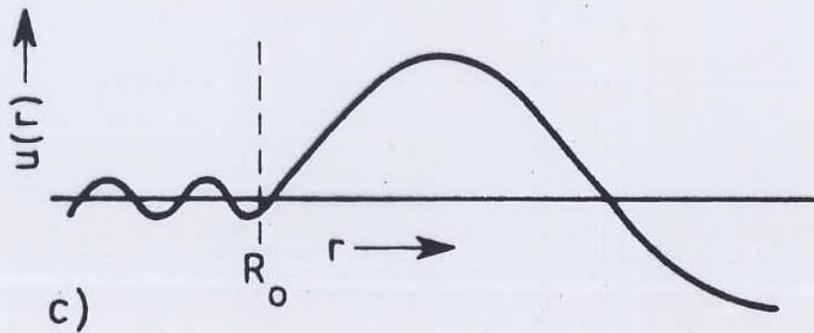
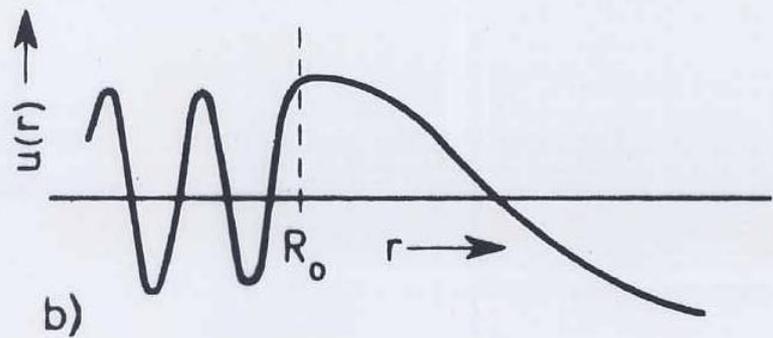
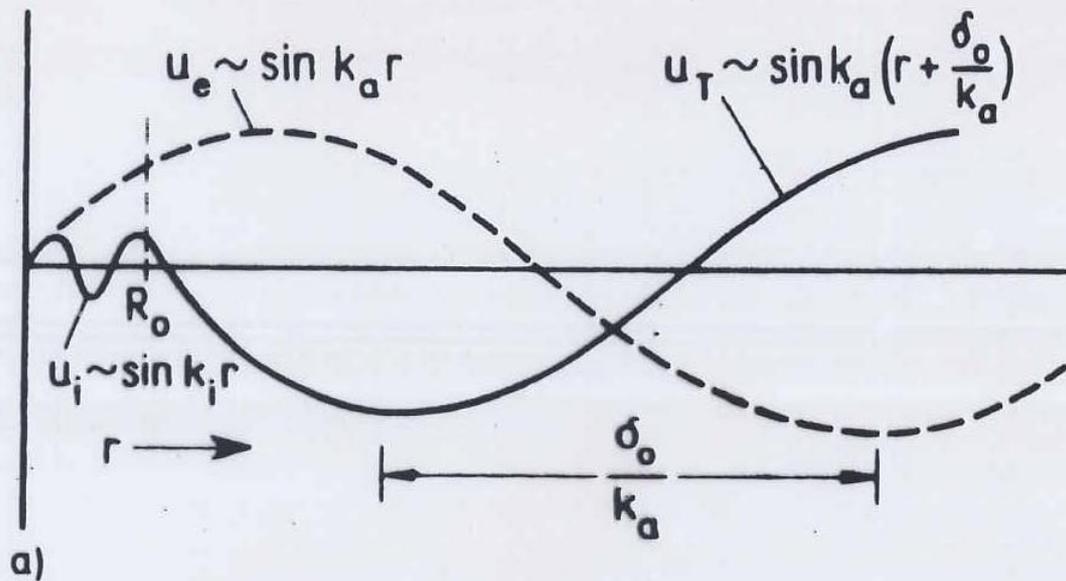
Solução para o potencial "desligado"

11 De "ligar" o Potencial

a onda,

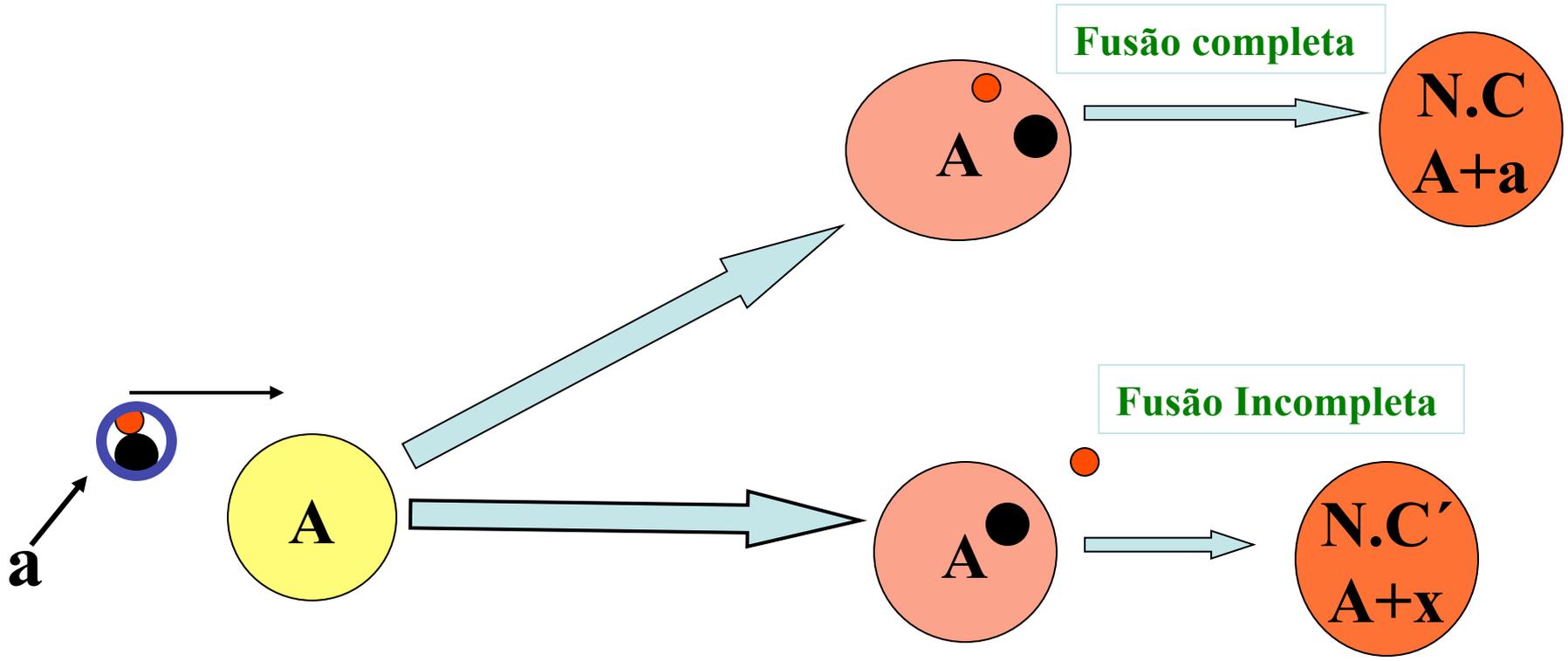
$$\psi_T = \frac{e^{i\delta_0}}{k_a} \sin k_a \left(r + \frac{\delta_0}{k_a} \right)$$

A onda é deslocada
(para a δ_0 atrativo.)



antes

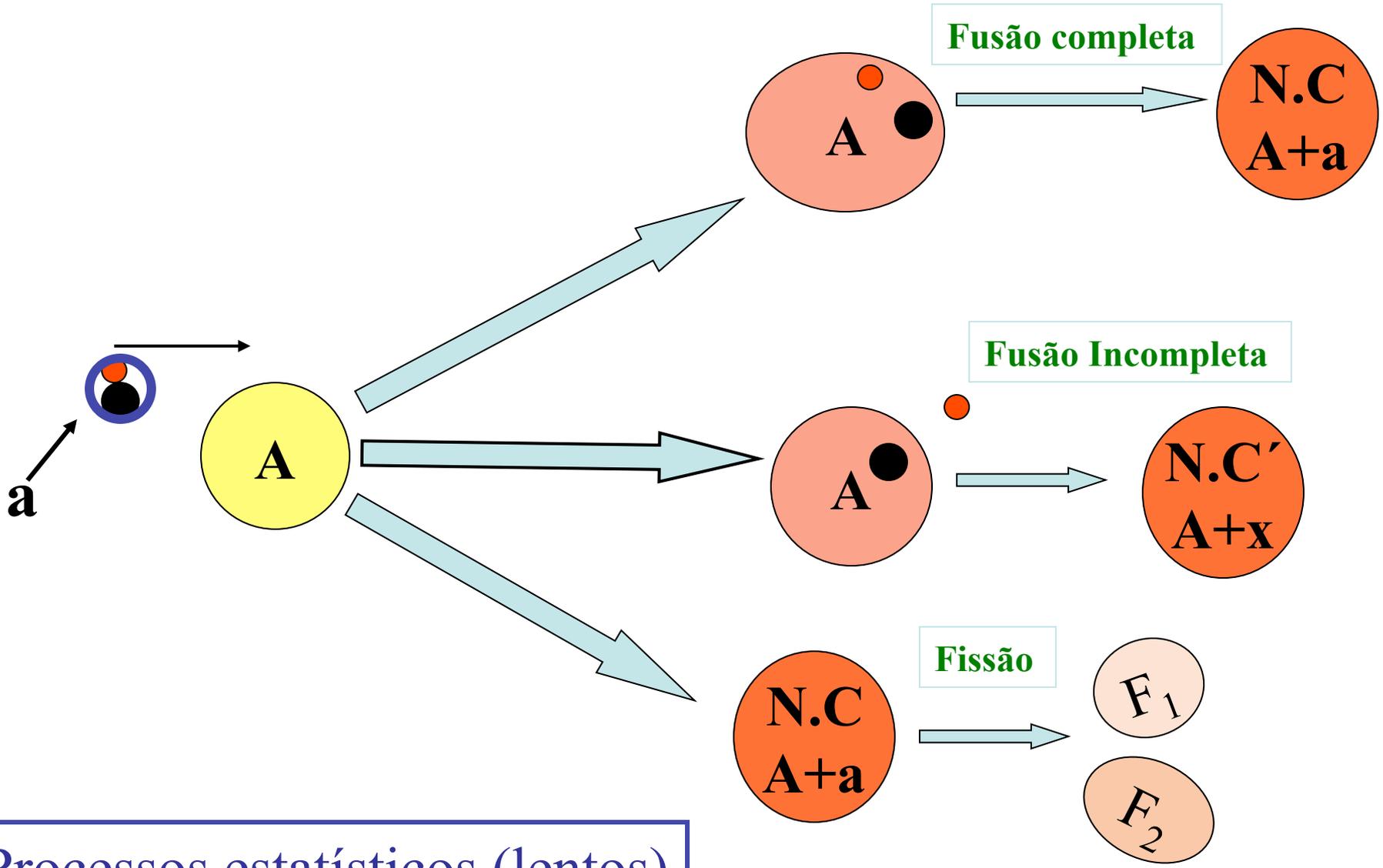
depois



Processos estatísticos (lentos)

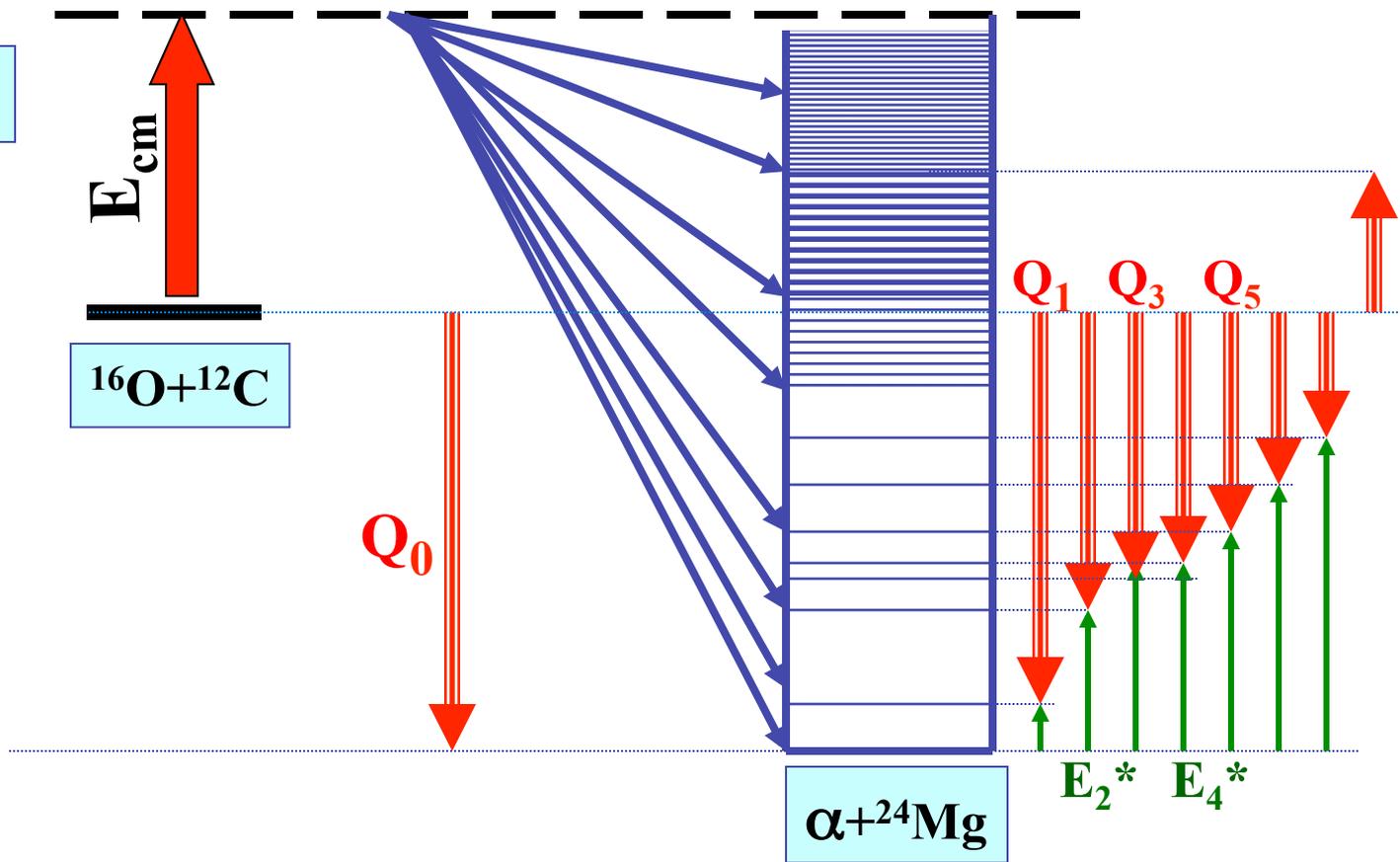
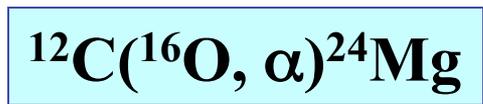
antes

depois



Processos estatísticos (lentos)

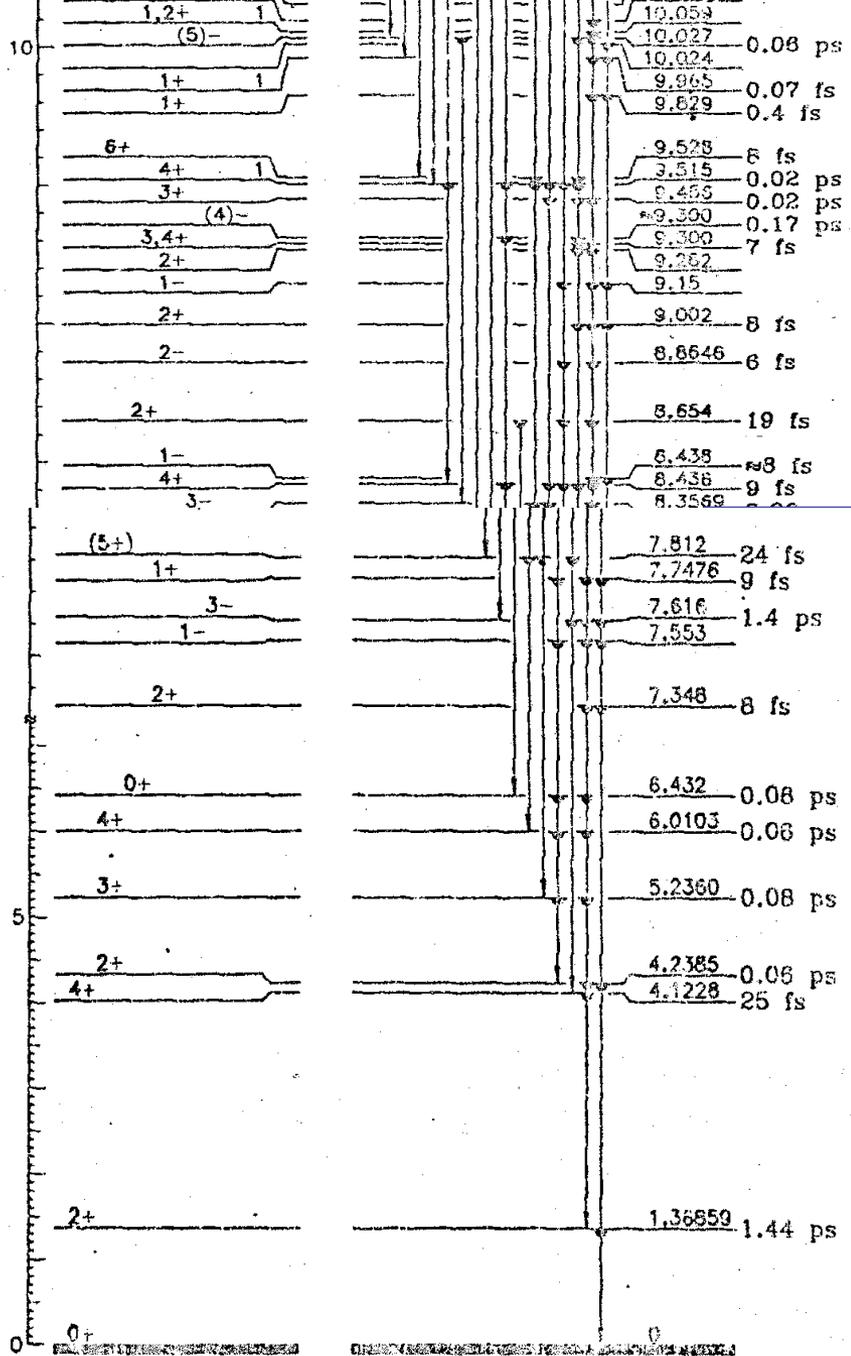
REAÇÃO DIRETA



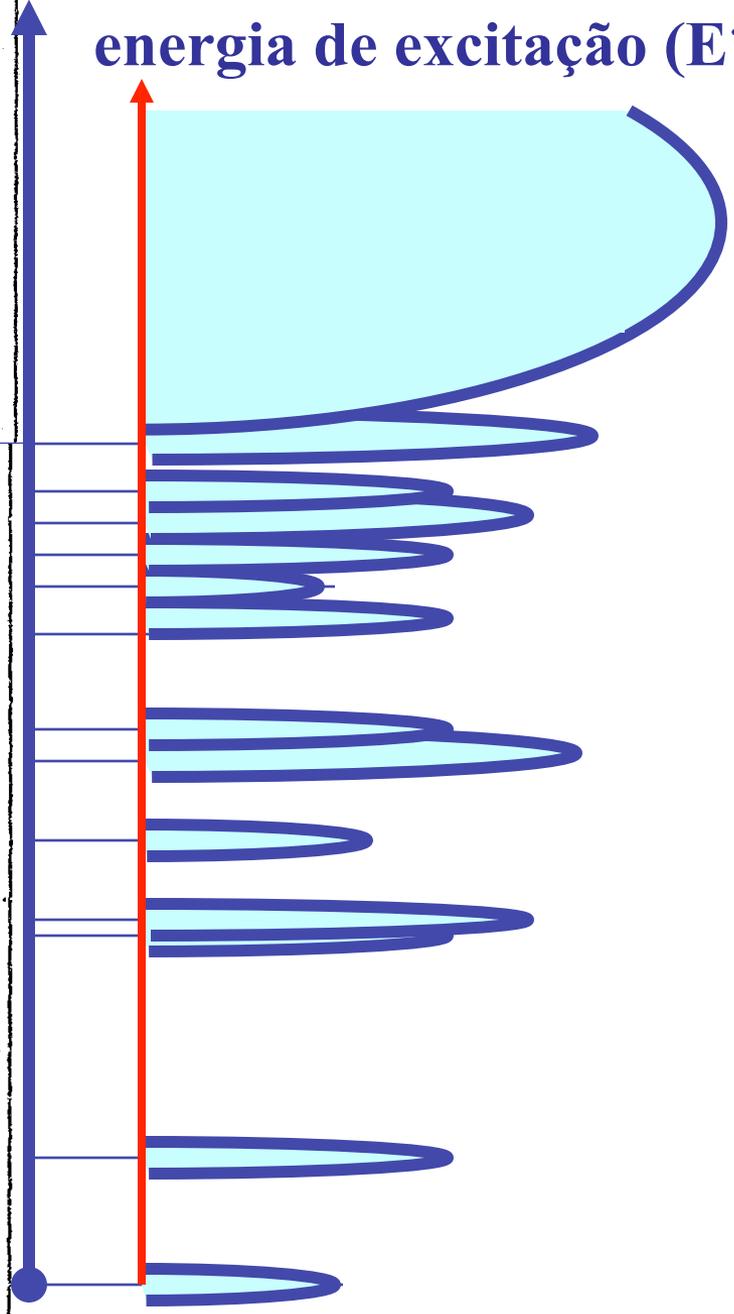
→ $E_{\text{cm}}(\alpha)$

→ $E_i^*[^{24}\text{Mg}(i)]$

→ $Q_i[^{24}\text{Mg}(i)]$

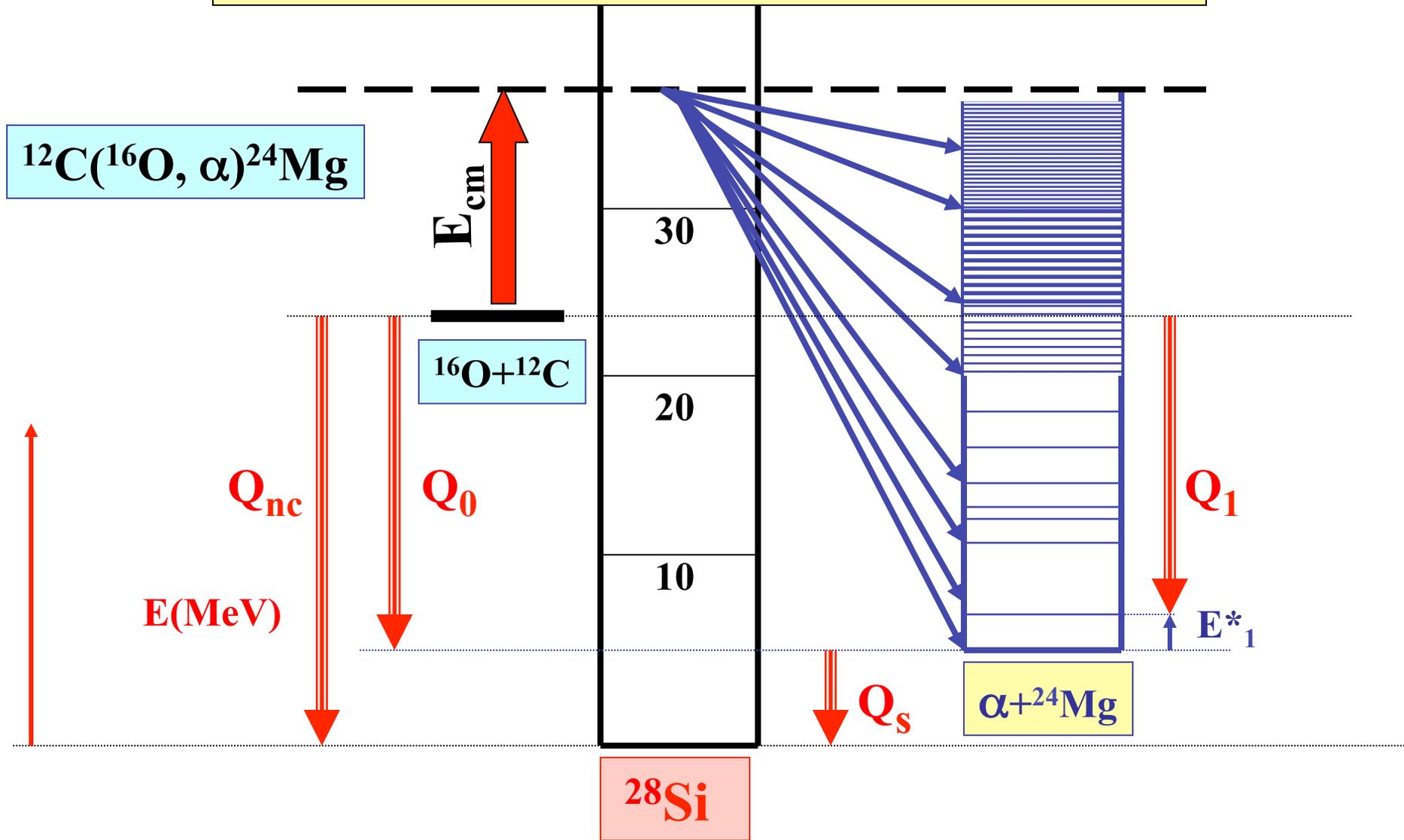


energia de excitação (E^*)



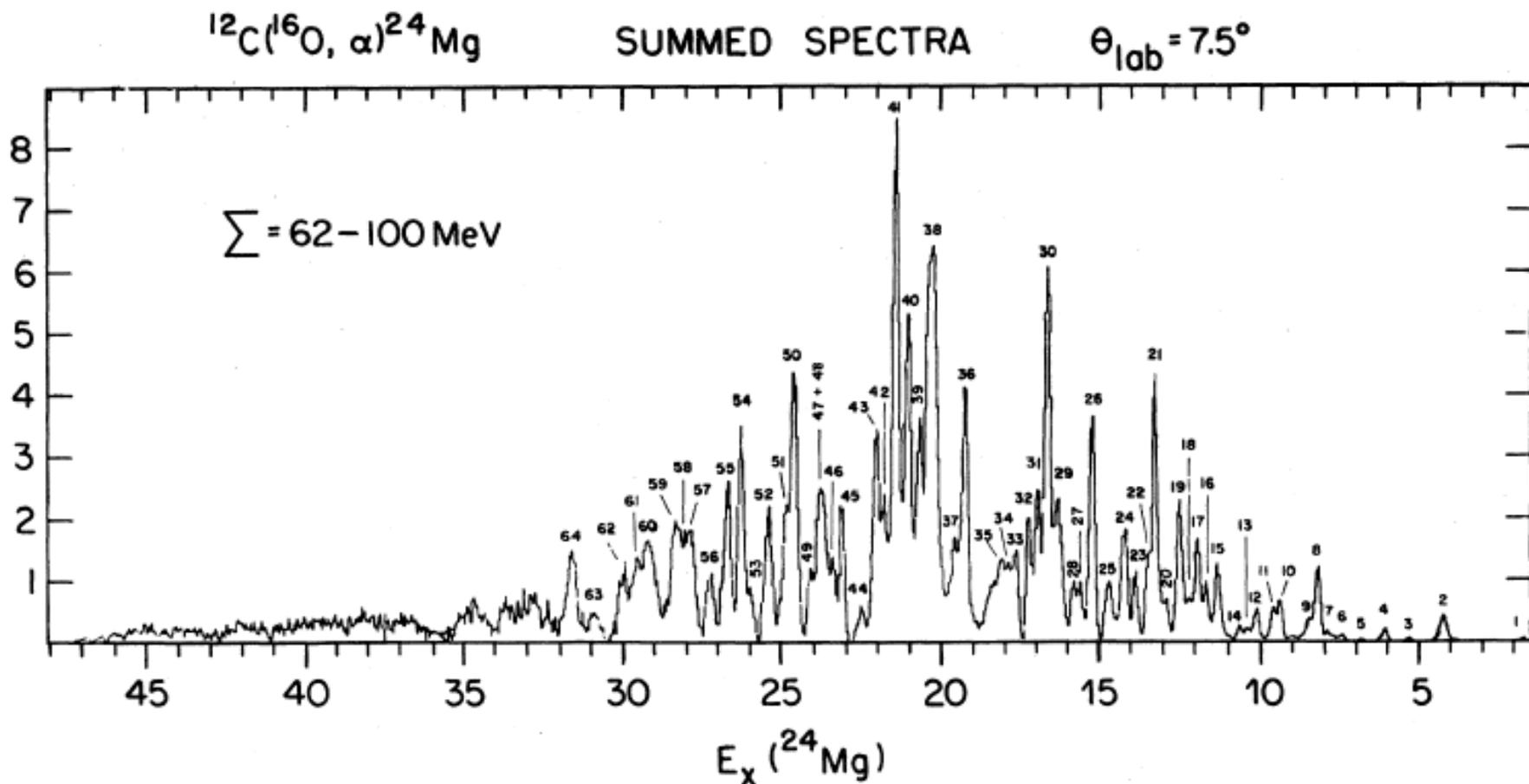
^{24}Mg
 ^{12}Mg

REAÇÃO VIA NÚCLEO COMPOSTO

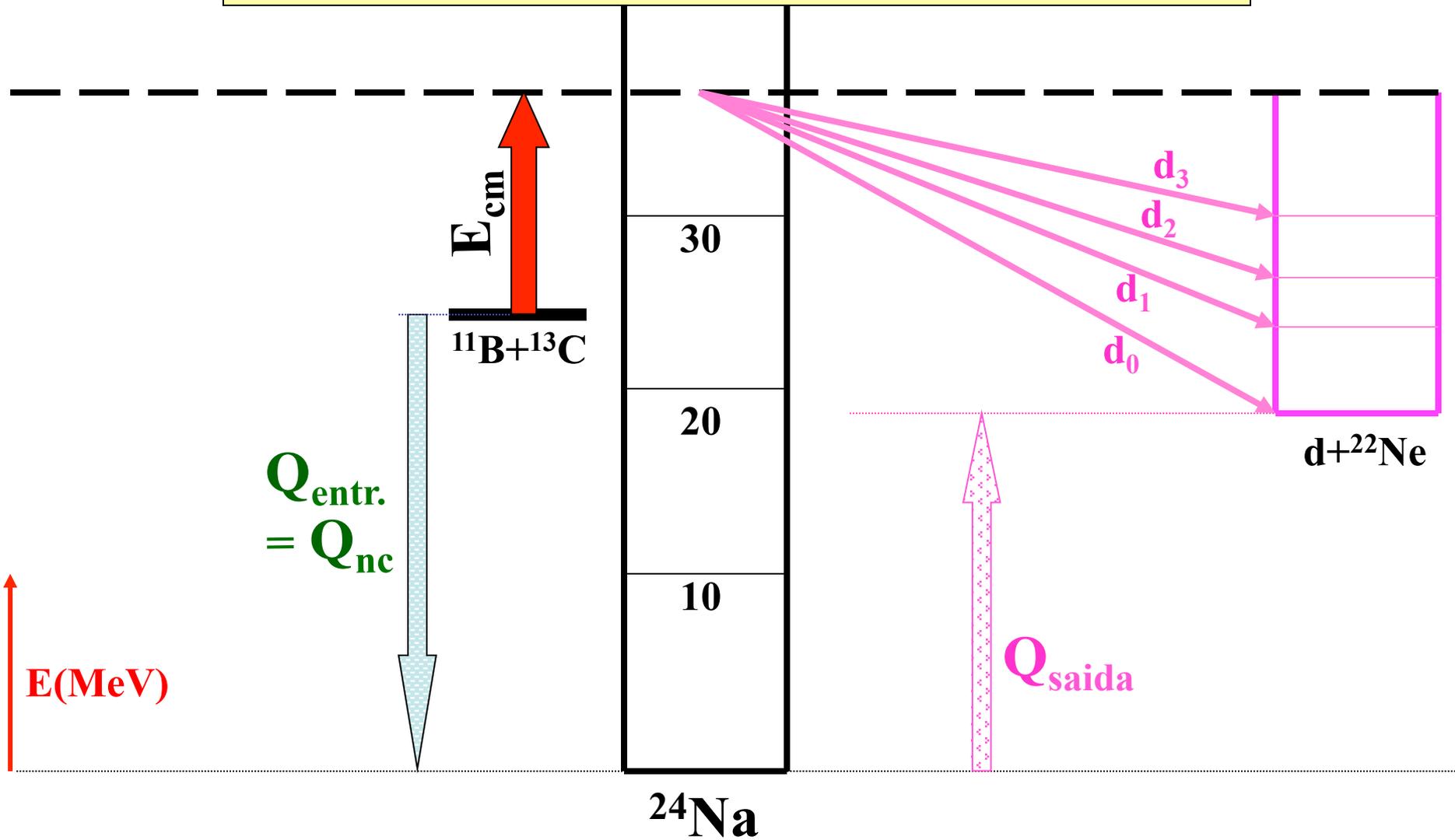


$^{12}\text{C}(^{16}\text{O}, \alpha)^{24}\text{Mg}^*$ reaction in the energy region $E_{\text{c.m.}} = 26.6$ to 42.9 MeVM. J. Bechara,* A. J. Lazzarini,[†] R. J. Ledoux, and E. R. Cosman*Department of Physics and Laboratory for Nuclear Science, Massachusetts Institute of Technology,
Cambridge, Massachusetts 02139*

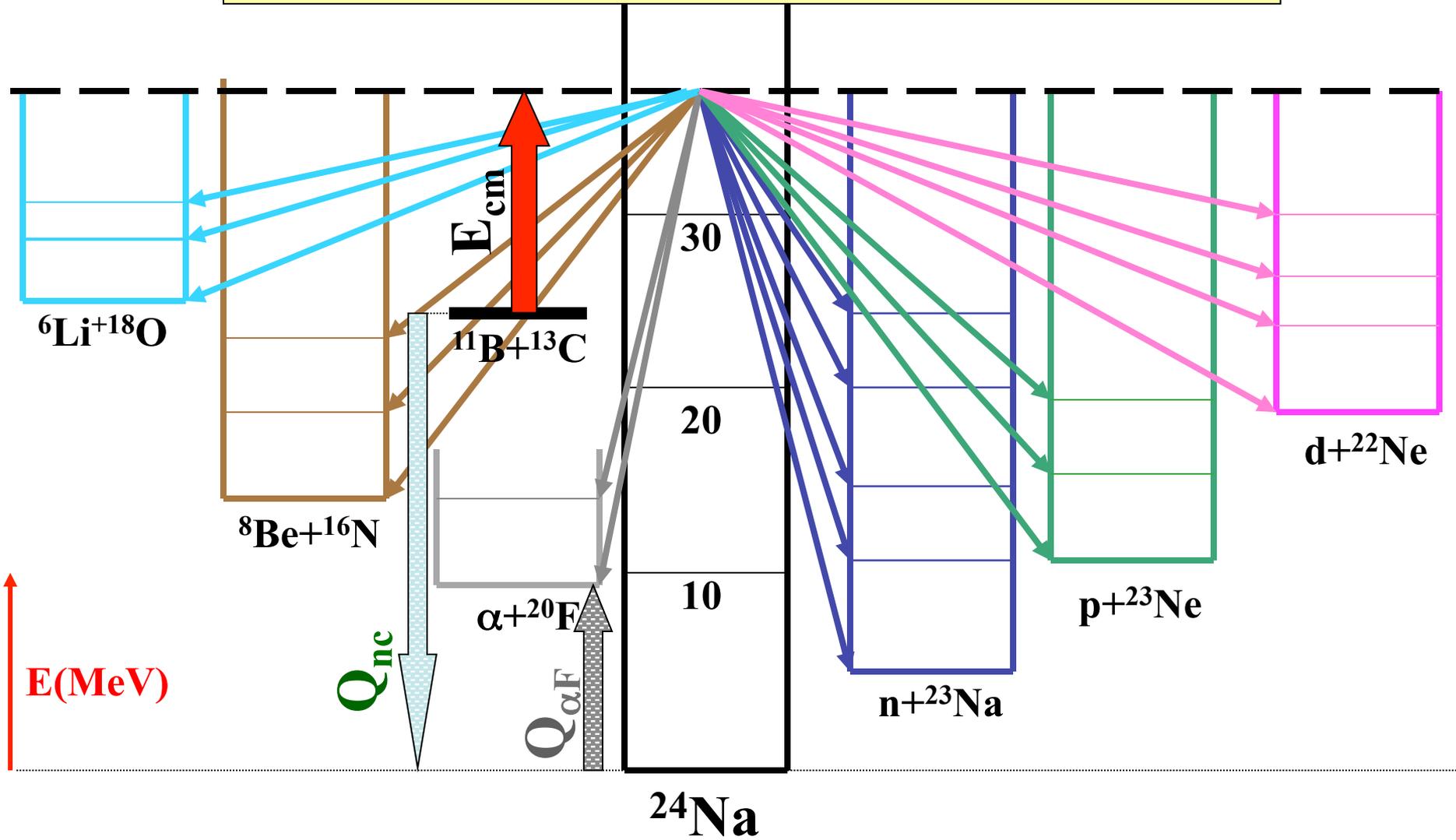
(Received 21 December 1981)

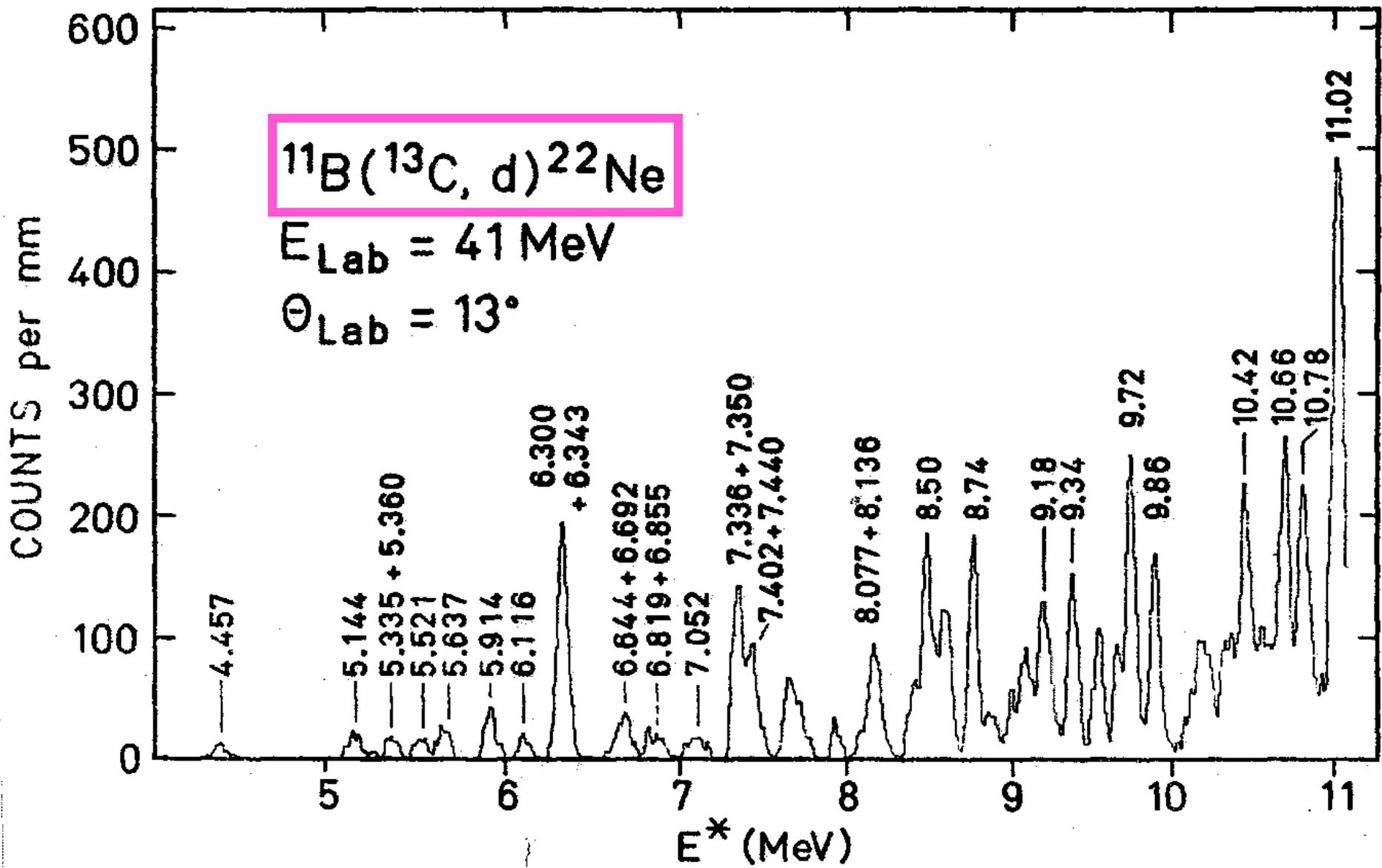


REAÇÃO VIA NÚCLEO COMPOSTO

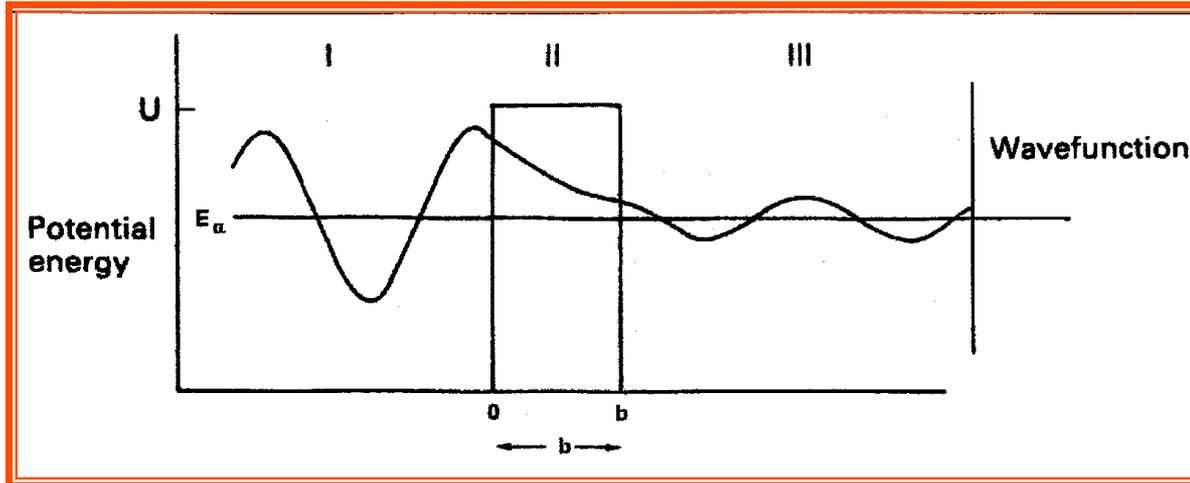


REAÇÕES VIA NÚCLEO COMPOSTO





Barrier Potential, $E > V_0$



$$\psi_1 = A e^{ik_1 x} + B e^{-ik_1 x}$$

$$\psi_2 = C e^{ik_2 x} + D e^{-ik_2 x}$$

$$\psi_3 = F e^{ik_3 x} + \cancel{G} e^{-ik_3 x}$$

$$k^I = k^3 = \sqrt{2mE} / \hbar \quad \text{and} \quad k^5 = \sqrt{2m(E - V_0)} / \hbar$$

BLOCO 4

reações nucleares

GENERALIDADES

- ESPALHAMENTO
- CINEMÁTICA

MODELO ÓPTICO

- POTENCIAL
- COEFICIENTE DE TRANSMISSÃO
- σ (REAÇÃO)

NÚCLEO COMPOSTO

REACÇÕES DIRETAS

**REAÇÕES NUCLEARES
COM
ÍONS PESADOS**

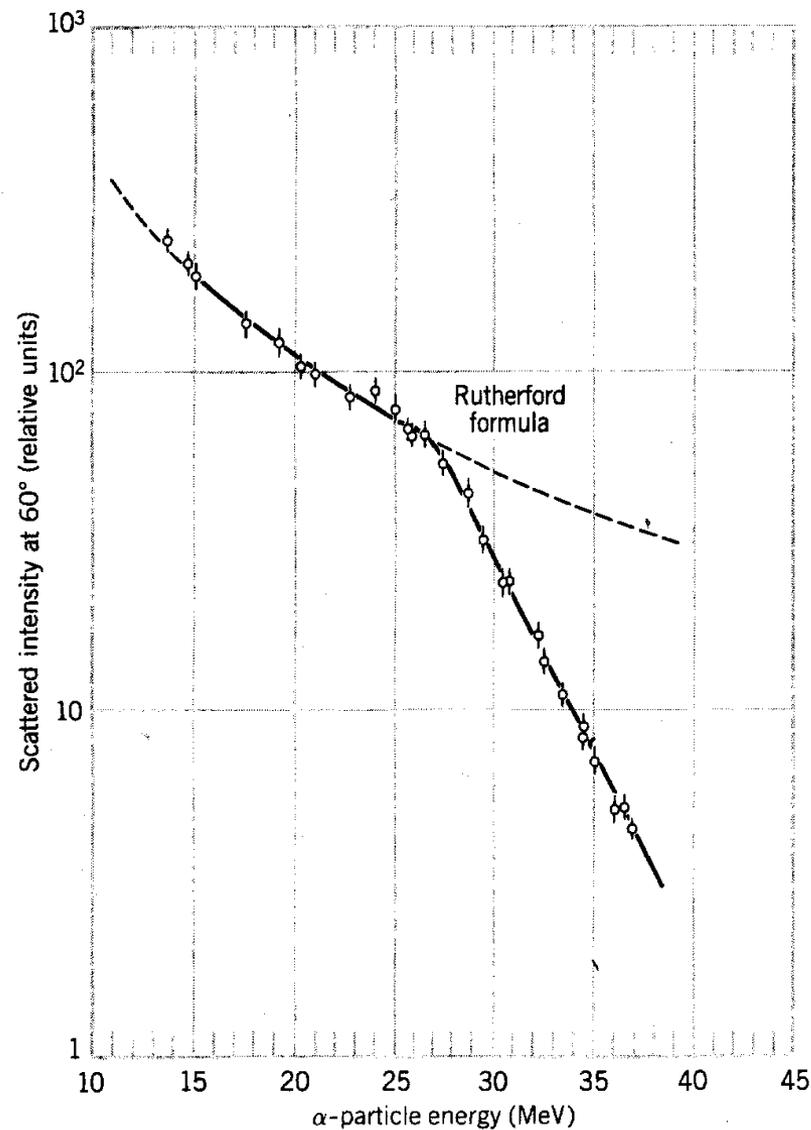
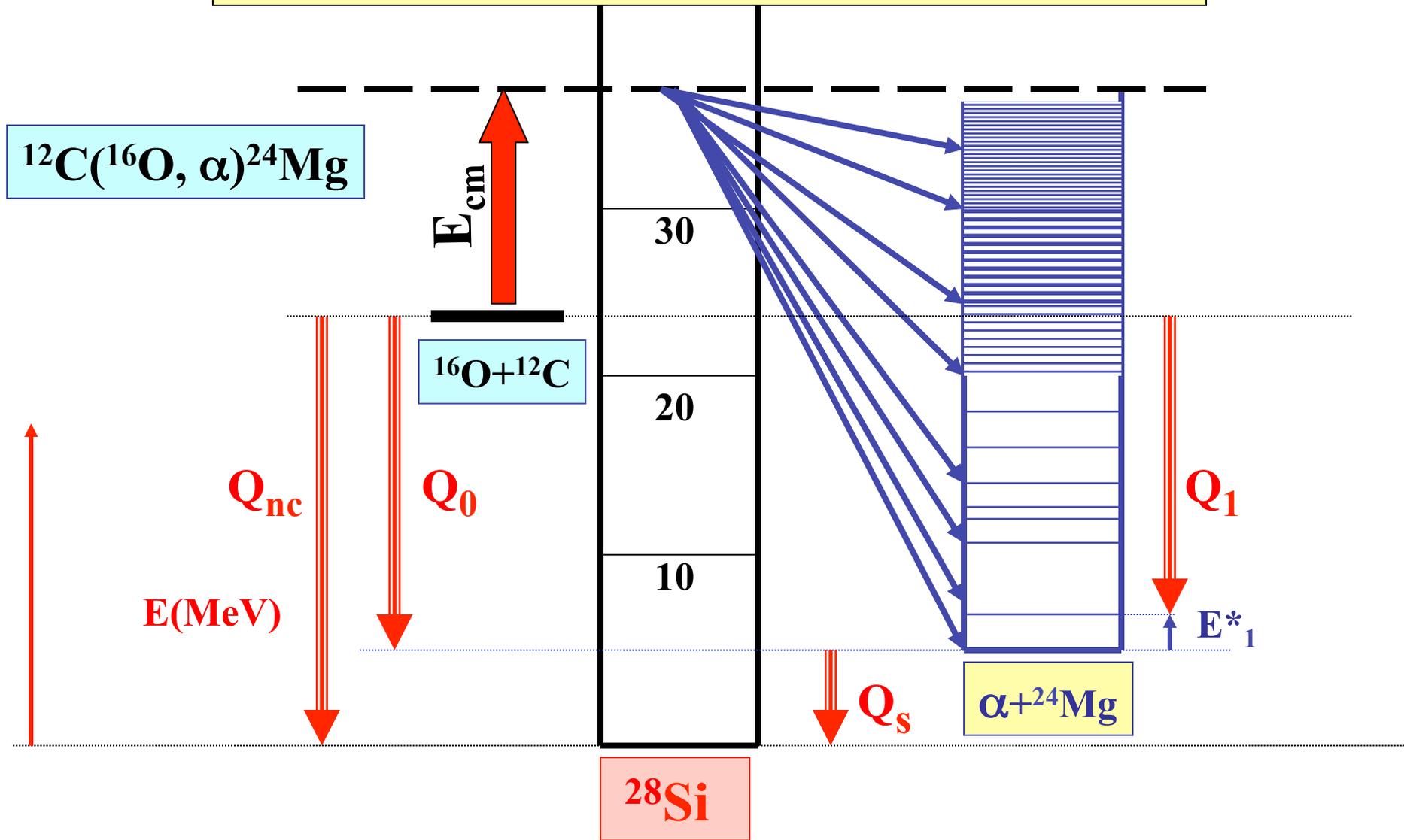


Figure 3.11 The breakdown of the Rutherford scattering formula. When the incident α particle gets close enough to the target Pb nucleus so that they can interact through the nuclear force (in addition to the Coulomb force that acts when they are far apart) the Rutherford formula no longer holds. The point at which this breakdown occurs gives a measure of the size of the nucleus. Adapted from a review of α particle scattering by R. M. Eisberg and C. E. Porter, *Rev. Mod. Phys.* **33**, 190 (1961).

REAÇÃO VIA NÚCLEO COMPOSTO



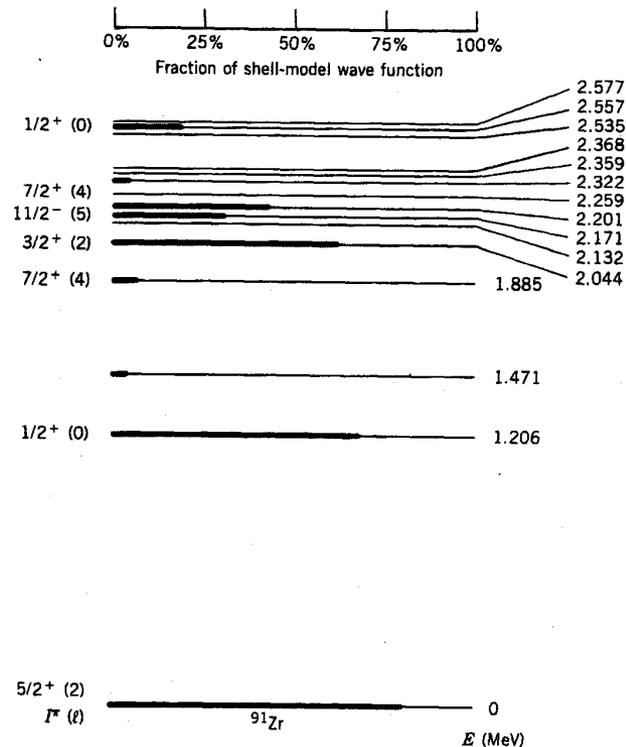
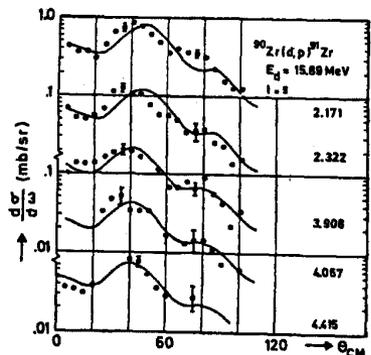
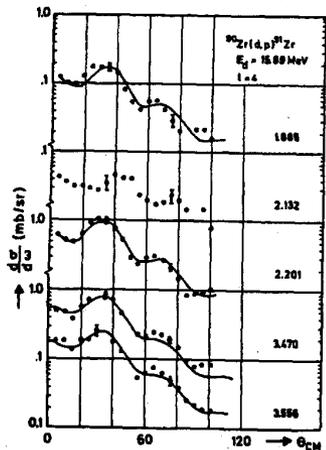
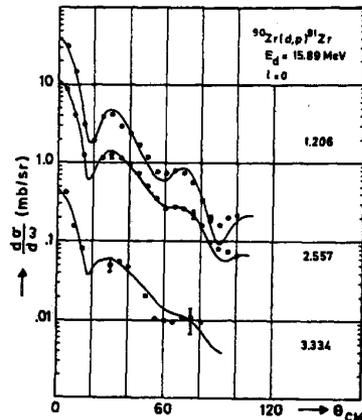
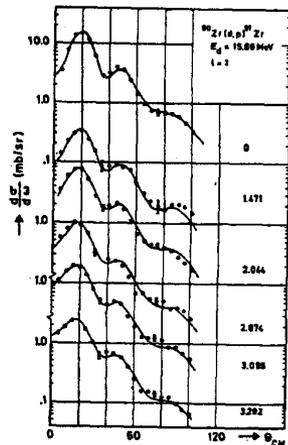
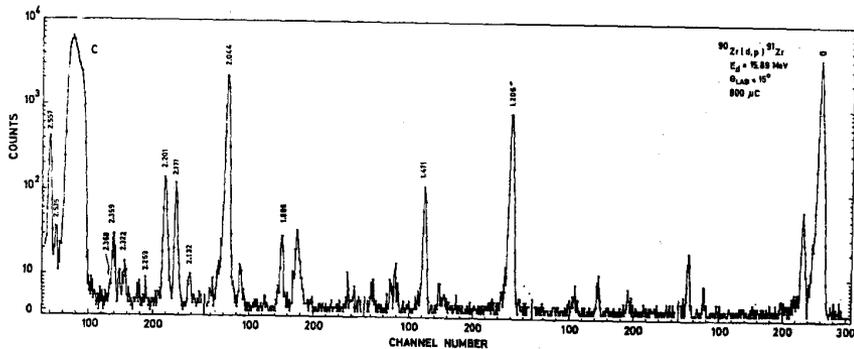


Figure 11.24 Deduced level scheme for ^{91}Zr . Each ℓ value (except zero) deduced from the angular distributions of Figure 11.23 leads to a definite parity assignment but to two possible l values, $\ell \pm \frac{1}{2}$. Which one is correct must be determined from other experiments. The fraction of the single-particle strengths represented by each level is indicated by the length of the shading; thus the ground state is nearly pure $d_{5/2}$ shell-model state.

Figure 11.23 (top) Proton spectrum from $^{90}\text{Zr}(d,p)^{91}\text{Zr}$. Peaks are identified with

Let's consider a specific example. The compound nucleus $^{64}\text{Zn}^*$ can be formed through several reaction processes, including $p + ^{63}\text{Cu}$ and $\alpha + ^{60}\text{Ni}$. It can also decay in a variety of ways, including $^{63}\text{Zn} + n$, $^{62}\text{Cu} + n + p$, and $^{62}\text{Zn} + 2n$. That is

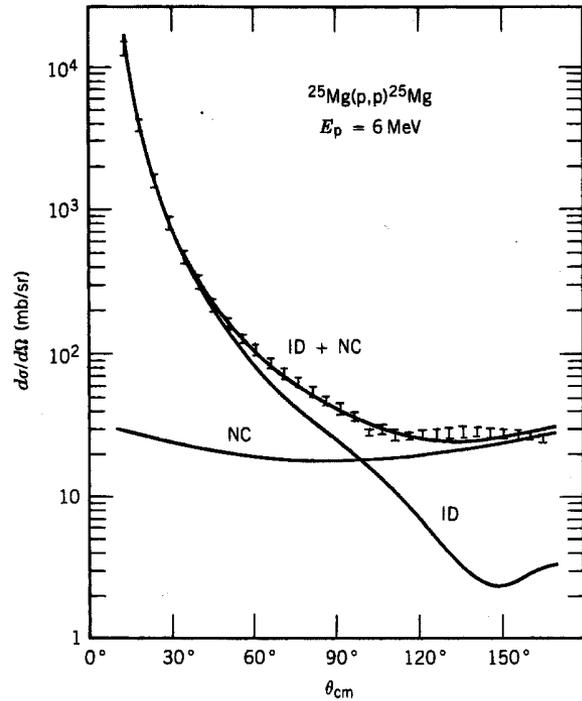
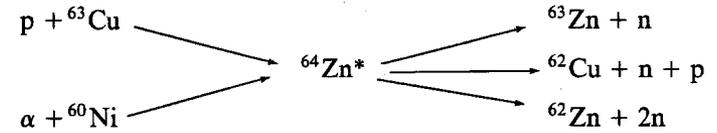


Figure 11.20 The curve marked NC shows the contribution from compound-nucleus formation to the cross section of the reaction $^{25}\text{Mg}(p,p)^{25}\text{Mg}$. The curve marked ID shows the contribution from direct reactions. Note that the direct part has a strong angular dependence, while the compound-nucleus part shows little angular dependence. From A. Gallmann et al., *Nucl. Phys.* **88**, 654 (1966).

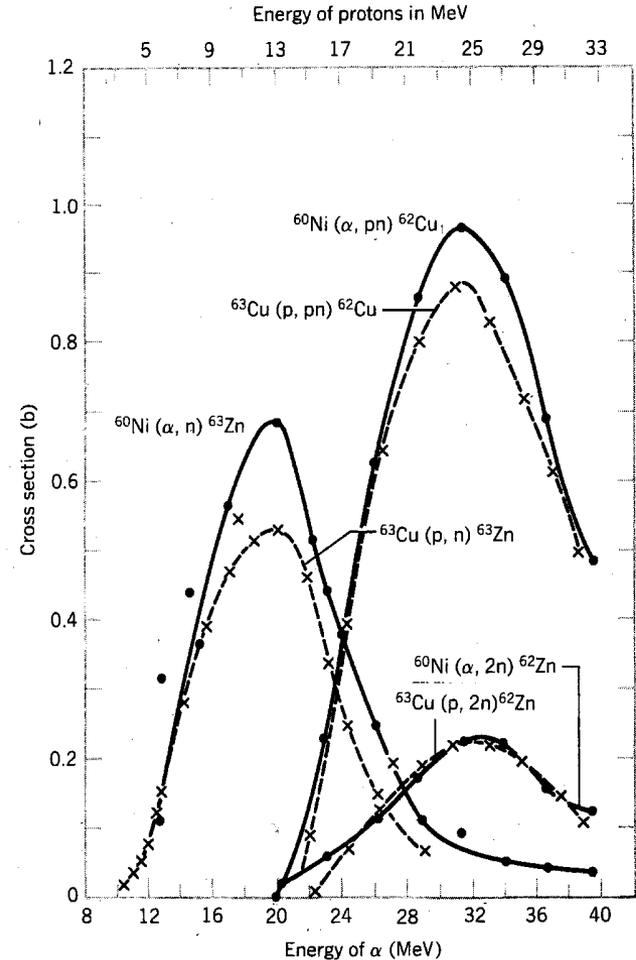
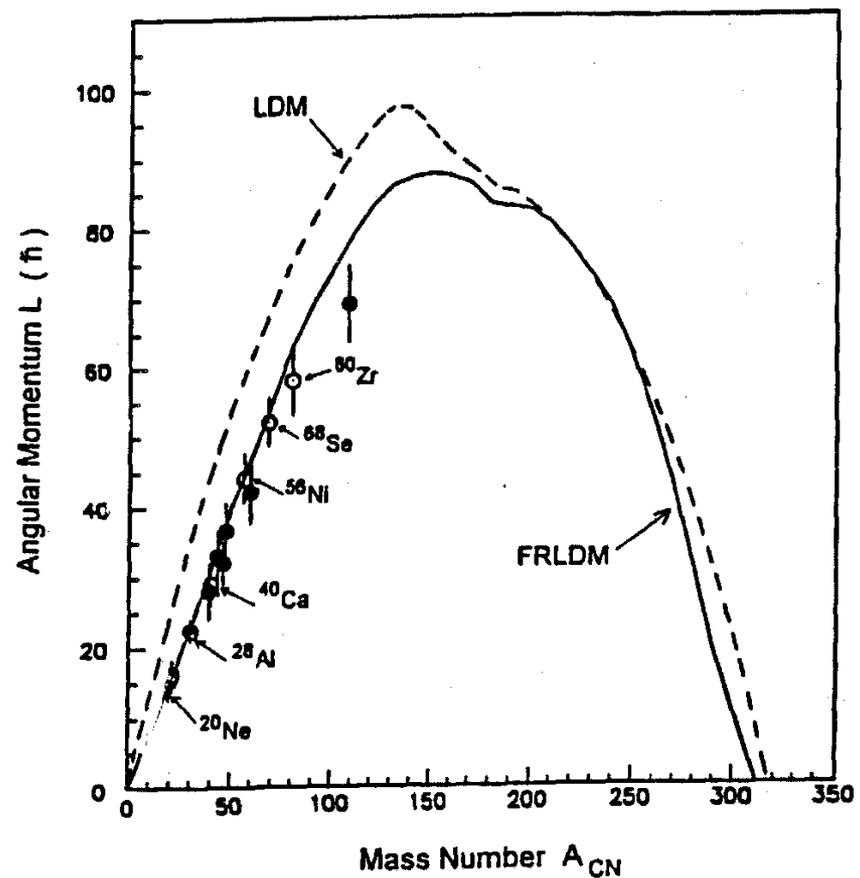
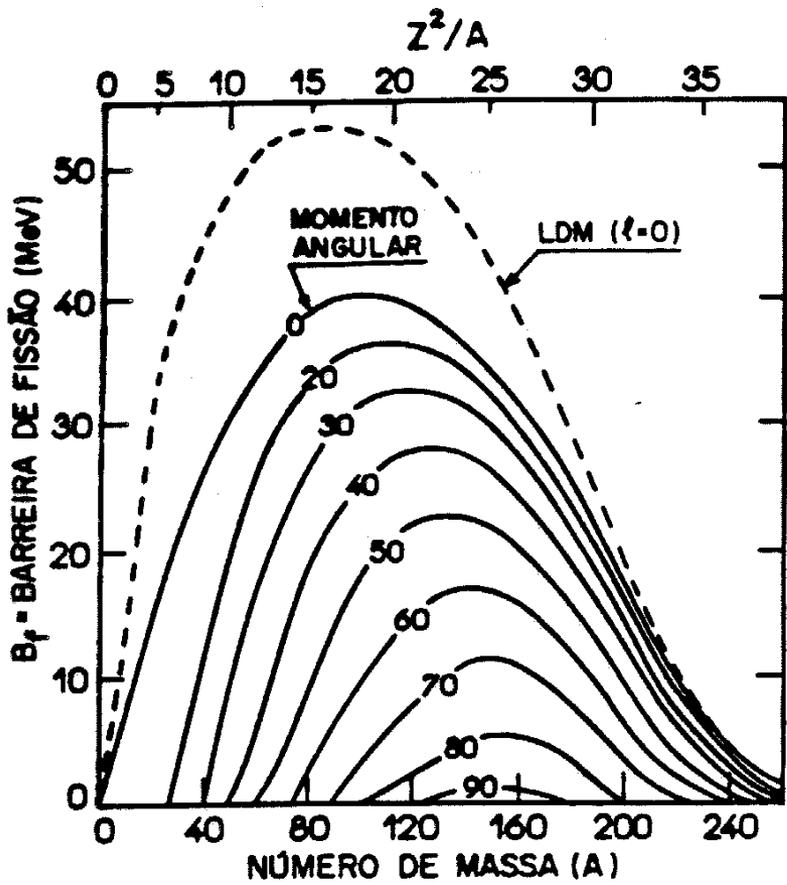


Figure 11.19 Cross sections for different reactions leading to the compound nucleus ^{64}Zn show very similar characteristics, consistent with the basic assumptions of the compound nucleus model. From S. N. Goshal, *Phys. Rev.* **80**, 939 (1950).



1

HIPÓTESE de BOHR E NÚCLEO COMPOSTO

$$X(a, b)Y$$

$$\sigma_{ab} = \sigma_c(a) G_c(b)$$

↑
Seção de choque

↑
Probabilidade

$$\sum_b G_c(b) = 1$$

Se α e β representam canais

$$\sigma(\alpha, \beta) = \sigma_c(\alpha) G_c(\beta)$$

$$G_c(\beta) \text{ dependem de } \begin{cases} E_c \\ J_c \\ \pi_c \end{cases}$$

$\sigma(d, \alpha) \equiv$ compound elastic

Se C tem uma vida média $\tau(E_c)$ até decair

$$\Gamma(E_c) = \frac{\hbar}{\tau(E_c)} \Rightarrow \text{unidade de Energia}$$

↳ largura de níveis "estados"

$$\Gamma(E_c) = \sum_{\beta} \Gamma_{\beta}(E_c) \rightarrow \text{LARGURA PARCIAL}$$

2

$$G_c(\beta) = \frac{\Gamma_\beta}{\Gamma}$$

A partir do conceito de INDEPENDÊNCIA da formação e Decaimentos do N.C

$$\frac{\sigma_c(\alpha)}{\lambda_\alpha \Gamma_\alpha} = V(E_c)$$

Função de E_c^*
e \bar{n} depende do canal α

↑↑
a partir do Teorema da Reciprocidade

$$\frac{\sigma(\alpha, \beta)}{\sigma(\beta, \alpha)} = \frac{\lambda_\alpha^2}{\lambda_\beta^2}$$

$$\frac{\sigma_c(\alpha)}{\Gamma_\alpha \lambda_\alpha^2} = \frac{\sigma_c(\beta)}{\Gamma_\beta \lambda_\beta^2} = V(E_c)$$

$$G_c(\beta) = \frac{k_\beta^2 \sigma_c(\beta)}{\sum_\gamma k_\gamma^2 \sigma_c(\gamma)}$$

3

COEFICIENTE DE TRANSMISSÃO DE UMA BARREIRA DE POTENCIAL

Decompondo em ondas parciais

$$\sigma_c(\alpha) = \sum_{l=0}^{\infty} \sigma_{cl}(\alpha)$$

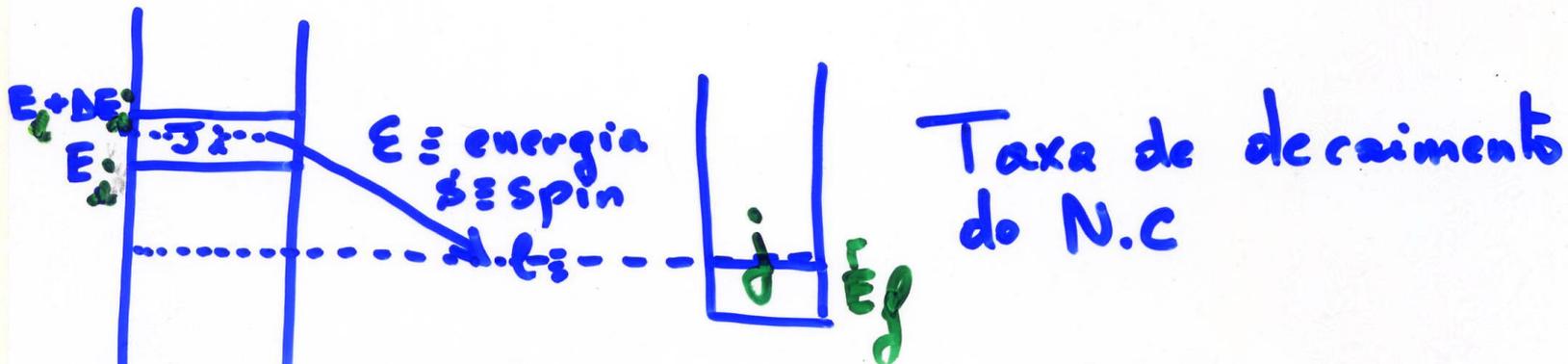
$$\sigma_{cl}(\alpha) = (2l+1)\pi \lambda^2 T_l(\alpha)$$

$$T = \frac{|A|^2 - |B|^2}{|A|^2}$$

σ de formação de um Núcleo Composto



EMIÇÃO DE NUCLEONS OU CLUSTERS



$$\begin{aligned}
 R(E_i, J_i \rightarrow E_f, j, s) dE &= \\
 &= \frac{1}{h} \sum_{s=|j-s|}^{|j+s|} \sum_{l=|J_i-s|}^{J_i+s} T_l(E) \frac{\rho(E_f, j)}{\rho(E_i, J_i)} dE
 \end{aligned}$$

4

TEORIA ESTATISTICA



HAUSER. FESHBACH

$$\underbrace{\vec{l} + \vec{s}}_{\text{c. entr.}} = \underbrace{\vec{J}}_{\substack{\downarrow \\ \text{nc}}} = \underbrace{\vec{l}' + \vec{s}'}_{\text{co saída}}$$

$$\begin{aligned} S &= I + i \\ S' &= I' + i' \end{aligned}$$

$$\sigma_{\alpha\alpha'} = \pi \lambda_{\alpha}^2 \sum_J \frac{2J+1}{(2I+1)(2i+1)} \frac{\left\{ \sum_{s_i} T_{\ell_i}(\alpha) \right\}^J \left\{ \sum_{s_i'} T_{\ell_i'}(\alpha') \right\}^J}{\sum_{\alpha'', s_i', \ell_i'} T_{\ell_i}(\alpha'')}$$

$$\left\{ \sum_{s_i, \ell_i} T_{\ell_i}(\alpha) \right\}^J = \sum_{S_i = |I_i - i_i|}^{I_i + i_i} \sum_{\ell_i=0}^{\infty} \sum_{J_i = \ell_i + s_i}^{\ell_i + S_i} T_{\ell_i}(\alpha_i)$$

$$\left\{ \sum_{s', e'} T_{e'}(d'') \right\}^3 = \sum_{S_2=1-S_1}^{L_2+1} \sum_{l_2=0}^{m_2} \sum_{J=l_2-S_2}^{L_2+S_2} T_{e(l_2)}(E'')$$

$$\sum_{d''} T_{e''}(d'') = \sum_{d''} \sum_{e''} \sum_{s''} \sum_{I''} \underbrace{\int T_{e''} \rho_{I''}(E'') dE''}_{T_{e''}(E'')}$$

COMO REPRESENTAR $\rho(E'')$

ref: Mayer-Kukuk

I REAÇÕES de NÚCLEO COMPOSTO

$$\sigma_{\alpha\beta} = \sigma_{dc} \cdot G_{\beta}$$

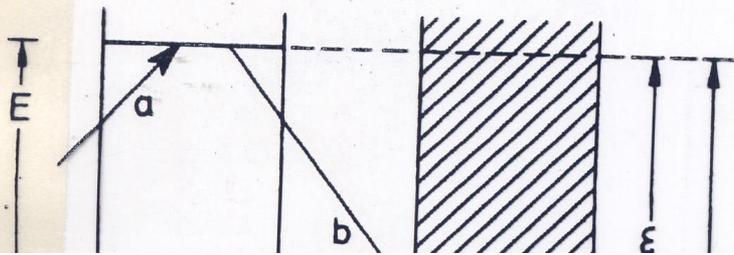
$$G_{\beta} = \frac{\Gamma_{\beta}}{\Gamma} \text{ com } \Gamma = \sum_{\beta'} \Gamma_{\beta}$$

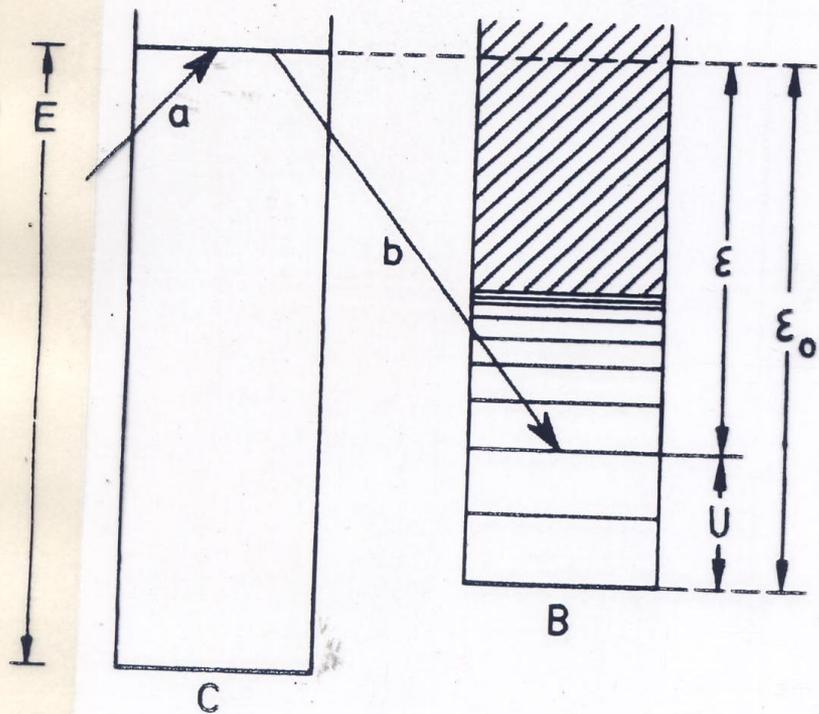
TEOREMA DA RECIPROCIDADE:

$$\sigma_{\alpha\beta} k_a^2 = \sigma_{dc} k_a^2 \frac{\Gamma_{\beta}}{\Gamma} = \sigma_{\beta c} k_{\beta}^2 \frac{\Gamma_{\alpha}}{\Gamma}$$

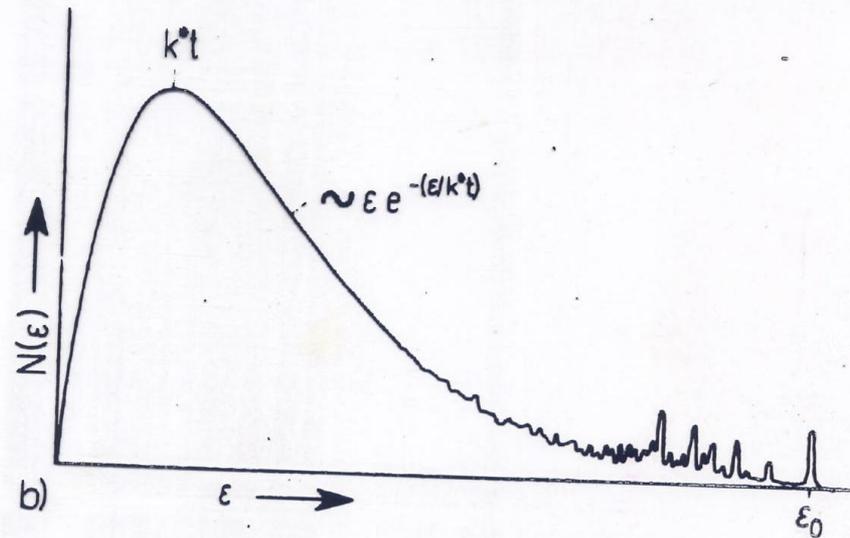
$$\sigma_{\alpha\beta} k_a^2 = \sigma_{\beta\alpha} k_{\beta}^2$$

$$\sigma_{\alpha\beta} = \sigma_{dc} \cdot \frac{\sigma_{\beta c} k_{\beta}^2}{\sum_{\beta'} \sigma_{\beta' c} k_{\beta'}^2}$$





$$\sum_{\beta} \sigma_{\beta} \cdot k_{\beta}^2$$



a)

Fig.113

- a) Relações energéticas para o decaimento de um núcleo composto.
 b) Espectro de energia das partículas emitidas (esquemáticamente).

$$\sigma_{dc} \rightarrow \langle \sigma_{dc} \rangle = \left(\frac{\pi}{k_d^2} \right) T_d$$

$$\langle \sigma_{d\beta} \rangle = \frac{\pi}{k_d^2} T_d \cdot \frac{T_{\beta}}{\sum T_i}$$

II

$$g(U) \sim \frac{1}{U} e^{2\sqrt{aU}} \quad \text{com } a = \frac{\pi^2}{6D_0}$$

Introduzimos $S(U) = k^* \log \frac{g(U)}{g(0)} \rightarrow g(U) = g(0) e^{S(U)/k^*}$

$$\Rightarrow S(U) = 2k^* \sqrt{aU}$$

desenvolvendo $S(U)$ para $U = \epsilon_0 - \epsilon$ em torno de ϵ_0

$$S(\epsilon_0 - \epsilon) = S(\epsilon_0) - \epsilon \left(\frac{dS}{d\epsilon} \right)_{\epsilon=0}$$

Para $\frac{dS}{d\epsilon} = \frac{1}{t} \Rightarrow g(U) = c e^{-\epsilon/k^* t} \Rightarrow S \equiv \text{entropia} \begin{cases} k^* = 1 \\ t \equiv \text{temperatura} \end{cases} \begin{cases} k^* = 1 \\ t \equiv \text{MeV} \end{cases}$

$$\log g \sim 2\sqrt{aU} - \frac{1(1+1)}{2\sigma^2}$$

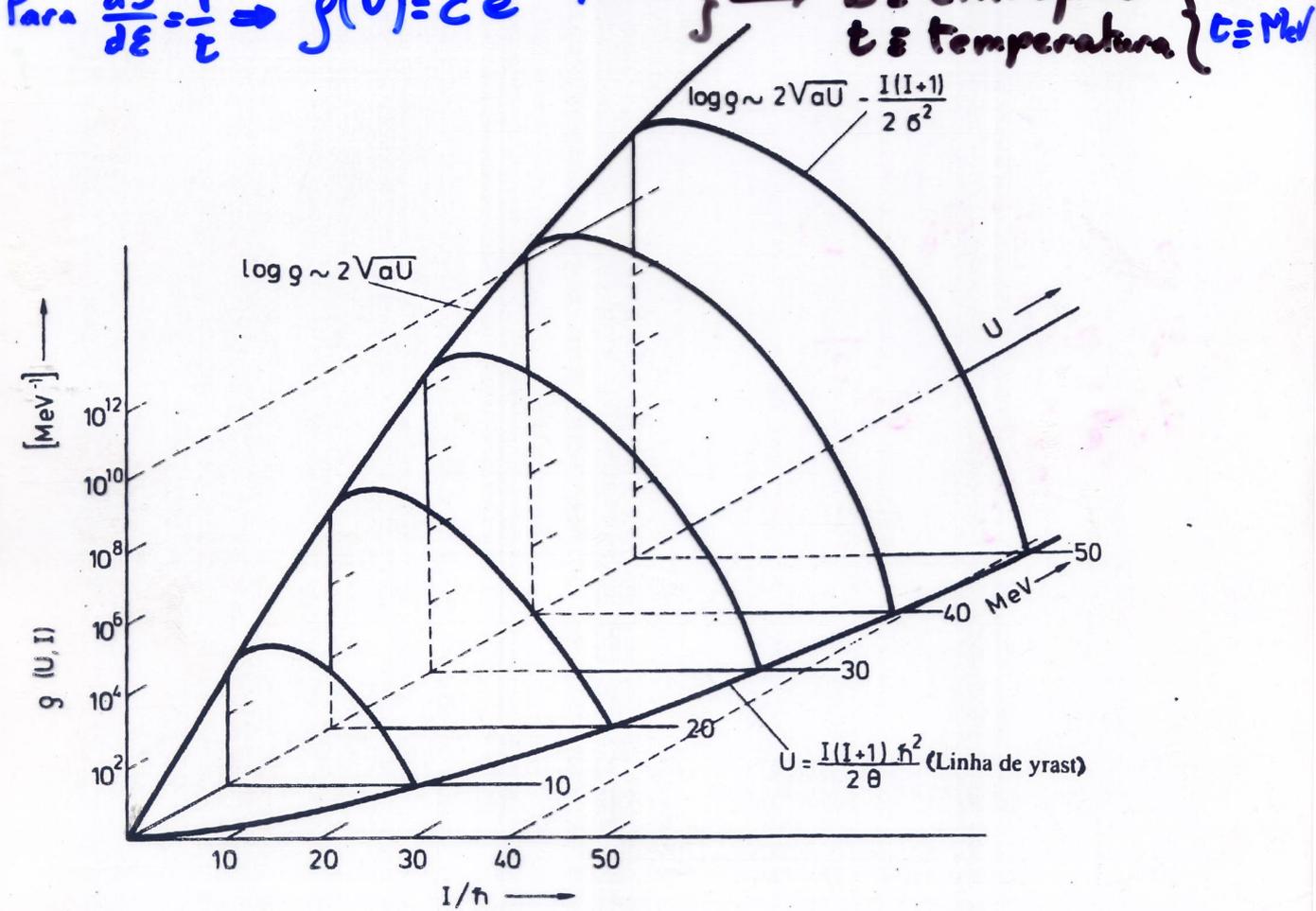


Fig. 114

Densidade de níveis (em MeV⁻¹), em função de U e I. Os valores indicados referem-se a ⁶⁵Zn.

$$g(U, I) \sim \frac{1}{\nu^2} (2I+1) e^{2\sqrt{aU} - E_{rot}/t} = \frac{1}{\nu^2} (2I+1) e^{\left\{ 2\sqrt{aU} - \frac{I(I+1)}{2\sigma^2} \right\}}$$

$$\sigma^2 = \frac{\theta t}{\hbar^2}$$

$$E_{rot} = \frac{I(I+1)\hbar^2}{20} = \frac{I(I+1)}{20} t$$

III

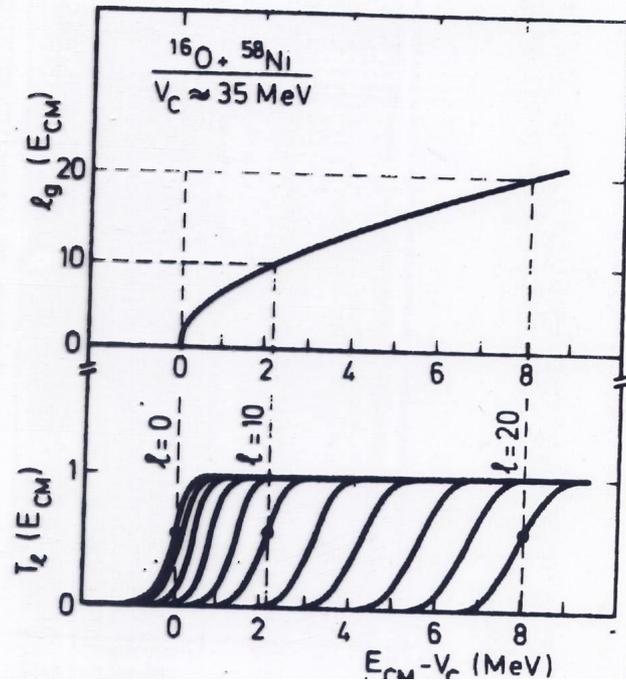
Reações Nucleares e Ions Pesados

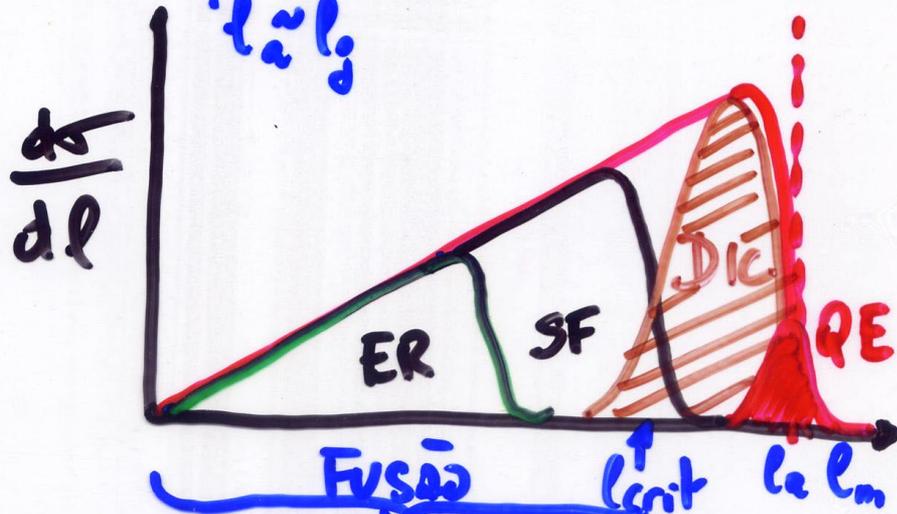
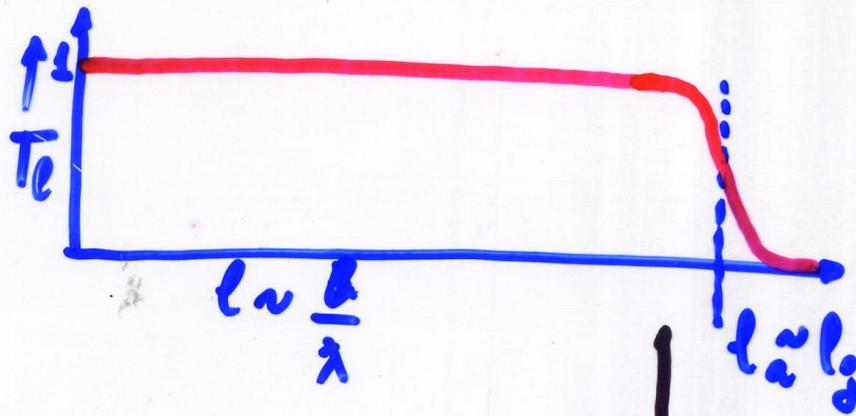
$$\sigma_r = \pi \lambda^2 \sum_l (2l+1) (1 - |< \eta_l >|^2) = \pi \lambda^2 \sum_l (2l+1) T_l$$

$$T_l = \begin{cases} 1 & \text{para } l < l_a \\ 0 & \text{para } l > l_a \end{cases} \left. \vphantom{\begin{cases} 1 \\ 0 \end{cases}} \right\} \sigma_r = \pi \lambda^2 (l_a + 1)^2 \approx \pi \lambda^2 l_a^2$$

118

mento angular de raspagem e coeficientes de transmissão em função da energia cinética acima da barreira de Coulomb para a reação $^{16}\text{O} + ^{58}\text{Ni}$ (segundo [Nör 76]).

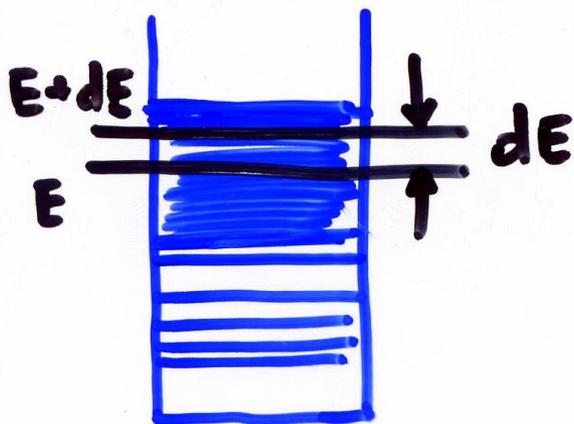




$$\sigma_r = \pi \lambda^2 \left\{ l_{crit}^2 + (l_c - l_c)^2 + \sum_{l_{crit}}^{l_{crit}} (l_{crit})^2 \right\}$$

IV

DENSIDADE DE NIVEIS



nº de combinações que nucleons podem ser colocados nos diversos níveis de partícula-independente de tal forma que a energia de excitação esteja entre

$$E < E' < E + dE$$

- modelo termodinâmico (mec. est.)
- combinatória (comput.) conservando a energia e mom. angular
- decorrente do fato que a densidade de estados são prat. gaussianas

- Modelo de níveis equidistantes.
 espaçamento $\propto g^{-1}$ (MeV)

\equiv sistema de partiz. \bar{n} interagentes
 \therefore Fermi gas onde g^{-1} decresce $\propto \sqrt{E}$

$$w(E) = \frac{\sqrt{T}}{12} \frac{\exp 2\sqrt{aE}}{E^{5/4} a^{1/4}}$$

$$a = \frac{\pi^2 g^2}{6}$$

