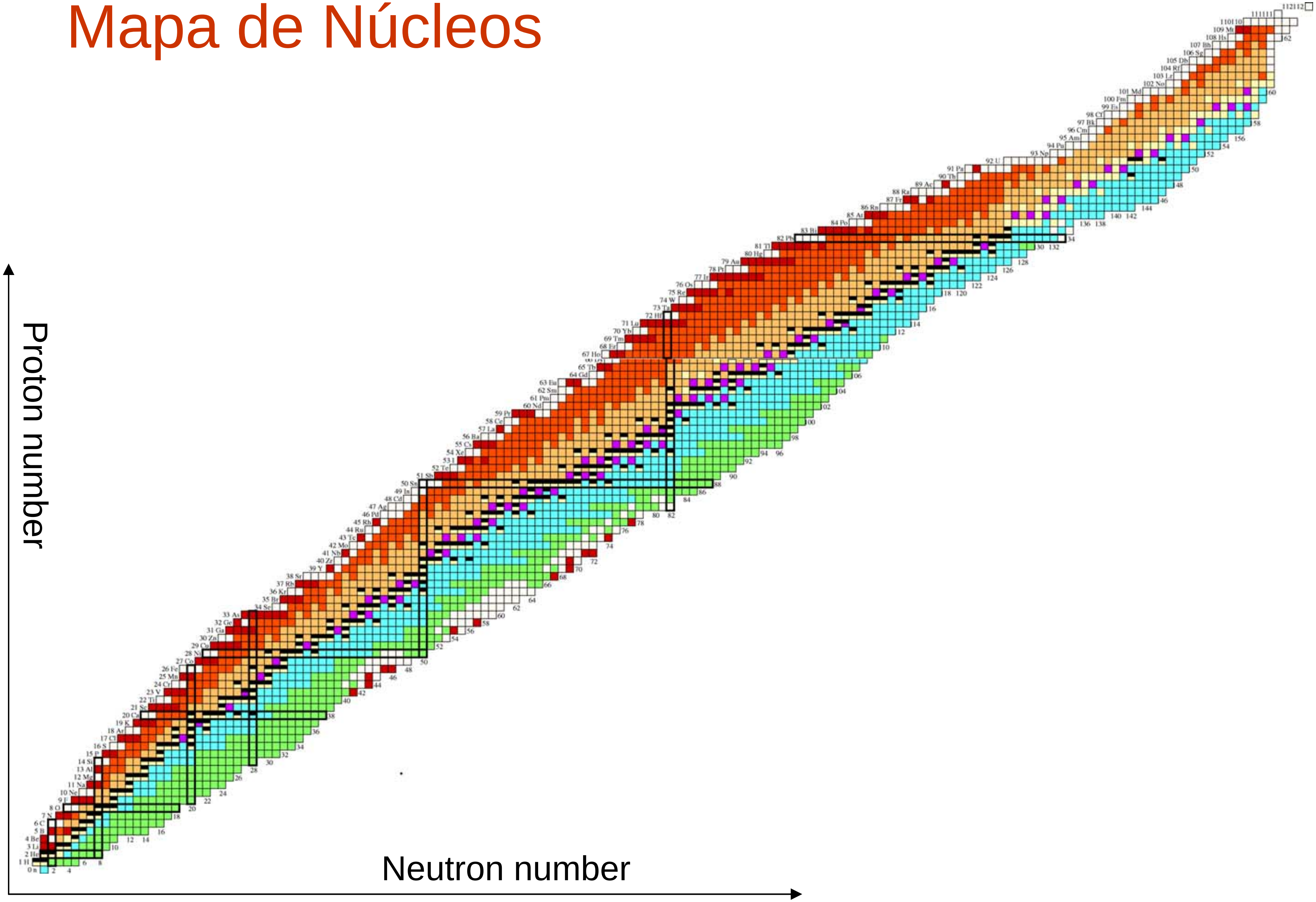
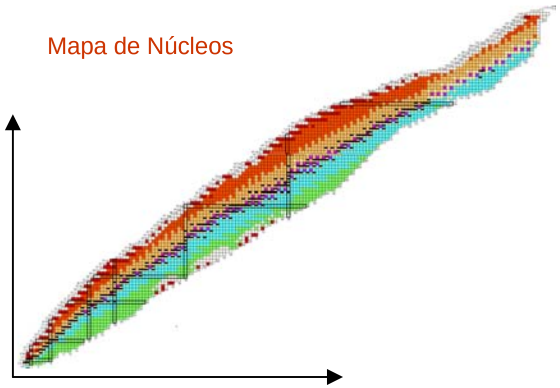
E. Garrido
6 de Junio de 2007

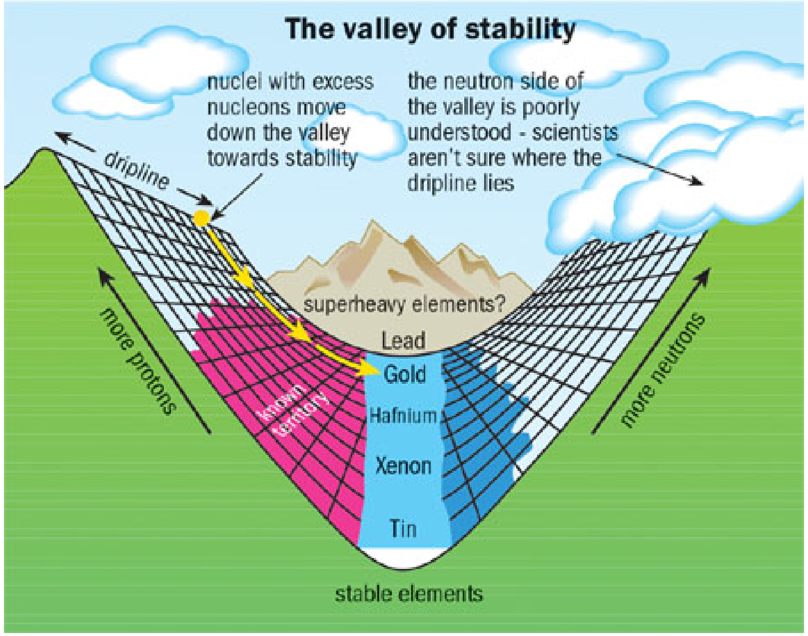
Mapa de Núcleos

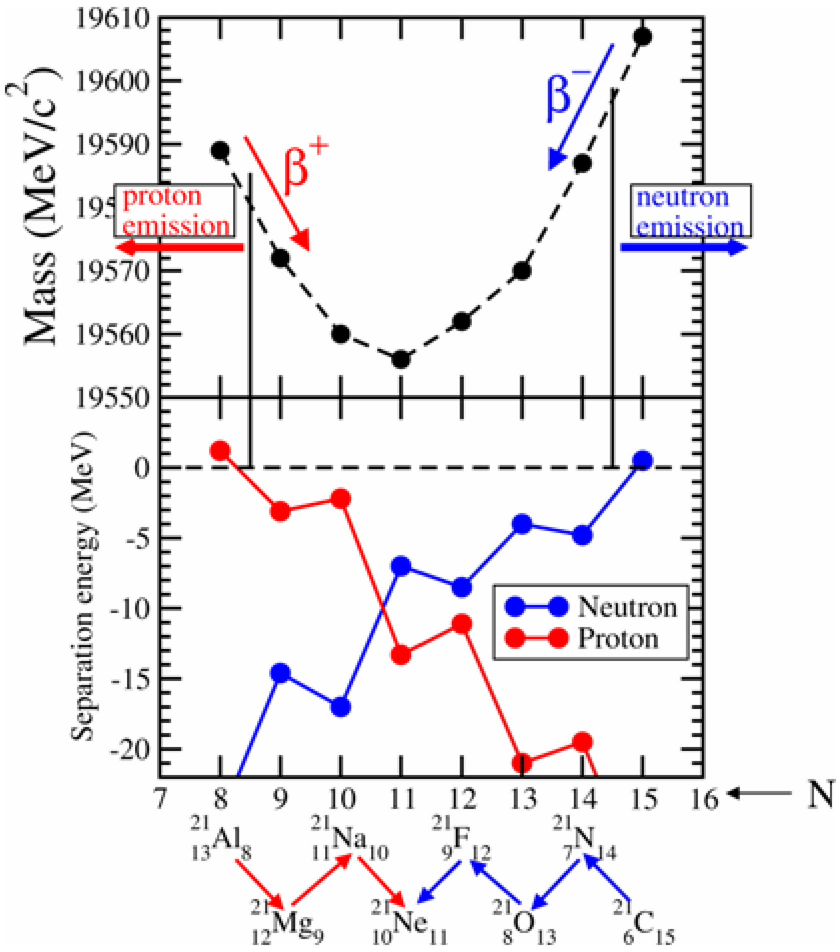


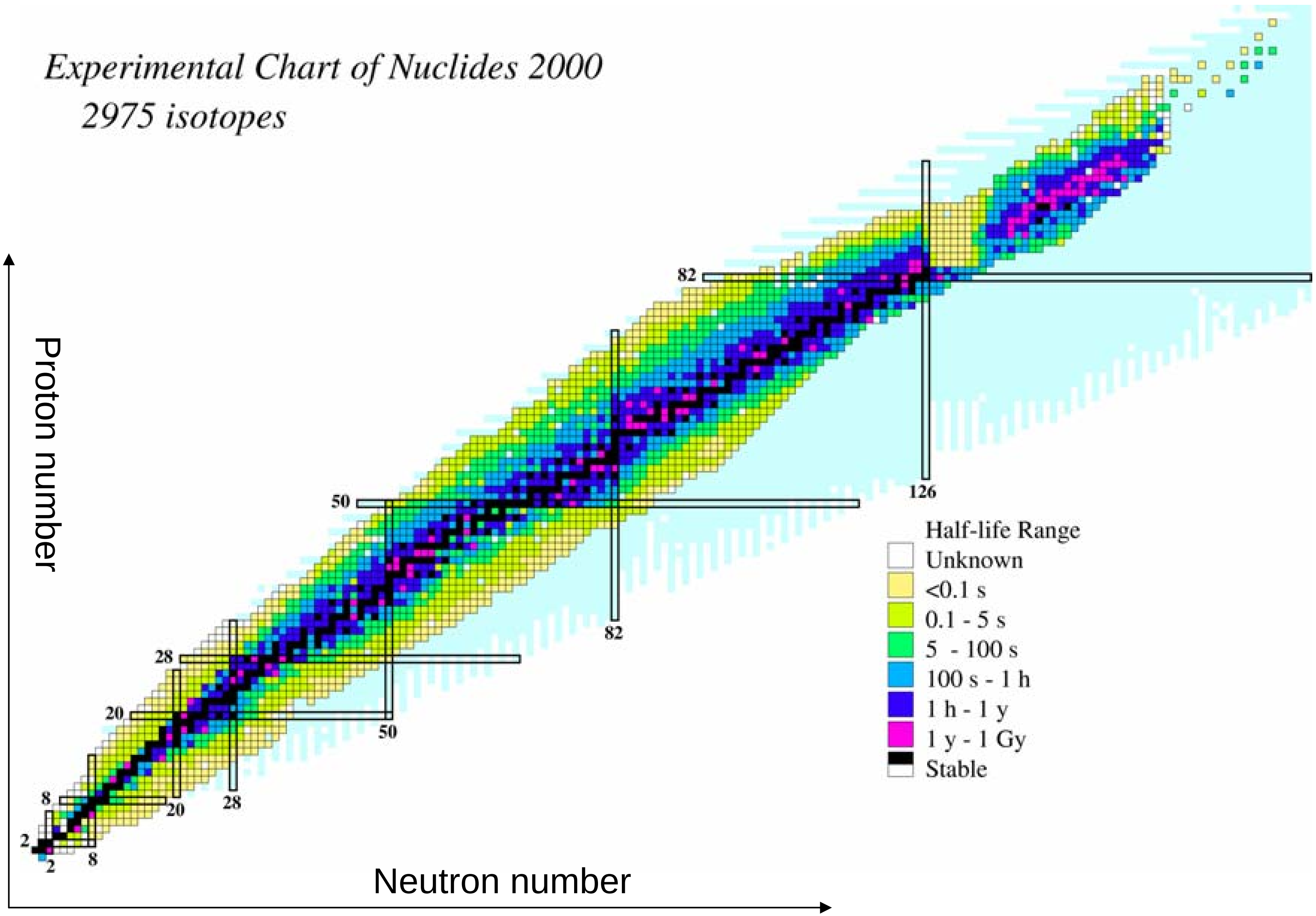
El valle de estabilidad

Mapa de Núcleos

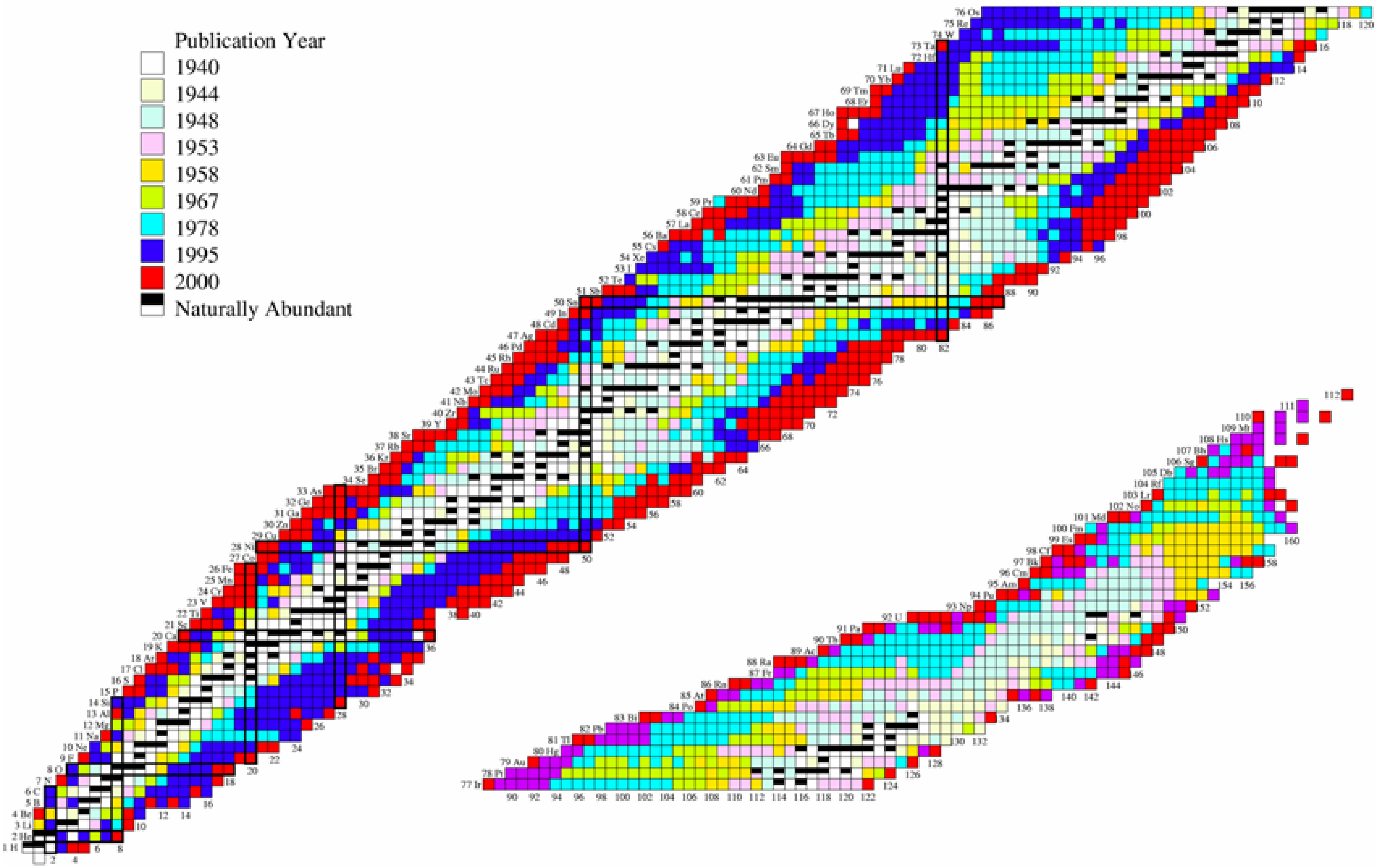




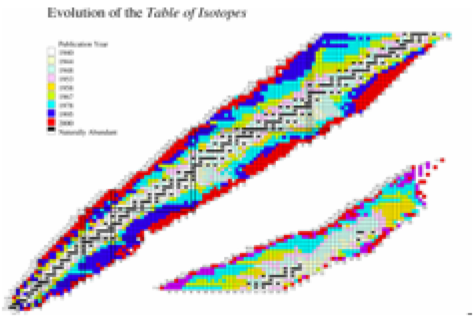


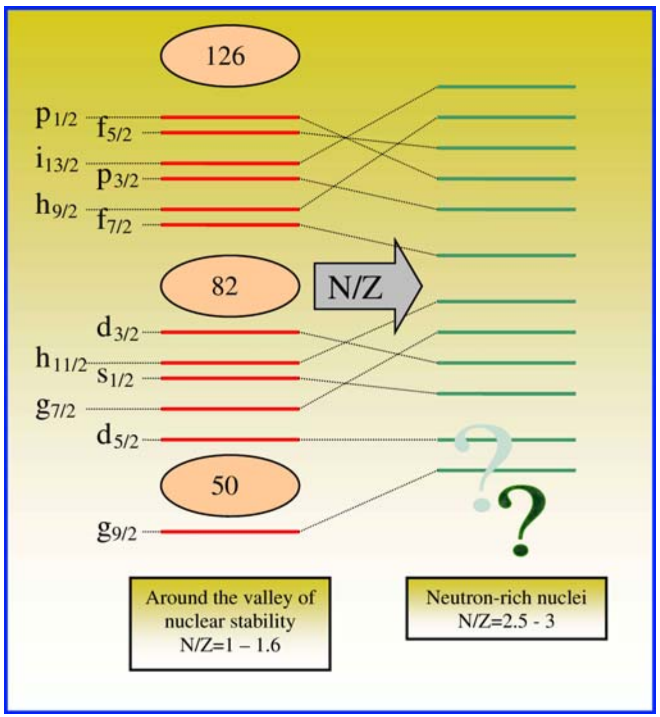

Experimental Chart of Nuclides 2000
2975 isotopes
Proton number
Neutron number
2
8
20
28
50
82
126
Half-life Range
Unknown
<0.1 s
0.1 - 5 s
5 - 100 s
100 s - 1 h
1 h - 1 y
1 y - 1 Gy
Stable

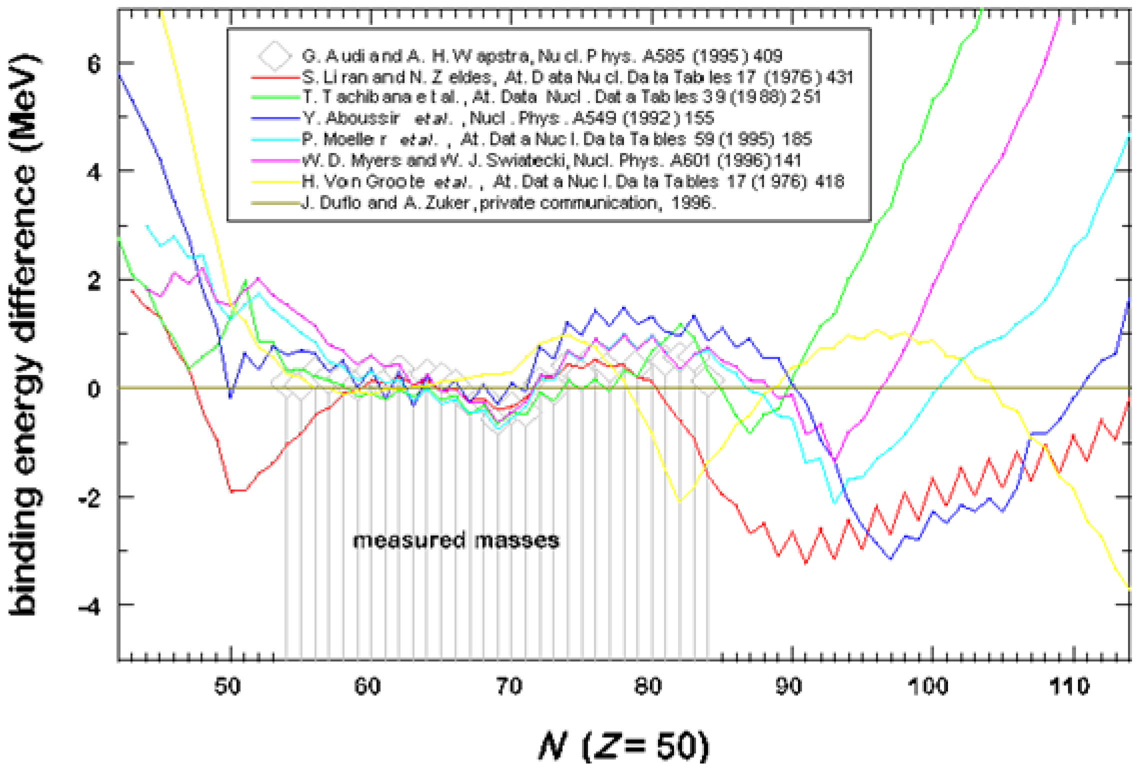
Evolution of the *Table of Isotopes*



¿¿Nuevos fenómenos en las proximidades de las “driplines”??







¿Validez del modelo de capas?

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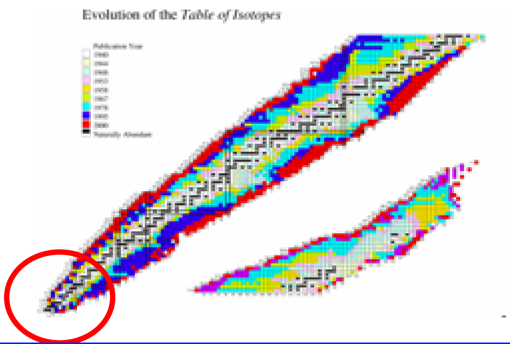

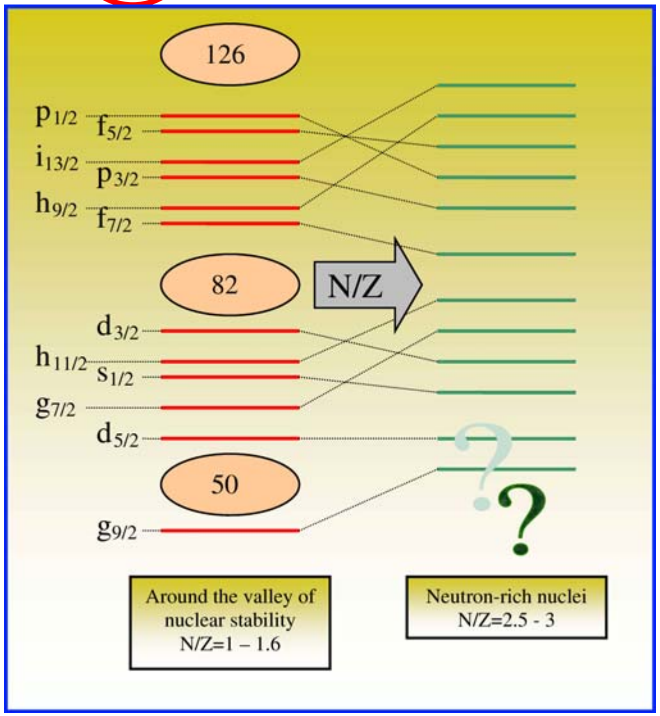

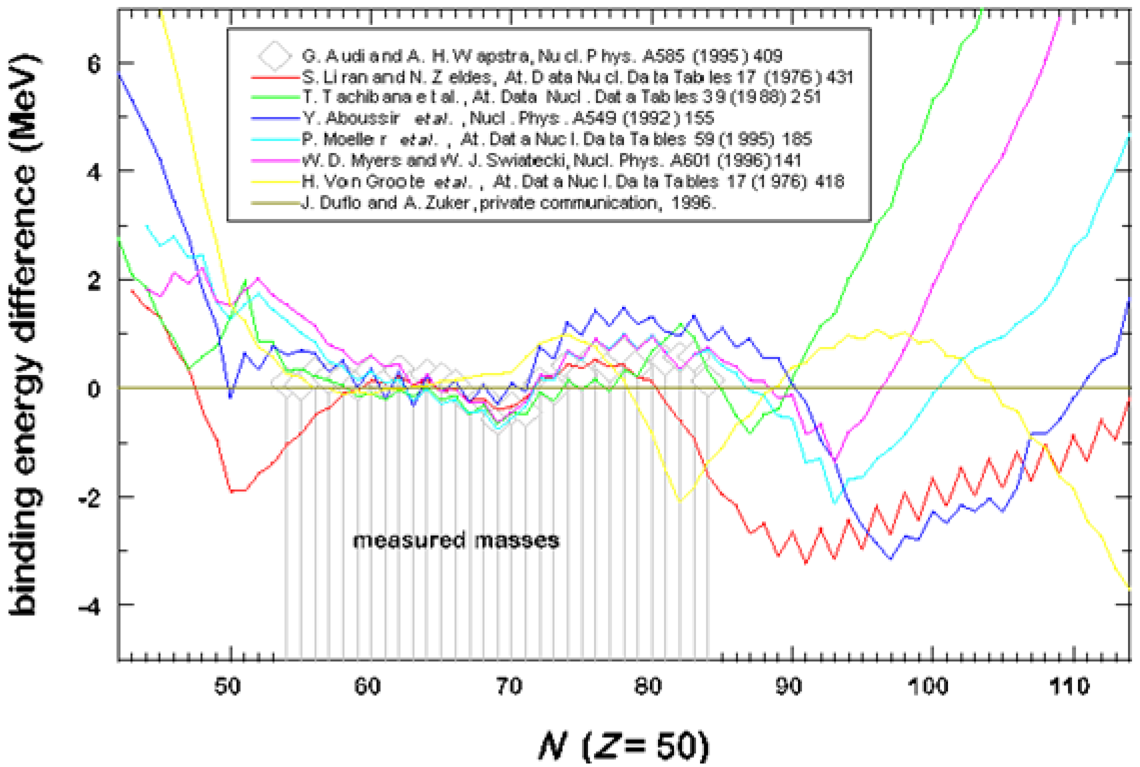

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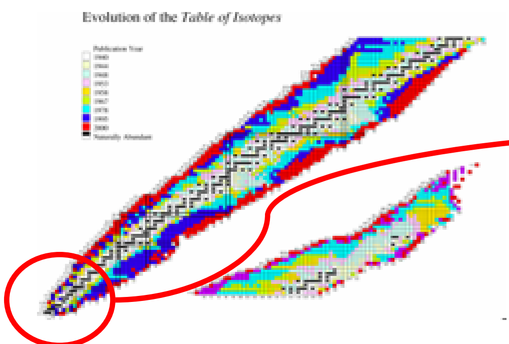
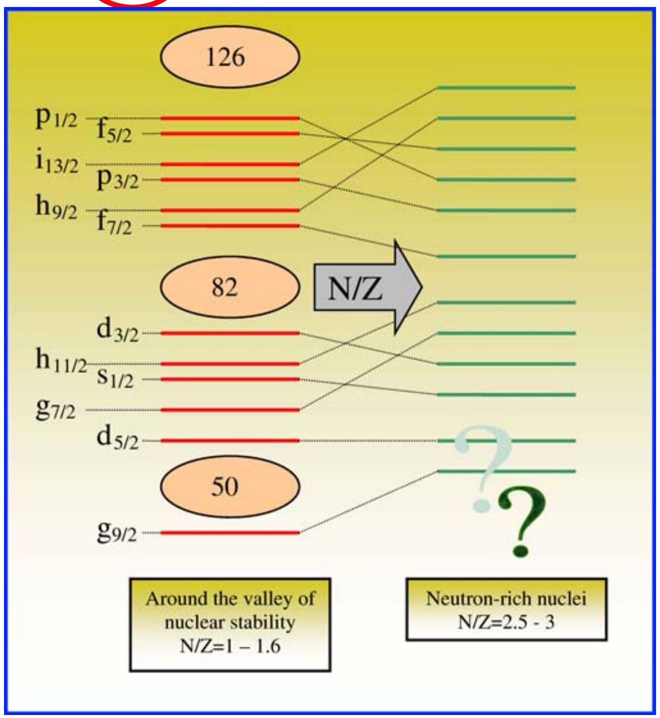


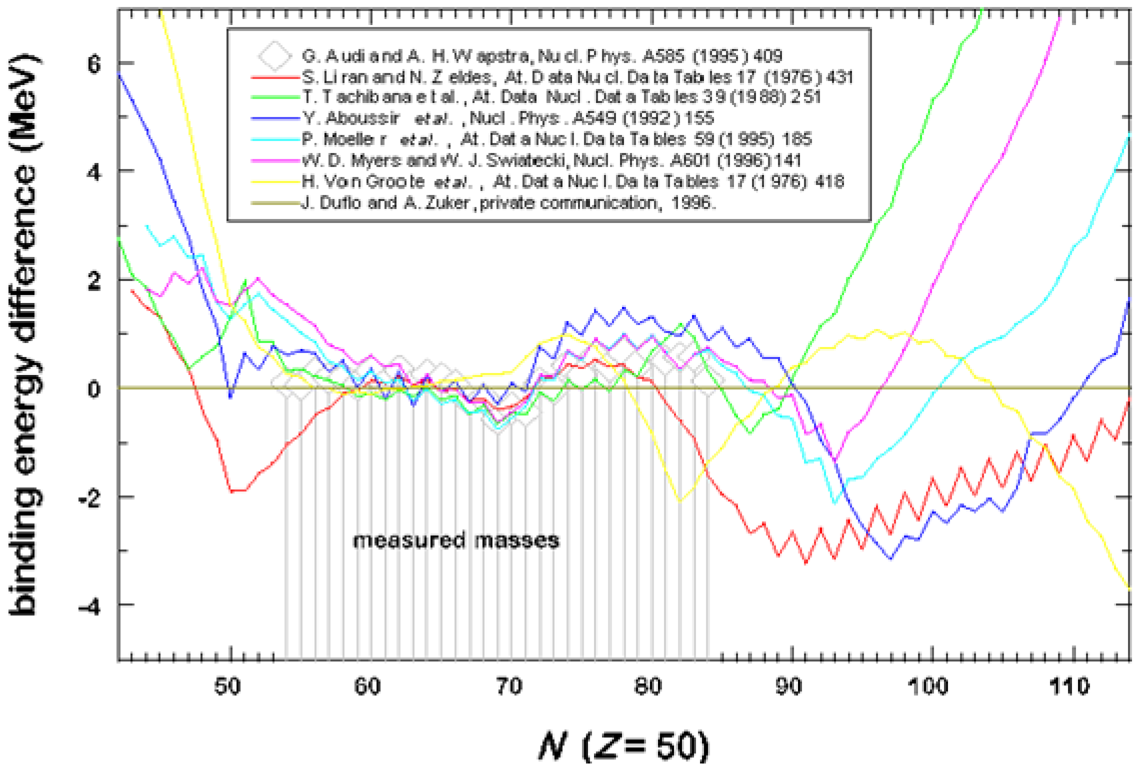
Núcleos ligeros en las “driplines”

Técnicas diferentes

Estructuras exóticas

Núcleos con halo (de neutrones)





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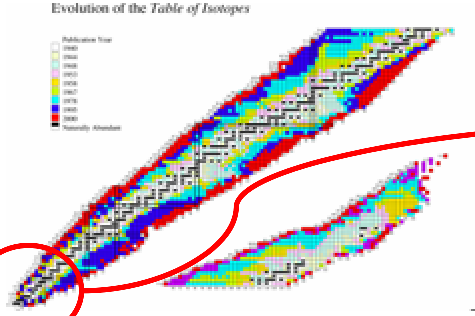

Núcleos ligeros en las “driplines”

Técnicas diferentes

Estructuras exóticas

Núcleos con halo (de neutrones)

- ✓ Peculiaridades de lo núcleos ligeros en las “*driplines*”
- ✓ Energías y tamaños
- ✓ Evidencias experimentales
- ✓ Reacciones de fragmentación: “*Sudden approximation*”

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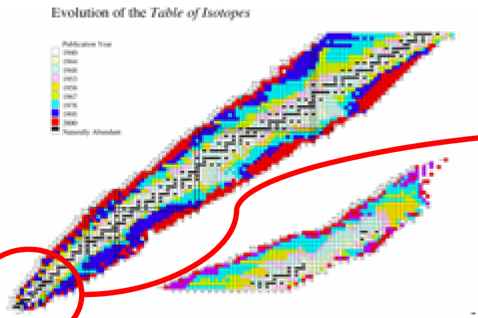

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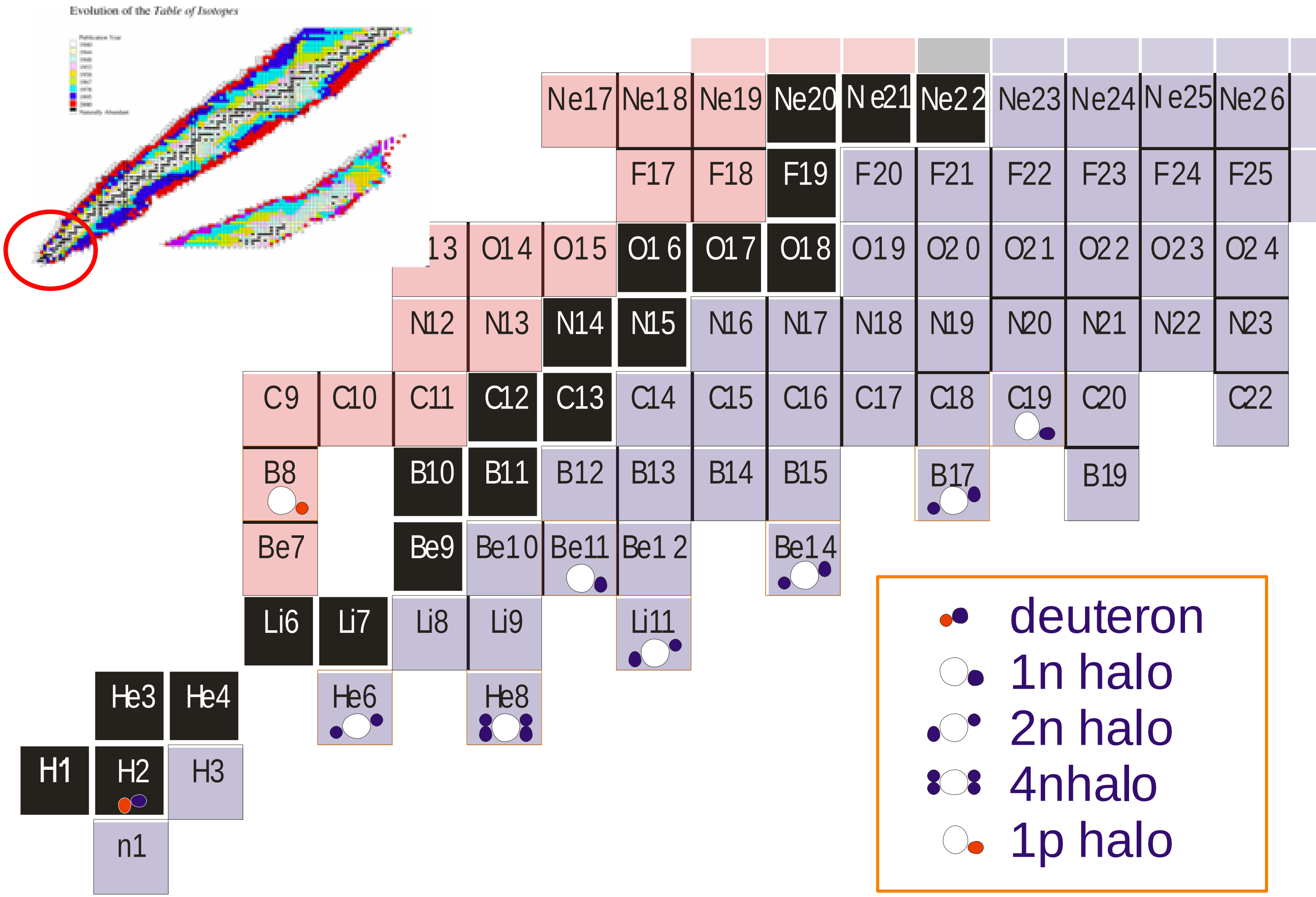
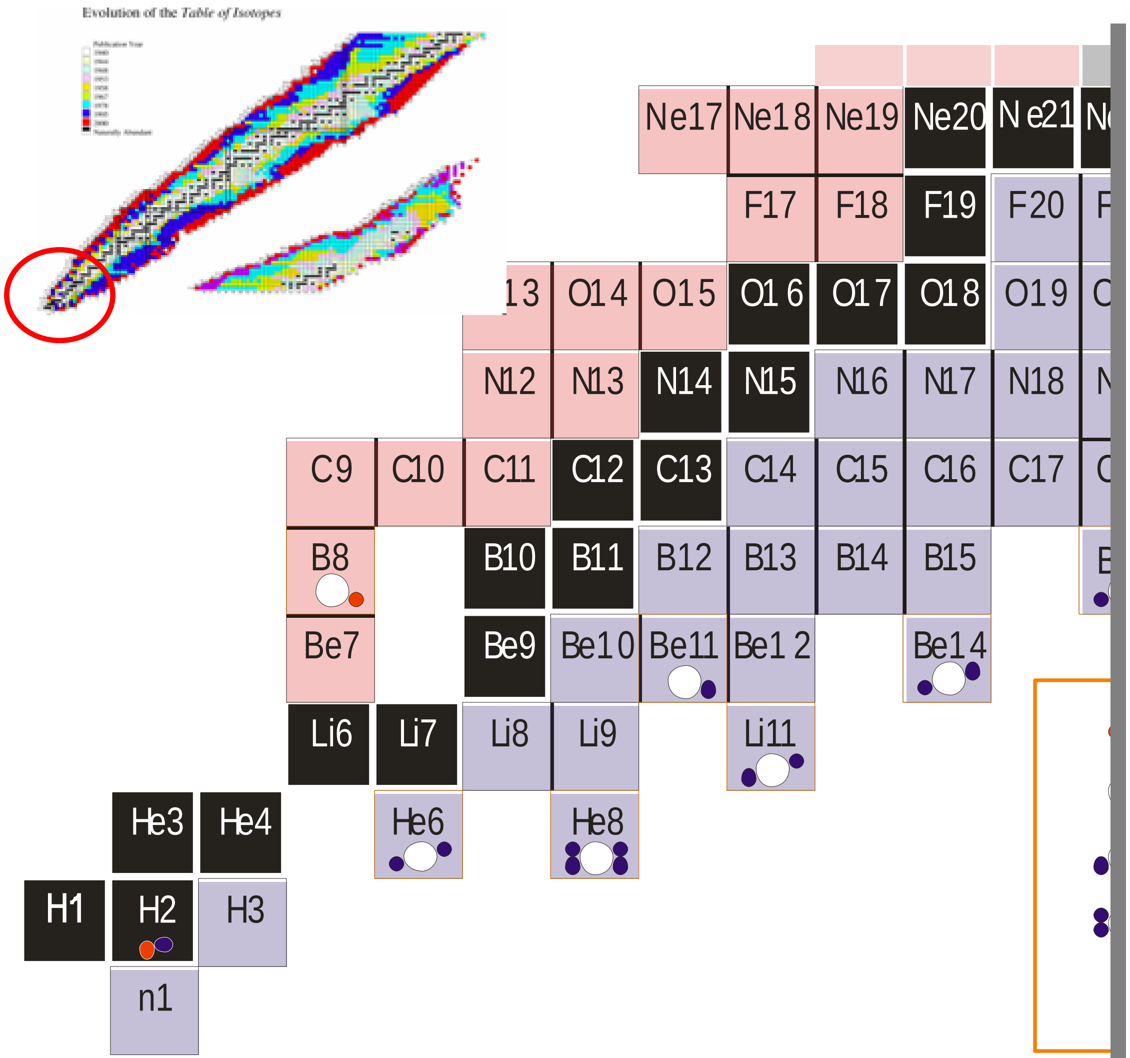
Sistemas de tres cuerpos en Física Nuclear

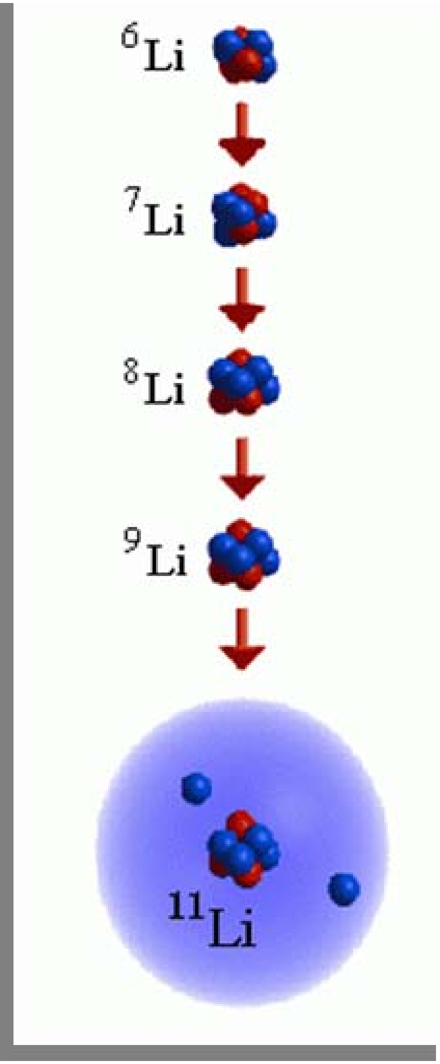
- ✓ Función de onda para un sistema de tres cuerpos
- ✓ Estados de Efimov
- ✓ Estados resonantes: “Complex scaling”

Núcleos Ligeros en las “driplines”: Núcleos con halo

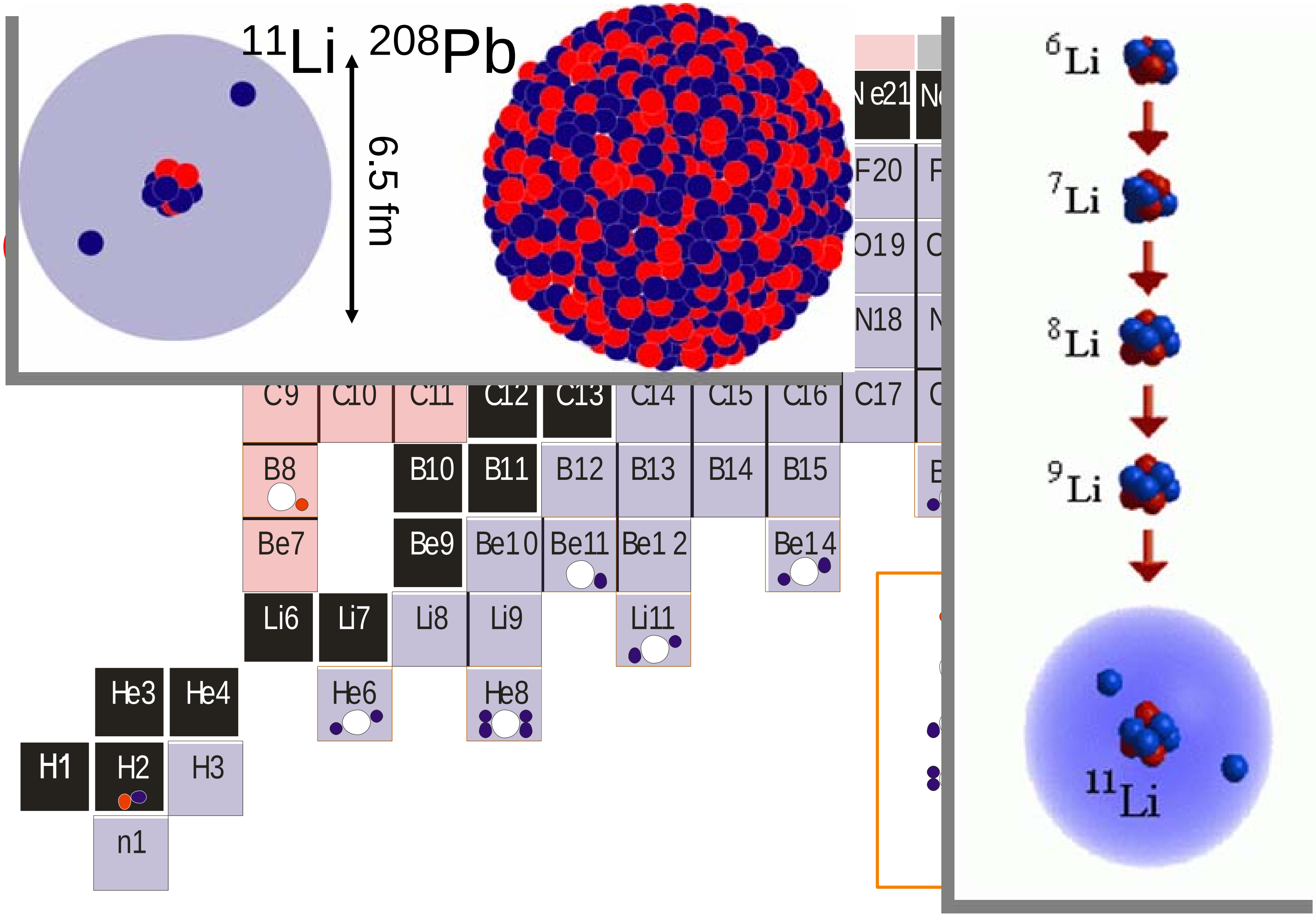


Núcleos Ligeros en las “driplines”: Núcleos con halo

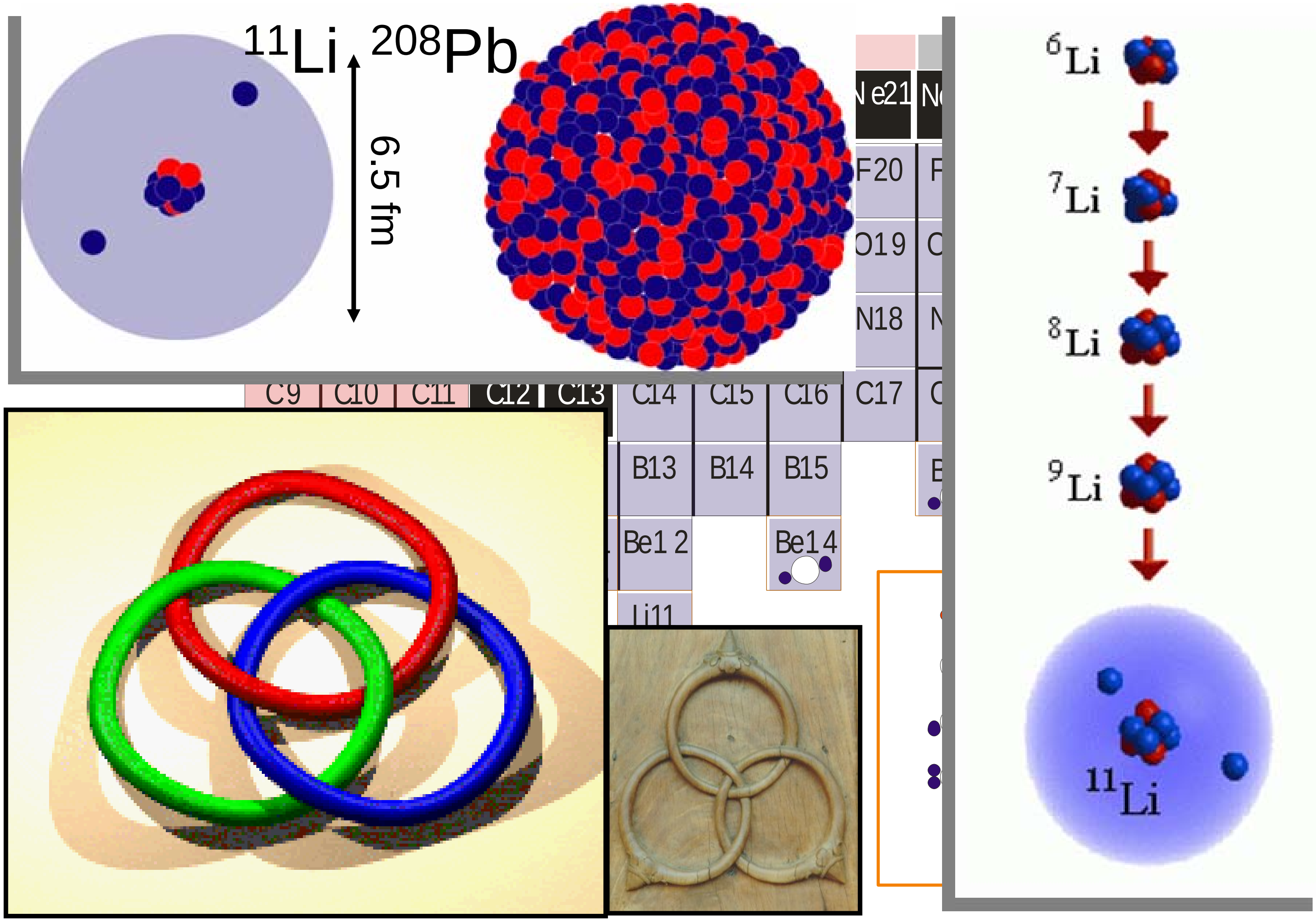




Núcleos Ligeros en las “driplines”: Núcleos con halo



Núcleos Ligeros en las “driplines”: Núcleos de Borromeo



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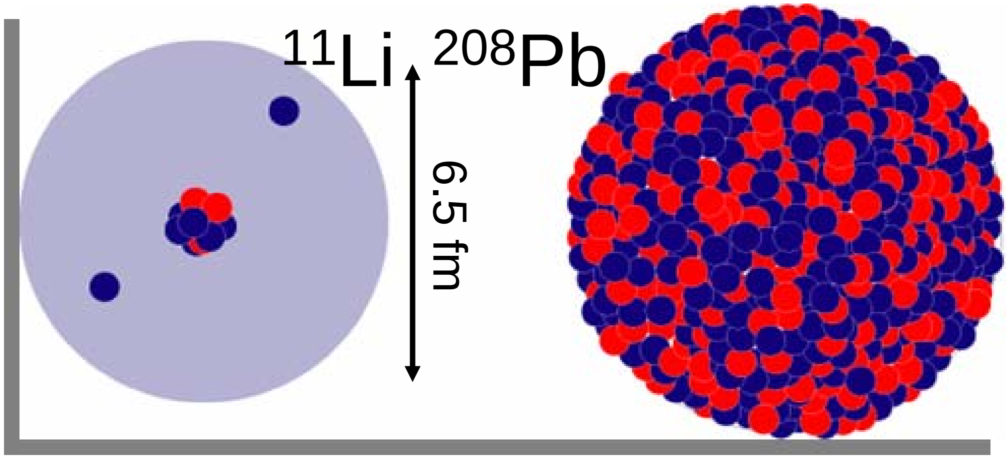
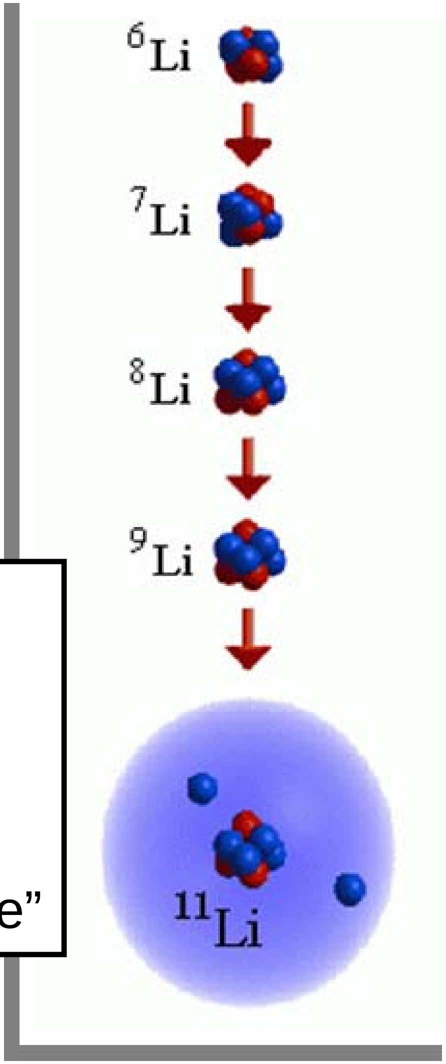
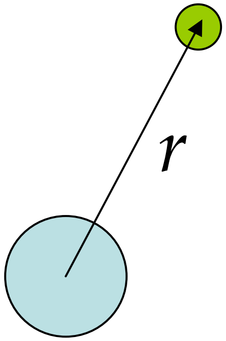




Núcleos con halo:

- ✓Sistemas que “clusterizan”
- ✓Sistemas poco ligados
- ✓Espacialmente muy extensos
- ✓Se extienden a la zona prohibida “clásicamente”

Un caso sencillo: Sistemas de dos cuerpos



Si la interacción es central ⟹ $\Psi_{\ell m}(\vec{r}) = \dfrac{u_\ell(r)}{r} Y_{\ell m}(\Omega)$

$$\left[-\frac{\hbar^2}{2\mu}\frac{d^2}{dr^2} + V(r) - E + \frac{\hbar^2}{2\mu}\frac{\ell(\ell+1)}{r^2}\right] u_\ell(r) = 0$$

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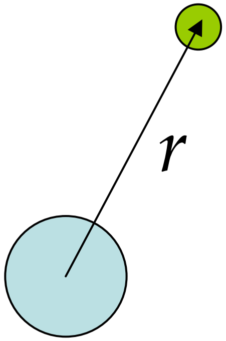

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$$\langle r^n \rangle = \int_0^\infty r^n \left(u_\ell(r)\right)^2 dr \equiv I_n^\ell(r<a) + O_n^\ell(r>a)$$

$$P_\ell = \frac{O_0^\ell}{I_0^\ell + O_0^\ell}$$

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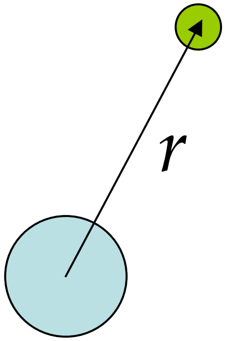

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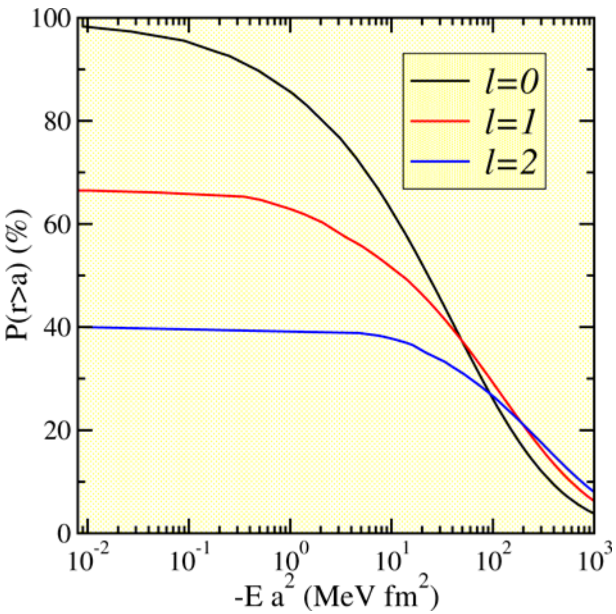

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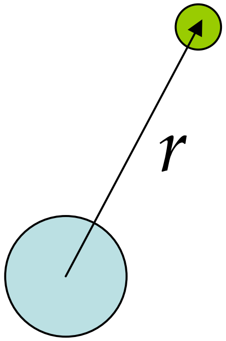

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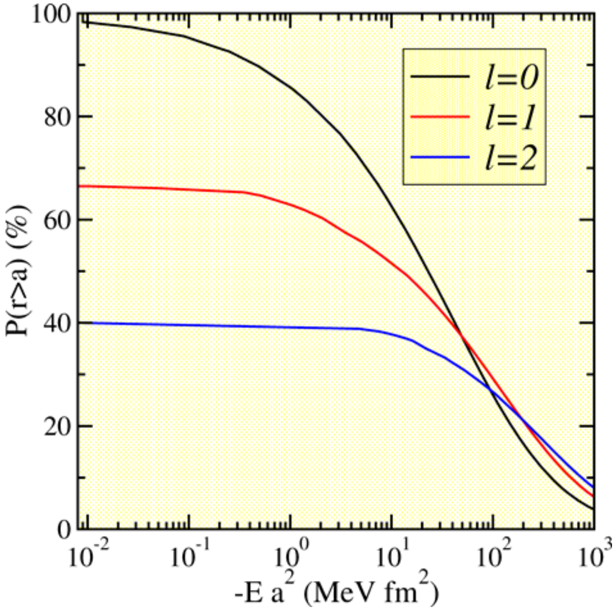

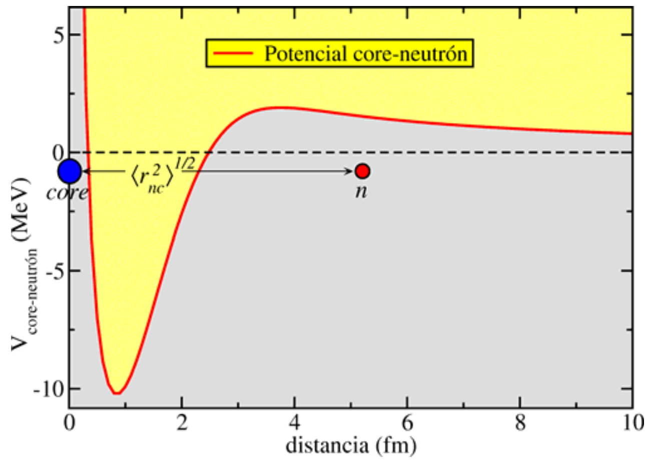

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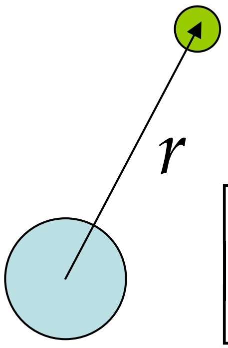

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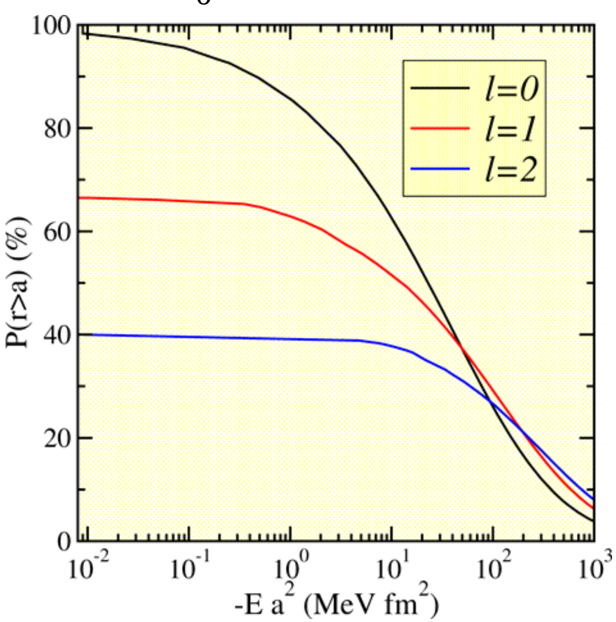

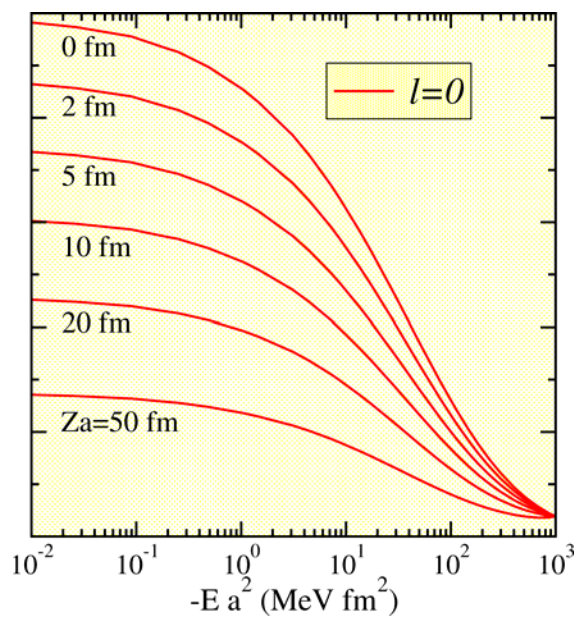

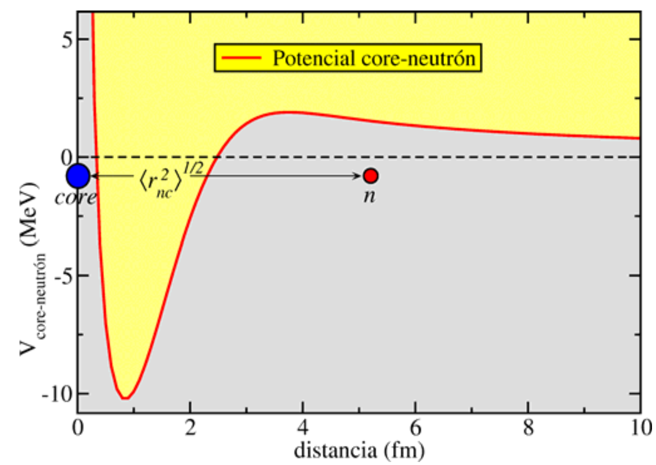

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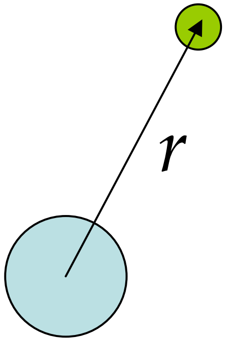

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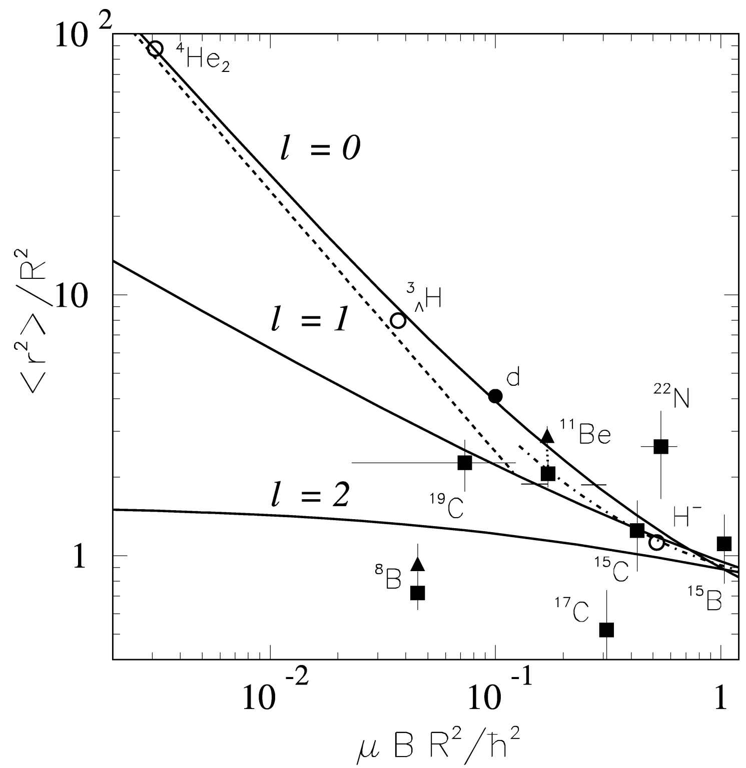

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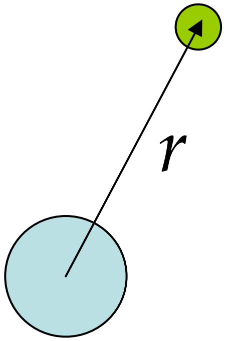

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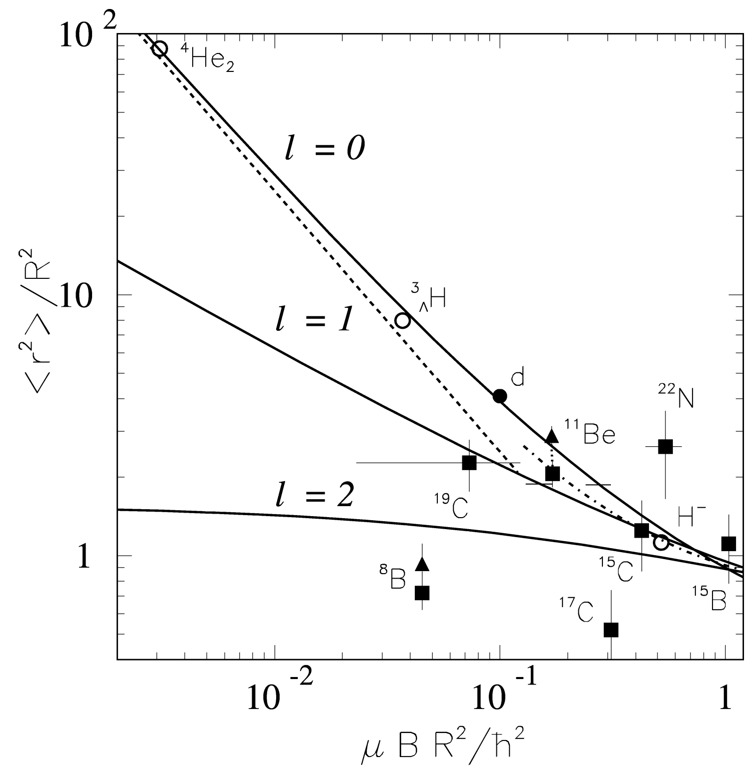
$$\text{Si } \ell = 0 \Rightarrow \langle r^2 \rangle = \frac{\hbar^2}{4\mu B}$$



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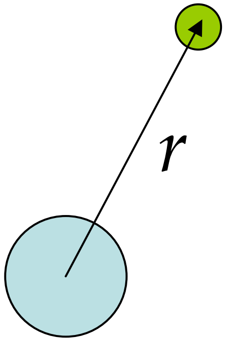

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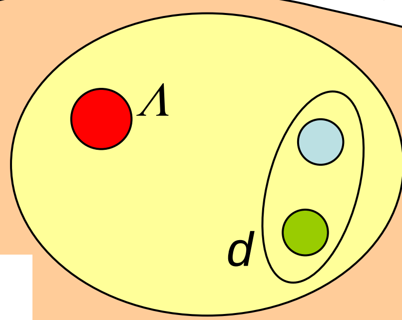
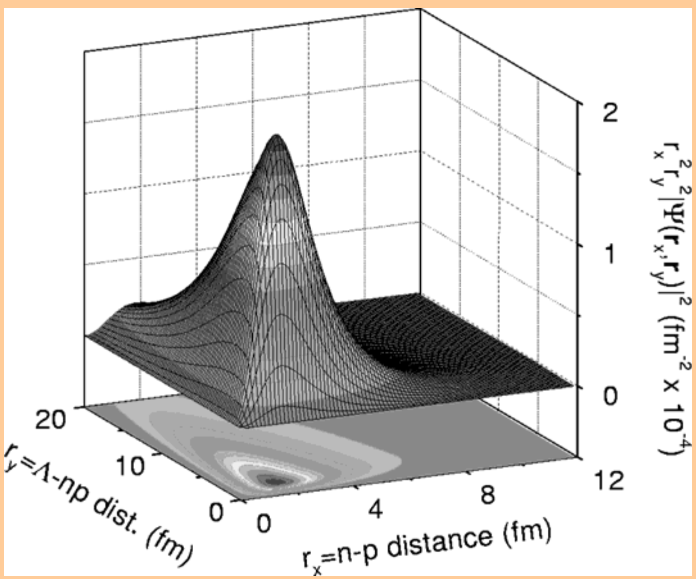
Hypertriton= $n + p + \Lambda$

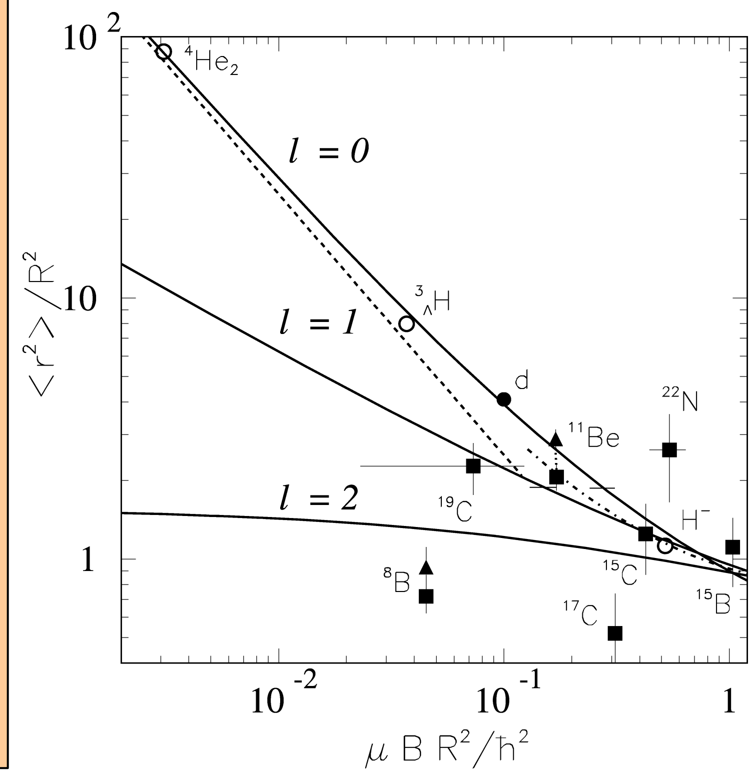




$$\left\langle r^2_{n-p} \right\rangle^{1/2} = 1.97 \text{ fm}$$

$$\left\langle r^2_{\Lambda-d} \right\rangle^{1/2} = 11.7 \text{ fm}$$

$$S_\Lambda = 0.13 \pm 0.05 \text{ MeV}$$



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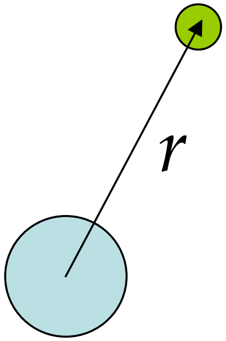

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¿Sistemas de N cuerpos?

Coordenadas $\Rightarrow$ $(\rho, \alpha_1, \alpha_2, \alpha_3, \cdots, \alpha_{3N-4})$ $\qquad m\rho^2 = \sum_{i<k} \frac{m_i m_k}{M} (\vec{r}_i - \vec{r}_k)^2$

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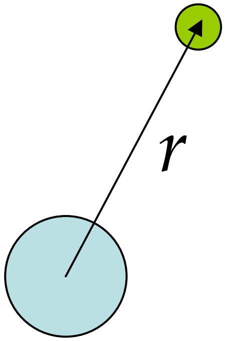

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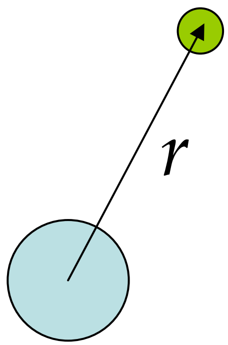
Barrera $\Rightarrow \frac{\hbar^2}{2m}\frac{(3N-4)(3N-6)}{4\rho^2}$

¡¡ Incluso si solamente hay ondas s !!

Un caso sencillo: Sistemas de dos cuerpos



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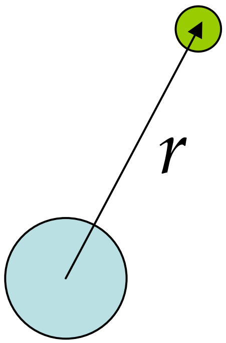
Barrera $\Rightarrow$ $$\frac{\hbar^2}{2m}\frac{(3N-4)(3N-6)}{4\rho^2} \equiv \frac{\hbar^2}{2m}\frac{\ell^*(\ell^*+1)}{\rho^2}$$ donde $$\ell^* = \frac{3N-6}{2}$$

¡¡ Incluso si solamente hay ondas s !!

Un caso sencillo: Sistemas de dos cuerpos



Si la interacción es central ➡ $\Psi_{\ell m}(\vec{r}) = \frac{u_\ell(r)}{r} Y_{\ell m}(\Omega)$

$$\left[-\frac{\hbar^2}{2\mu}\frac{d^2}{dr^2} + V(r) - E + \frac{\hbar^2}{2\mu}\frac{\ell(\ell+1)}{r^2} \right] u_\ell(r) = 0$$

¿Sistemas de N cuerpos?

Coordenadas $\Rightarrow \ (\rho, \alpha_1, \alpha_2, \alpha_3, \cdots, \alpha_{3N-4})$ $\qquad m\rho^2 = \sum_{i<k} \frac{m_i m_k}{M}(\vec{r}_i - \vec{r}_k)^2$

Barrera $\Rightarrow \frac{\hbar^2}{2m}\frac{(3N-4)(3N-6)}{4\rho^2} \equiv \frac{\hbar^2}{2m}\frac{\ell^*(\ell^*+1)}{\rho^2}$ donde $\ell^* = \frac{3N-6}{2}$

$\ell^* < 2 \Rightarrow N < \frac{10}{3} \Rightarrow$ No más de 3 partículas!!

Núcleos Ligeros en las “driplines”: Núcleos de Borromeo

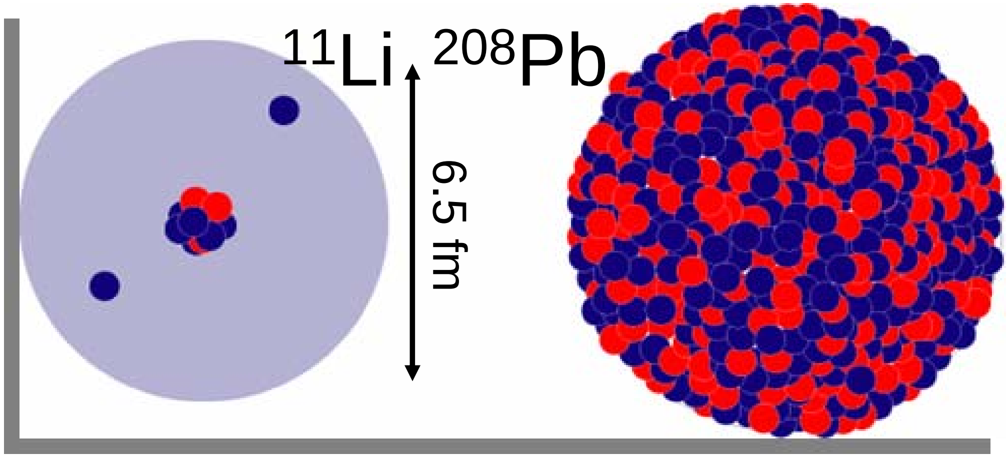
Núcleos con halo:

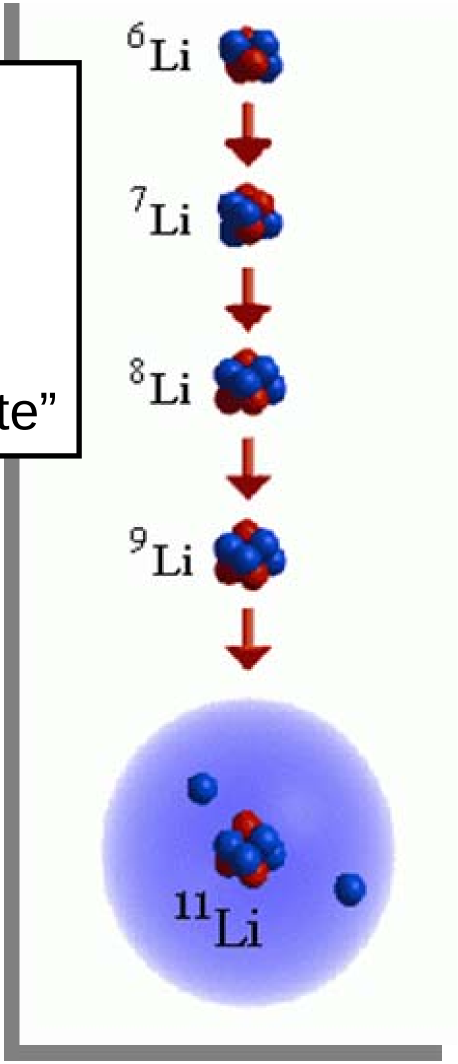
✓Sistemas que “clusterizan”

✓Sistemas poco ligados

✓Espacialmente muy extensos

✓Se extienden a la zona prohibida “clásicamente”





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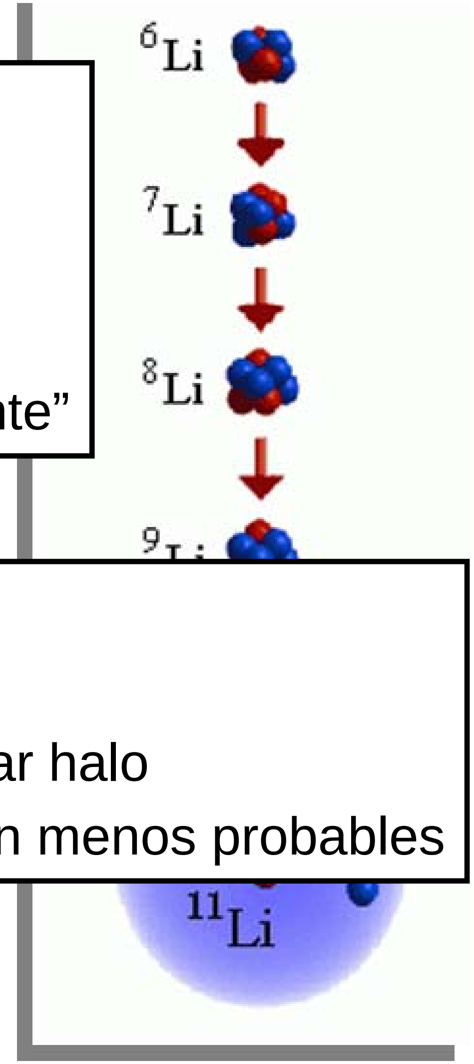
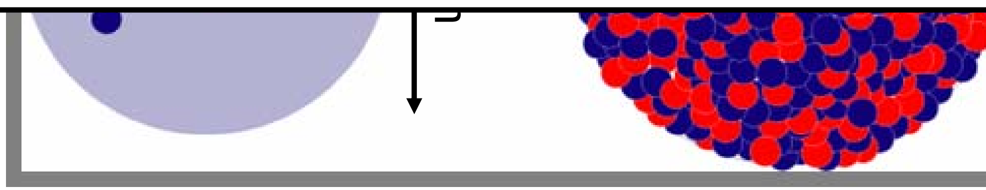


Además:

- ✓$\ell = 0,1$ favorece la formación del halo
- ✓Los protones tienen menos tendencia a formar halo
- ✓Halos en sistemas de más de 3 partículas son menos probables



Evidencias experimentales: Radios

Radios

$$\boxed{\sigma_I = \pi(R_T + R_P)^2}$$

Proy.	σ_I (mb)	R_P (fm)
^{4}He		1.41 ± 0.03
^{6}He		2.18 ± 0.02
^{8}He		2.48 ± 0.03
^{6}Li	688 ± 10	2.09 ± 0.02
^{7}Li	736 ± 6	2.23 ± 0.02
^{8}Li	768 ± 9	2.36 ± 0.02
^{9}Li	796 ± 6	2.41 ± 0.02
^{11}Li	1040 ± 60	3.14 ± 0.16
^{7}Be	738 ± 9	2.22 ± 0.02
^{9}Be	806 ± 9	2.45 ± 0.01
^{10}Be	813 ± 10	2.46 ± 0.03
^{11}Be		2.73 ± 0.05
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I. Tanihata, NPA 522 (1991) 275

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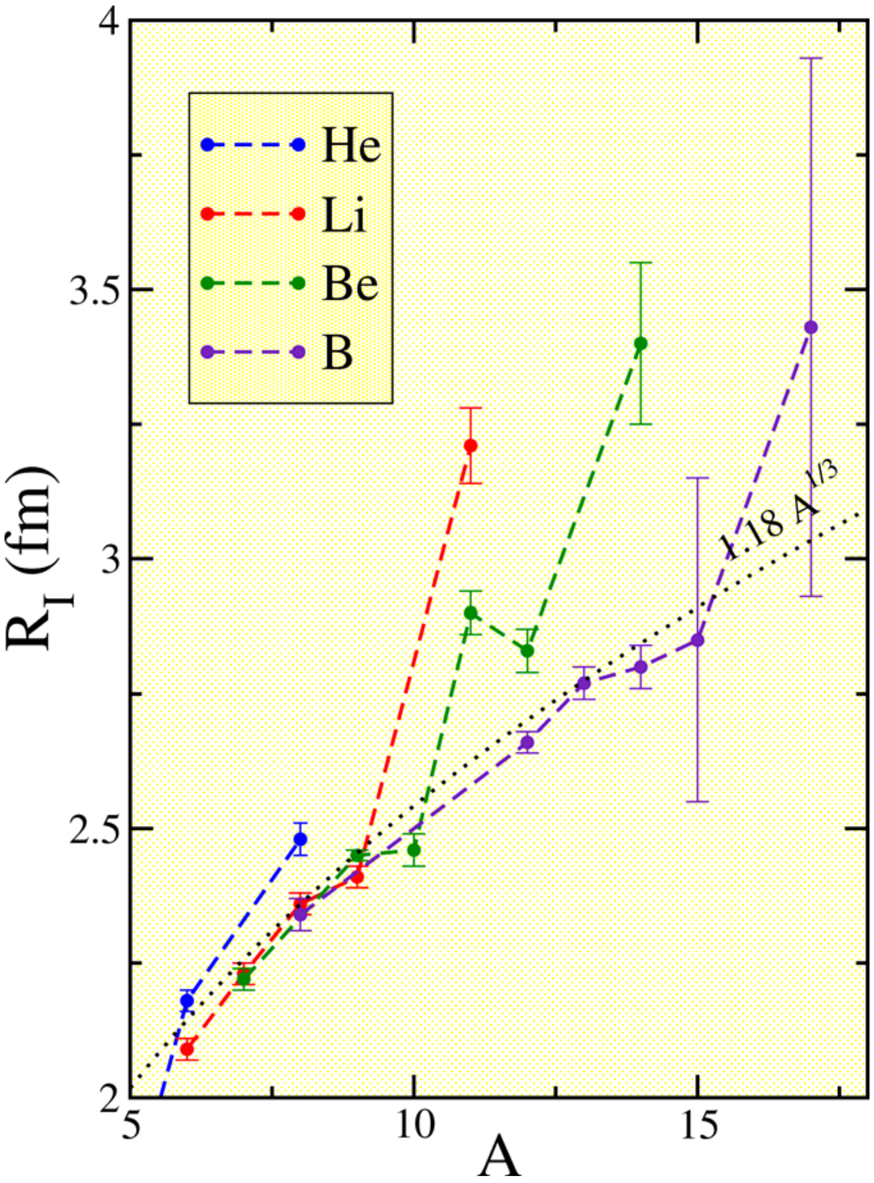
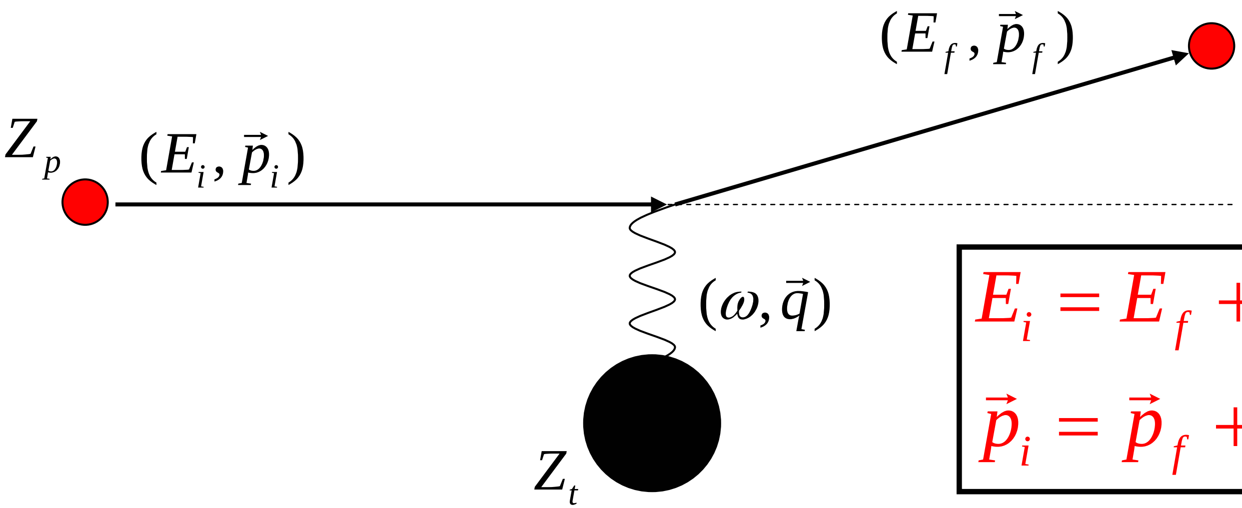
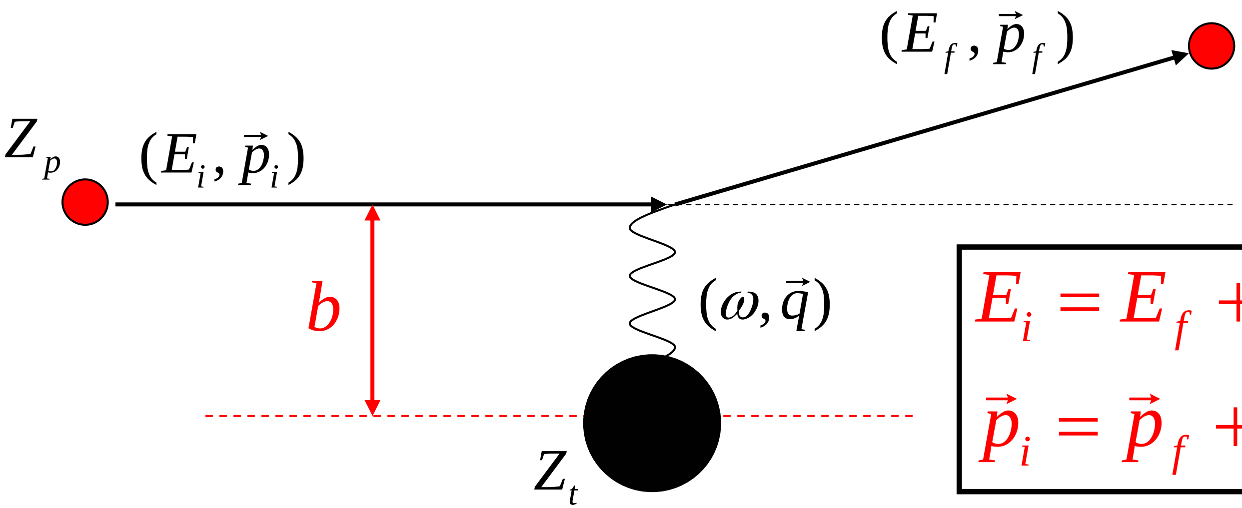


Evidencias experimentales: Disociación Coulombiana



$$\boxed{\begin{aligned} E_i &= E_f + \omega \\ \vec{p}_i &= \vec{p}_f + \vec{q} \end{aligned}}$$

Evidencias experimentales: Disociación Coulombiana



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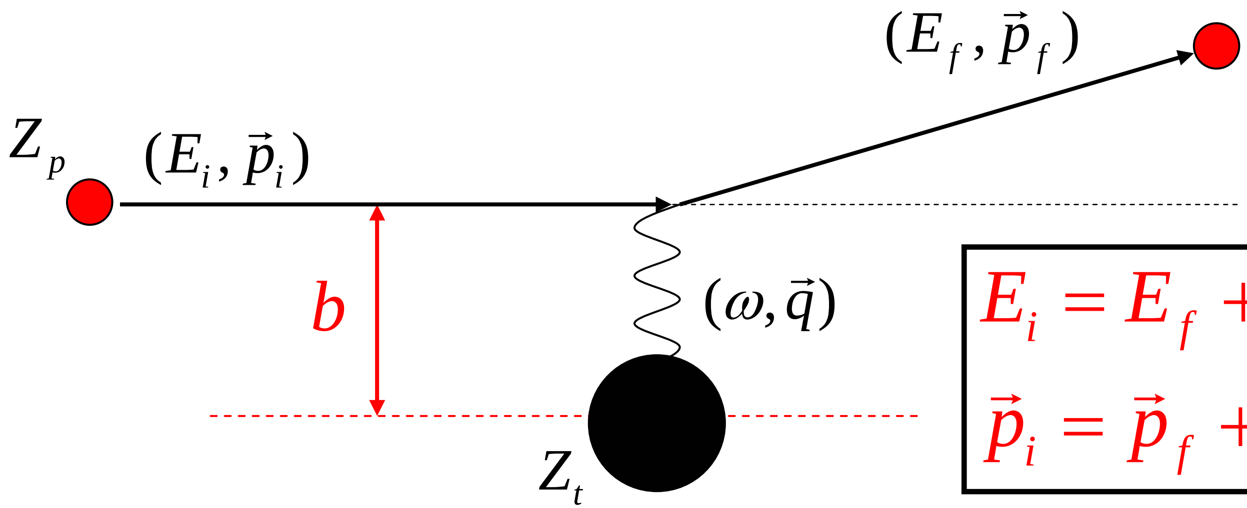
$$\boxed{b = \frac{Z_p Z_t e^2}{q} \frac{p_i}{T_i}}$$

Evidencias experimentales: Disociación Coulombiana



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Si q es suficientemente pequeño ($q < q_{\max}$)

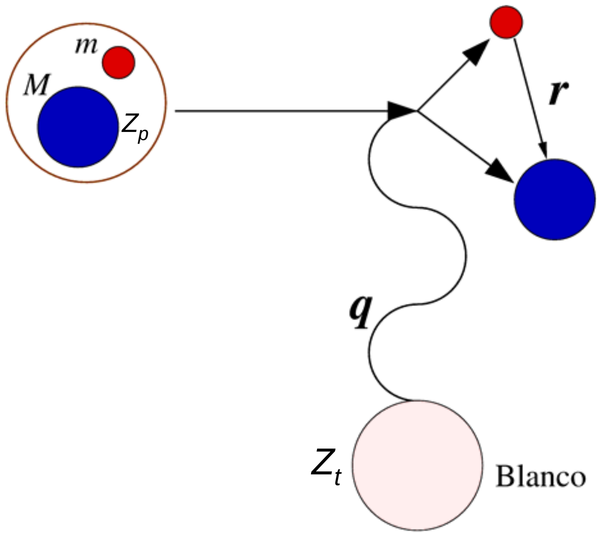
entonces $b > R_p + R_t$

$\Downarrow$

Sólo interacción Coulombiana

$$\boxed{q_{\max} = \frac{Z_p Z_t e^2}{R_p + R_t} \frac{p_i}{T_i}}$$

Evidencias experimentales: Disociación Coulombiana



Evidencias experimentales: Disociación Coulombiana

$$\vec{p}_r = \mu\left(\frac{\vec{p}_M}{M} - \frac{\vec{p}_m}{m}\right)$$

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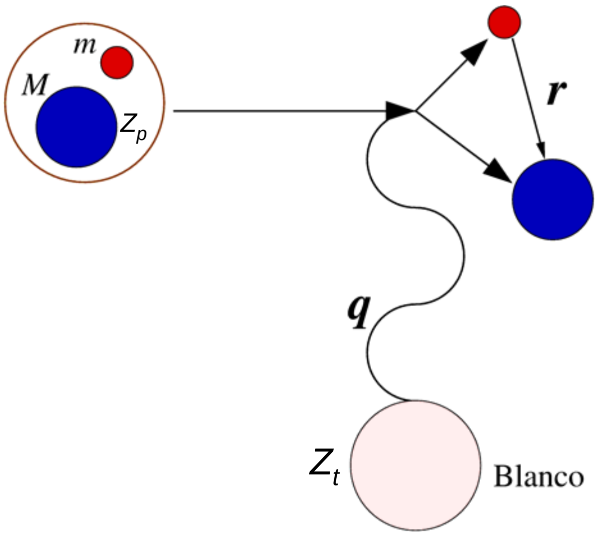

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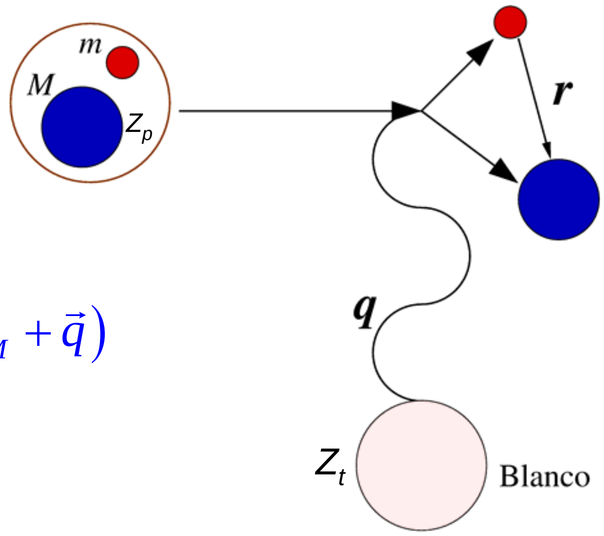

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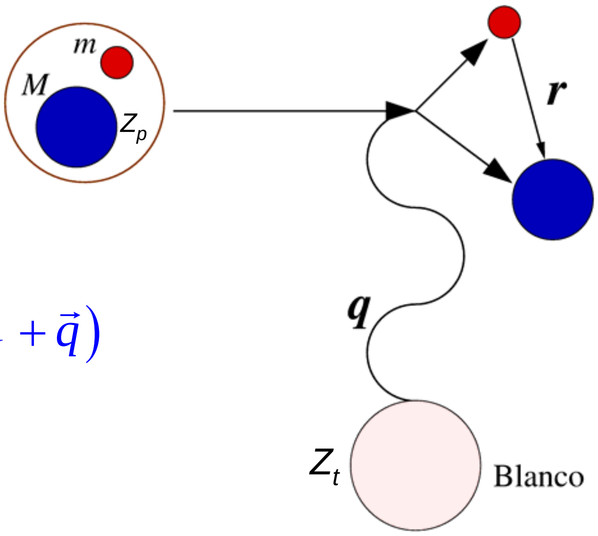
$$\Delta\vec{p}_r = \vec{p}_r - \vec{p}\,'_r = \frac{m}{m+M}\vec{q}$$



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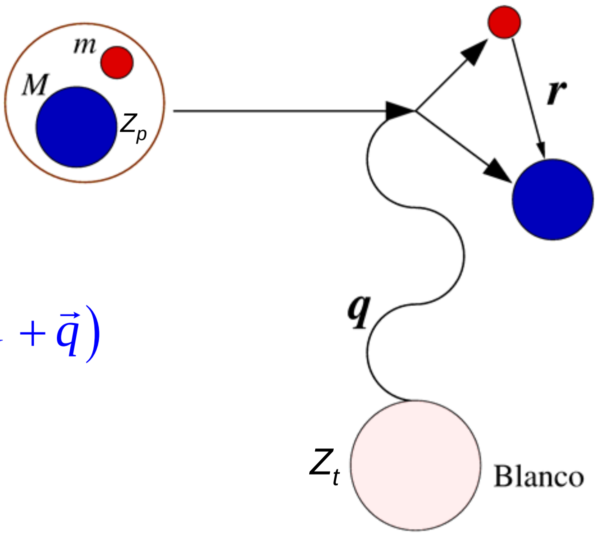

$$\Delta\vec{p}_r = \vec{p}_r - \vec{p}\,'_r = \frac{m}{m+M}\vec{q}$$

$$\text{En un proceso elástico} \Rightarrow \Psi_{\text{final}}(\vec{r}) = e^{i\Delta\vec{p}_r\cdot\vec{r}}\,\Psi(\vec{r})$$

$$P_{\text{elas}} = \left|\left\langle\Psi(\vec{r})\right| e^{i\Delta\vec{p}_r\cdot\vec{r}} \left|\Psi(\vec{r})\right\rangle\right|^2$$

Evidencias experimentales: Disociación Coulombiana

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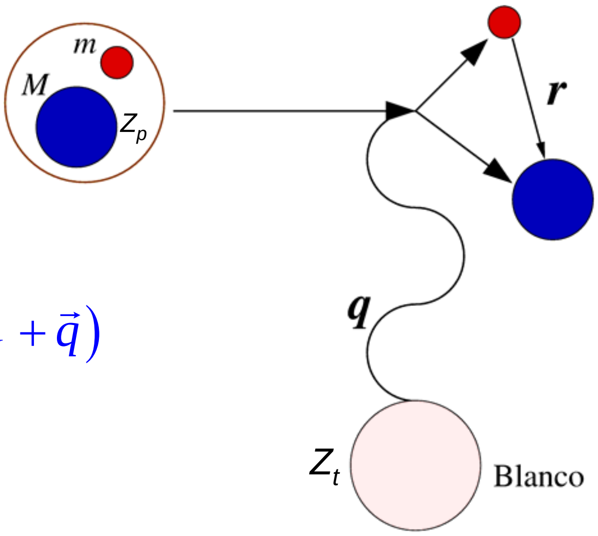

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$$\Delta\vec{p}_r \cdot \vec{r} \ll 1 \Rightarrow e^{i\Delta\vec{p}_r\cdot\vec{r}} \approx 1 + i\Delta\vec{p}_r\cdot\vec{r} - \frac{1}{2}\left(\Delta\vec{p}_r\cdot\vec{r}\right)^2 + \cdots$$

$$P_{\text{elas}} = \left|\left\langle\Psi(\vec{r})\right| e^{i\Delta\vec{p}_r\cdot\vec{r}} \left|\Psi(\vec{r})\right\rangle\right|^2$$

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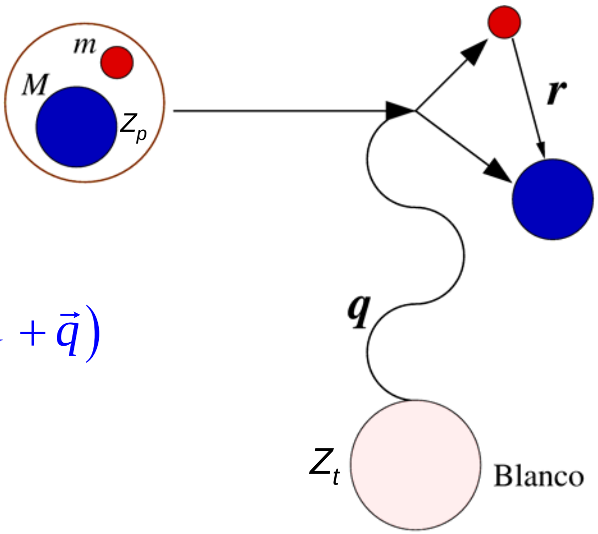


$$\Delta\vec{p}_r = \vec{p}_r - \vec{p}\,'_r = \frac{m}{m+M}\vec{q}$$

$$P_{\text{elas}} \approx 1 - (\Delta p_r)^2 \langle r^2 \rangle = 1 - \frac{m^2}{(m+M)^2} q^2 \langle r^2 \rangle$$

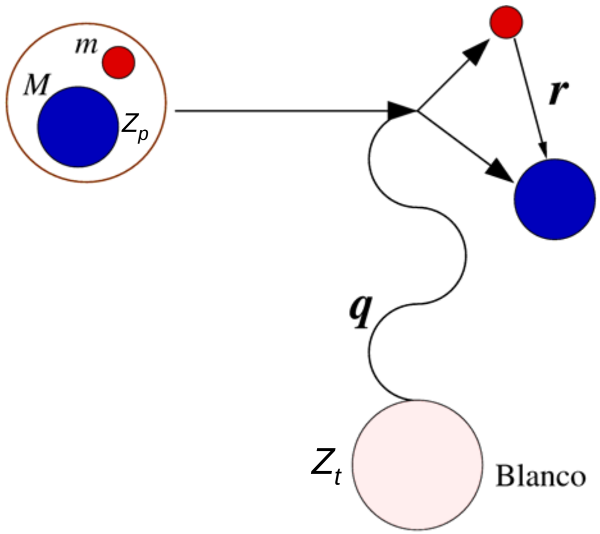
$$\Delta\vec{p}_r \cdot \vec{r} \ll 1 \Rightarrow e^{i\Delta\vec{p}_r\cdot\vec{r}} \approx 1 + i\Delta\vec{p}_r\cdot\vec{r} - \frac{1}{2}(\Delta\vec{p}_r\cdot\vec{r})^2 + \cdots$$

$$P_{\text{elas}} = \left|\langle\Psi(\vec{r})|e^{i\Delta\vec{p}_r\cdot\vec{r}}|\Psi(\vec{r})\rangle\right|^2$$

Evidencias experimentales: Disociación Coulombiana

Si sólo un estado ligado: $P_{\text{dis}} = 1 - P_{\text{elas}}$

$$P_{\text{dis}} = 1 - P_{\text{elas}} = \frac{m^2}{(m+M)^2} q^2 \left\langle r^2 \right\rangle$$



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Evidencias experimentales: Disociación Coulombiana

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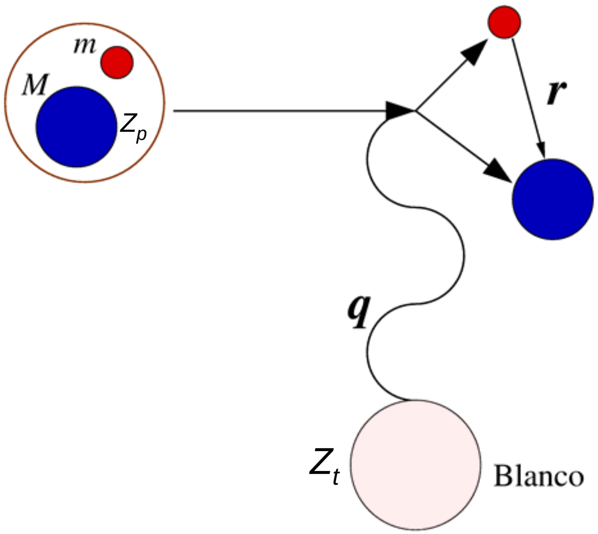
$$\frac{d\sigma_d}{dq} = \underbrace{\frac{8\pi \left(Z_p Z_t e^2 \right)^2}{v^2} \frac{1}{q^3}}_{\text{Sección eficaz de Rutherford}} \frac{m^2}{(m+M)^2} q^2 \left\langle r^2 \right\rangle$$



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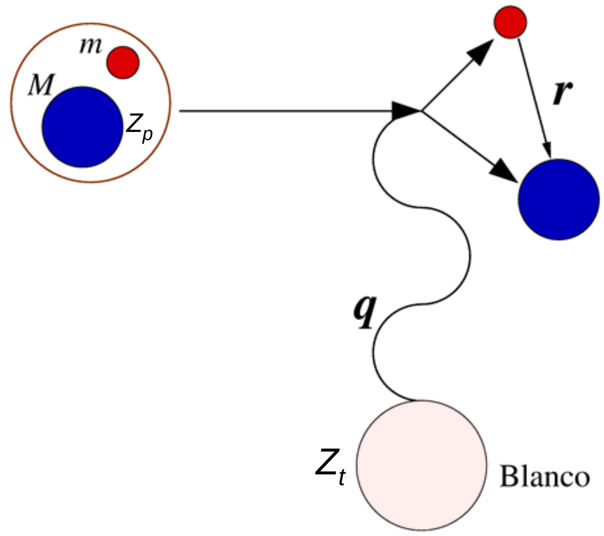

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Sección eficaz de disociación Coulombiana

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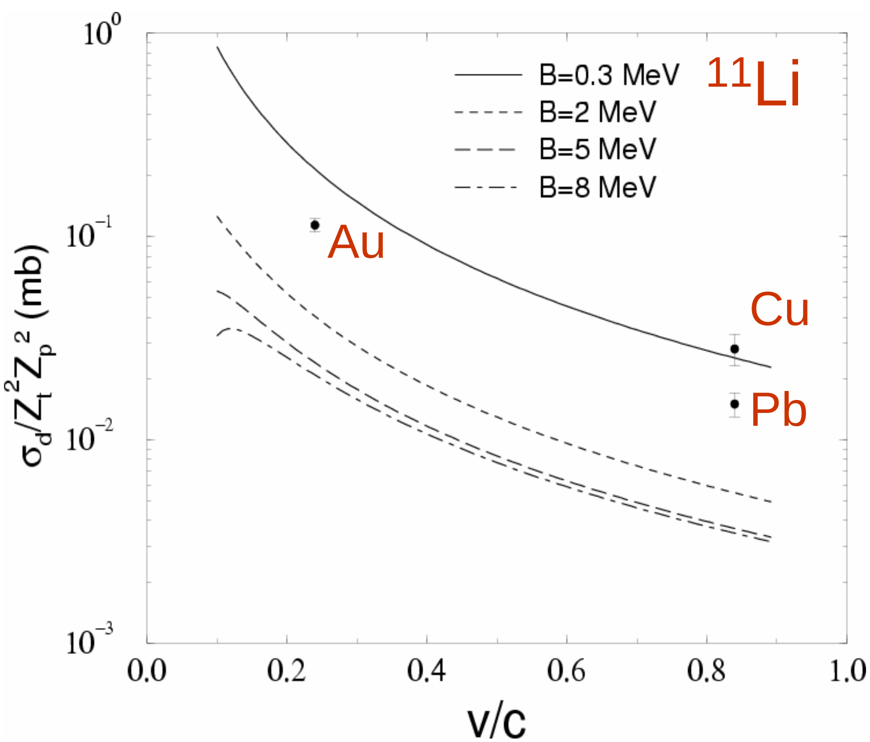
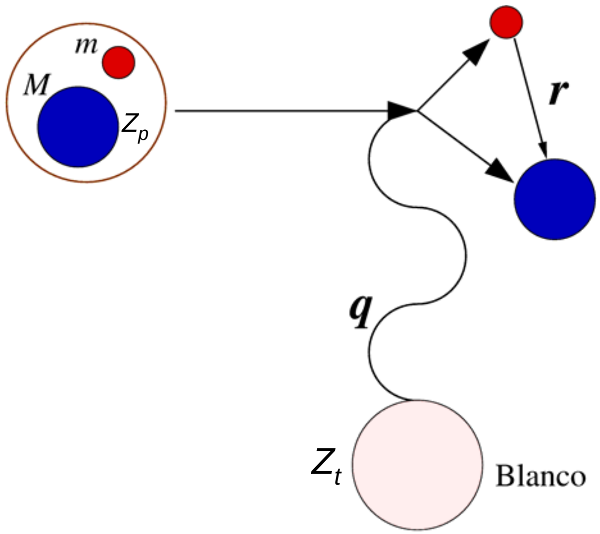
Evidencias experimentales: Disociación Coulombiana





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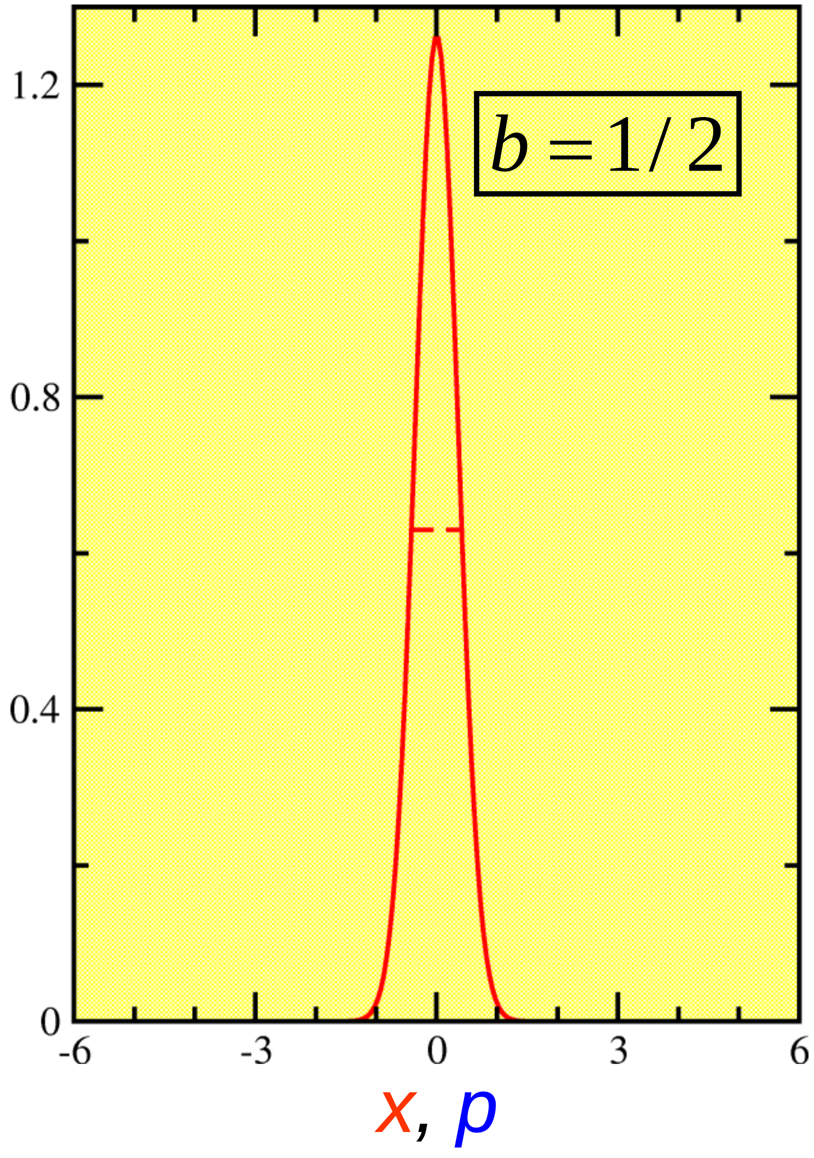
$$q_{\min} < q < q_{\max}$$

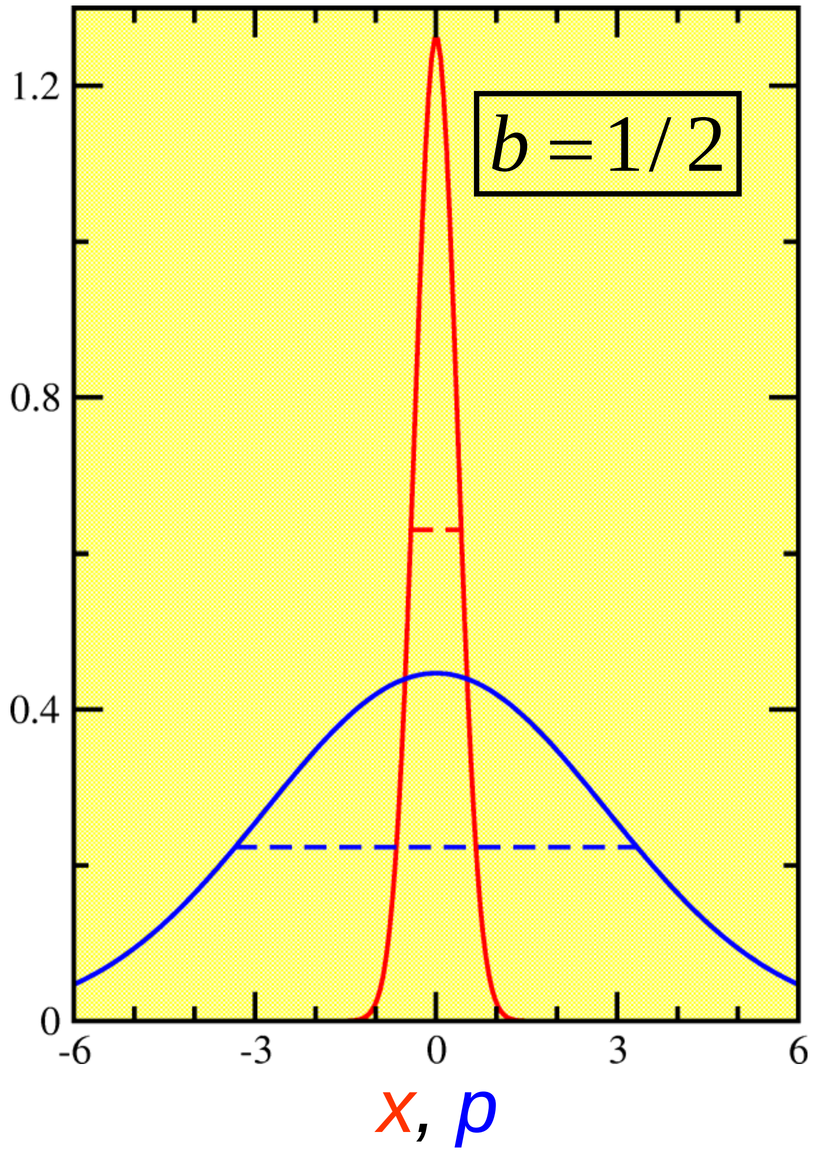
Evidencias experimentales: Distribuciones de momentos



$$\Gamma_x = 2b\sqrt{\ln 2}$$

$$\Psi(x) = \left(\frac{2}{\pi}\frac{1}{b^2}\right)^{\frac{1}{4}} \exp\left(-\frac{x^2}{b^2}\right)$$

Evidencias experimentales: Distribuciones de momentos



$$\Psi(p) = \left(\frac{2}{\pi}\frac{b^2}{4}\right)^{\frac{1}{4}} \exp\left(-p^2\frac{b^2}{4}\right)$$

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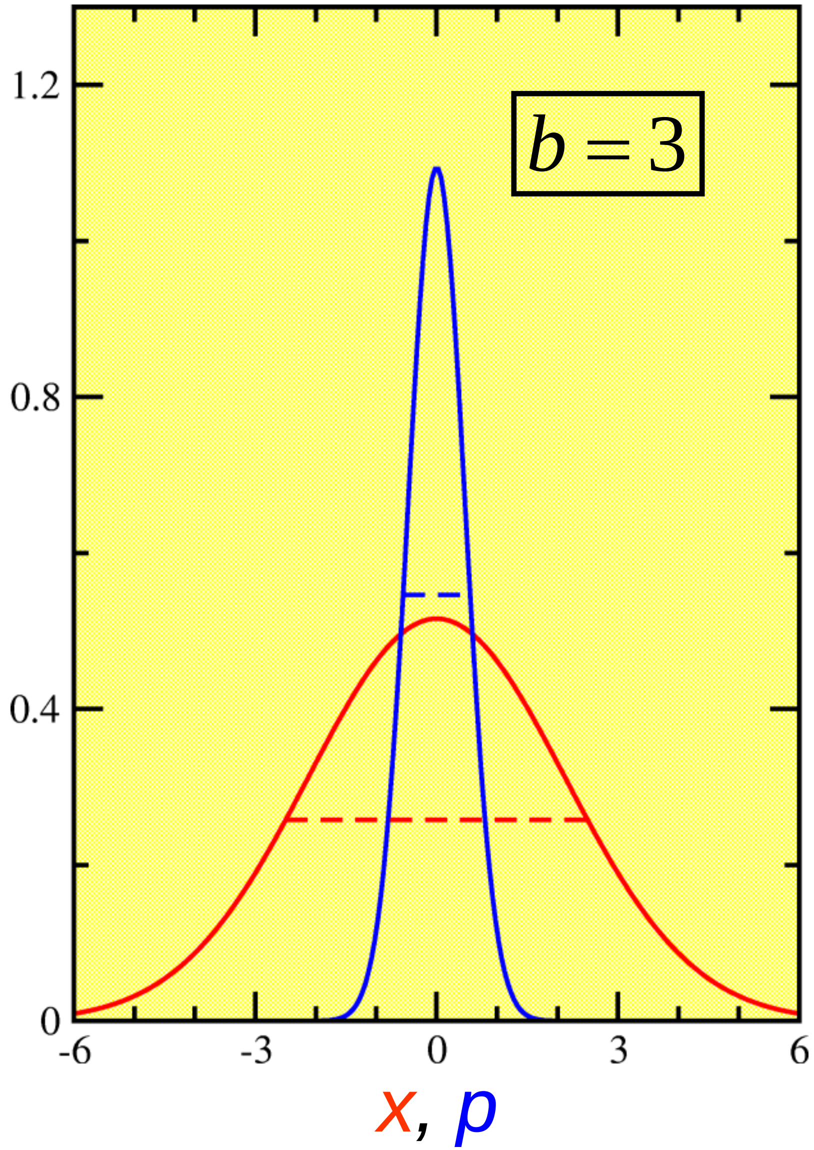

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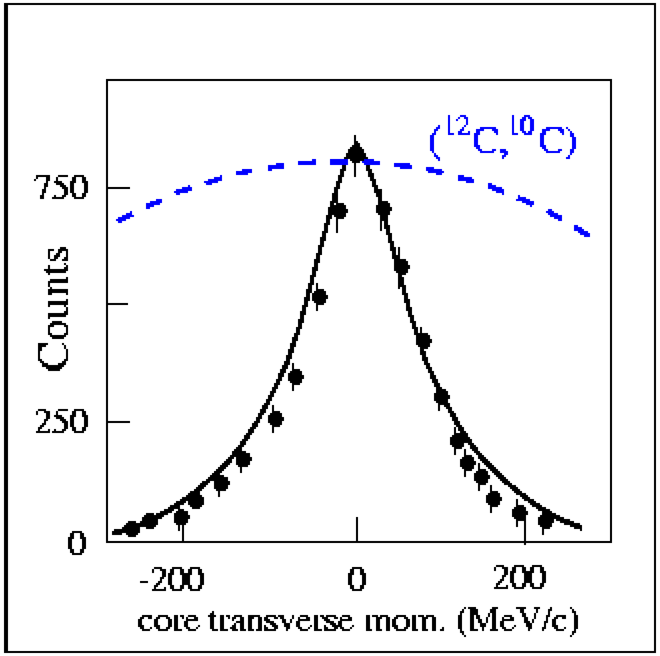
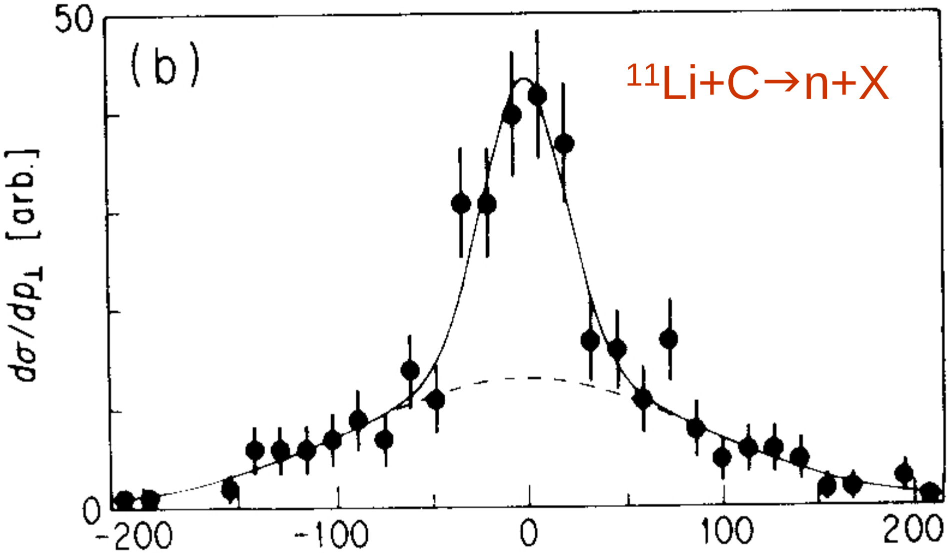
Evidencias experimentales: Distribuciones de momentos

$^{6}He + T \longrightarrow \alpha + n + n + T$

@ 400 MeV/u





p_{long} (MeV/c)

Reacciones de fragmentación

“SUDDEN APPROXIMATION”

Si la energía del proyectil es suficientemente alta

sólo un constituyente interacciona con el blanco, siendo arrancado del mismo

Reacciones de fragmentación en blancos ligeros (No Coulomb)

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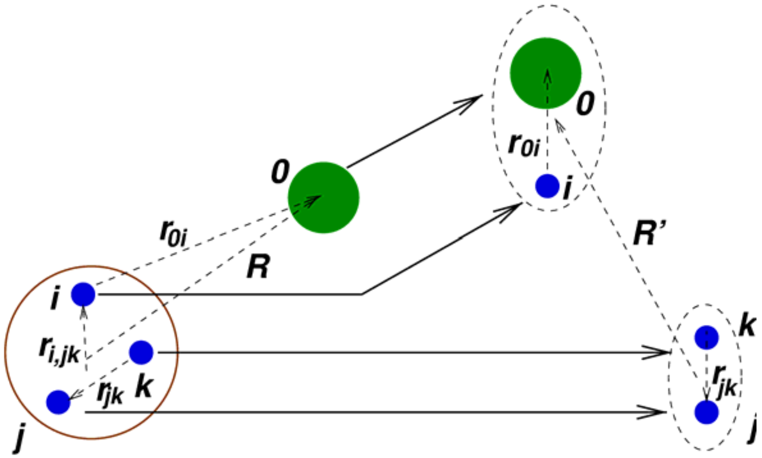

Reacciones de fragmentación en blancos ligeros (No Coulomb)

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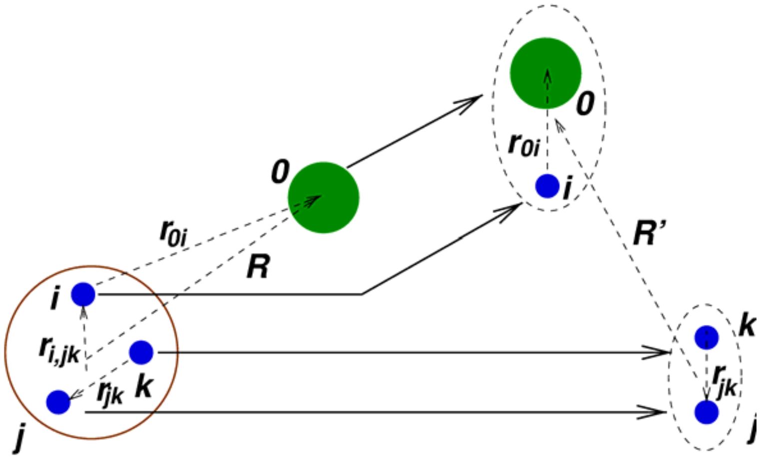

$$T^{(i)} = \left\langle \Phi^{(0i)}_{p'_{0i}\sigma'_i} \Phi^{(jk)}_{p'_{jk} s_{jk}\sigma_{jk}} e^{i\vec{P}'\cdot\vec{R}'} \right| V_{0i} \left| \Psi^{JM} e^{i\vec{P}\cdot\vec{R}} \right\rangle$$

$$T^{(i)} = \sum_{\sigma_i} T^{(0i)}_{\sigma_i\sigma_i} \left\langle \Phi^{(jk)}_{p'_{jk} s_{jk}\sigma_{jk}} e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}} \chi_{s_i\sigma_i} \middle| \Psi^{JM} \right\rangle$$

Reacciones de fragmentación en blancos ligeros (No Coulomb)

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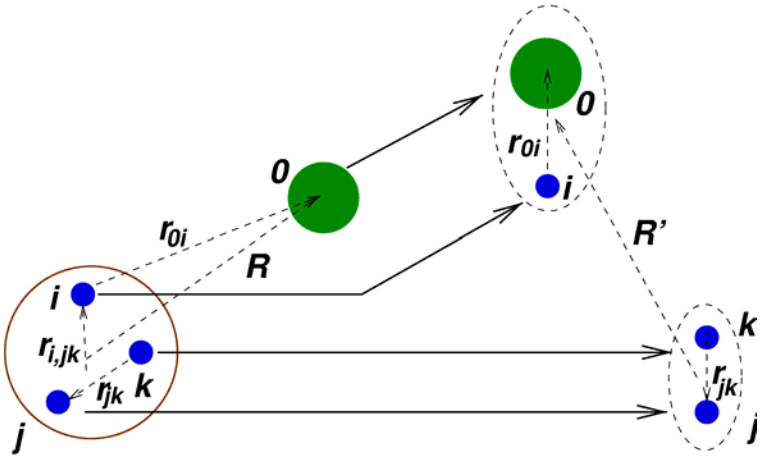

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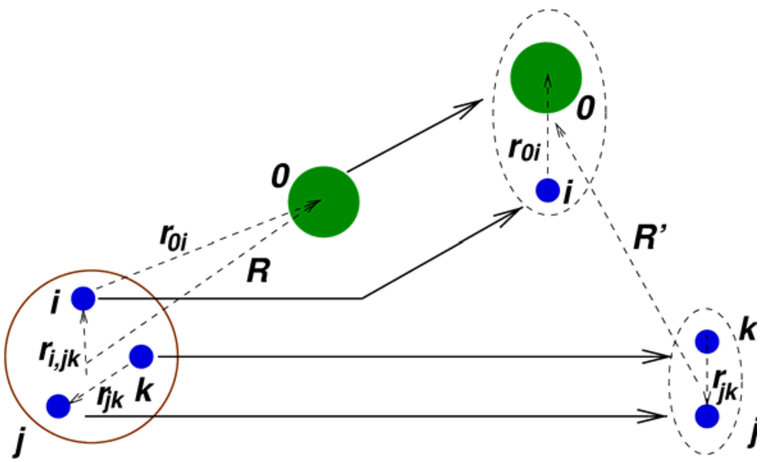
$$\boxed{d\sigma^{(i)} = \frac{2\pi}{v} \left| T^{(i)} \right|^2 \delta(E'_{0i} - E_{0i}) \frac{d\vec{p}'_{0i}}{(2\pi)^3} \frac{d\vec{p}'_{jk}}{(2\pi)^3} \frac{d\vec{P}'}{(2\pi)^3}}$$

Regla de oro de Fermi

Reacciones de fragmentación en blancos ligeros (No Coulomb)

$$\boxed{\frac{d^6\sigma^{(0i)}_{(\text{elas,abs})}}{d\vec{p}'_{i,jk}\,d\vec{p}'_{jk}} = \sigma^{(0i)}_{(\text{elas,abs})}\,\frac{1}{2J+1}\sum\left|\left\langle \Phi^{(jk)}_{p'_{jk}s_{jk}\sigma_{jk}}\, e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}}\,\chi_{s_i\sigma_i}\middle|\Psi^{JM}\right\rangle\right|^2}$$



$$T^{(i)} = \left\langle \Phi^{(0i)}_{p'_{0i}\sigma'_i}\,\Phi^{(jk)}_{p'_{jk}s_{jk}\sigma_{jk}}\, e^{i\vec{P}'\cdot\vec{R}'}\middle| V_{0i} \middle| \Psi^{JM} e^{i\vec{P}\cdot\vec{R}}\right\rangle$$

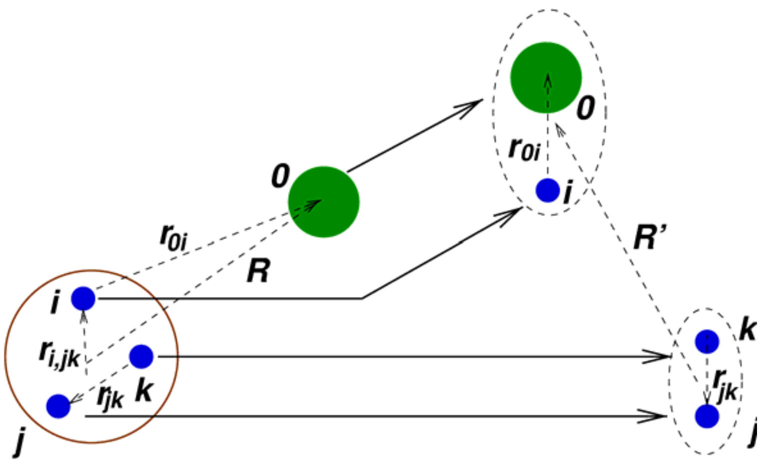
$$T^{(i)} = \sum_{\sigma_i} T^{(0i)}_{\sigma_i\sigma_i}\left\langle \Phi^{(jk)}_{p'_{jk}s_{jk}\sigma_{jk}}\, e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}}\,\chi_{s_i\sigma_i}\middle|\Psi^{JM}\right\rangle$$

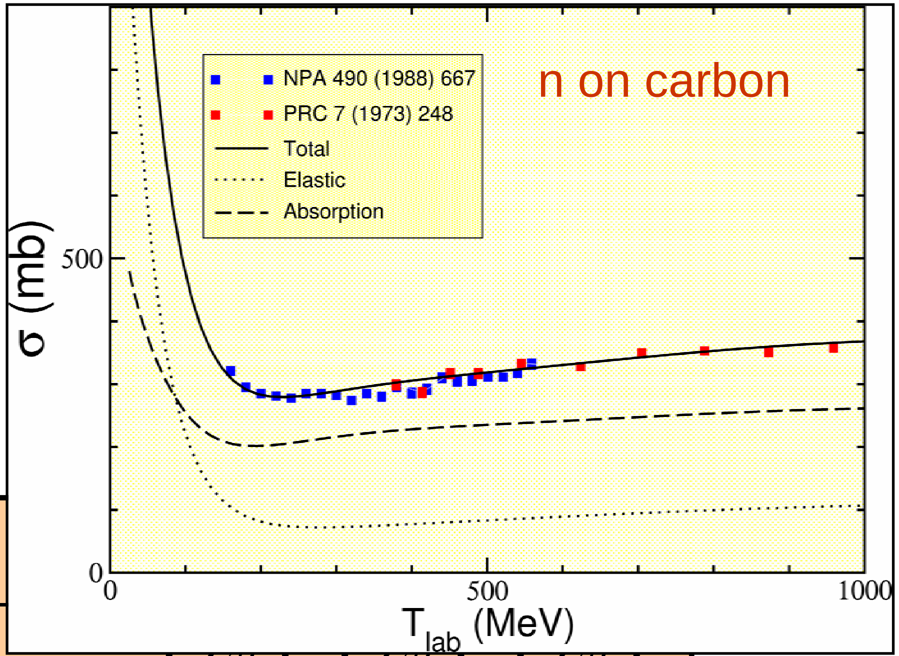
$$\boxed{d\sigma^{(i)} = \frac{2\pi}{v}\left|T^{(i)}\right|^2\delta(E'_{0i}-E_{0i})\,\frac{d\vec{p}'_{0i}}{(2\pi)^3}\,\frac{d\vec{p}'_{jk}}{(2\pi)^3}\,\frac{d\vec{P}'}{(2\pi)^3}}$$

Regla de oro de Fermi

Reacciones de fragmentación en blancos ligeros (No Coulomb)

$$\frac{d^6\sigma^{(0i)}_{(\mathrm{elas,abs})}}{d\vec{p}'_{i,jk}\, d\vec{p}'_{jk}} = \sigma^{(0i)}_{(\mathrm{elas,abs})} \frac{1}{2J+1}\sum \left| \left\langle \Phi^{(jk)}_{p'_{jk}s_{jk}\sigma_{jk}}\, e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}}\, \chi_{s_i\sigma_i} \middle| \Psi^{JM} \right\rangle \right|^2$$





$$d\sigma^{(i)} = \frac{2\pi}{v}\left|T^{(i)}\right|^2 \delta(E'_{0i} - \ldots$$

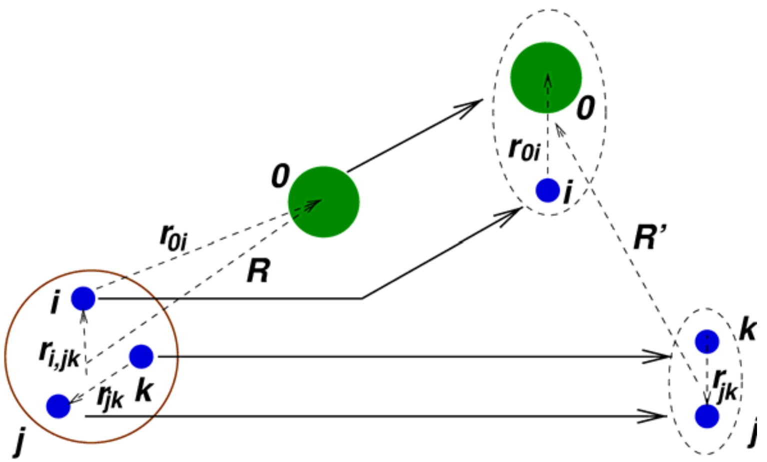
$$(2\pi) \quad (2\pi) \quad (2\pi)$$

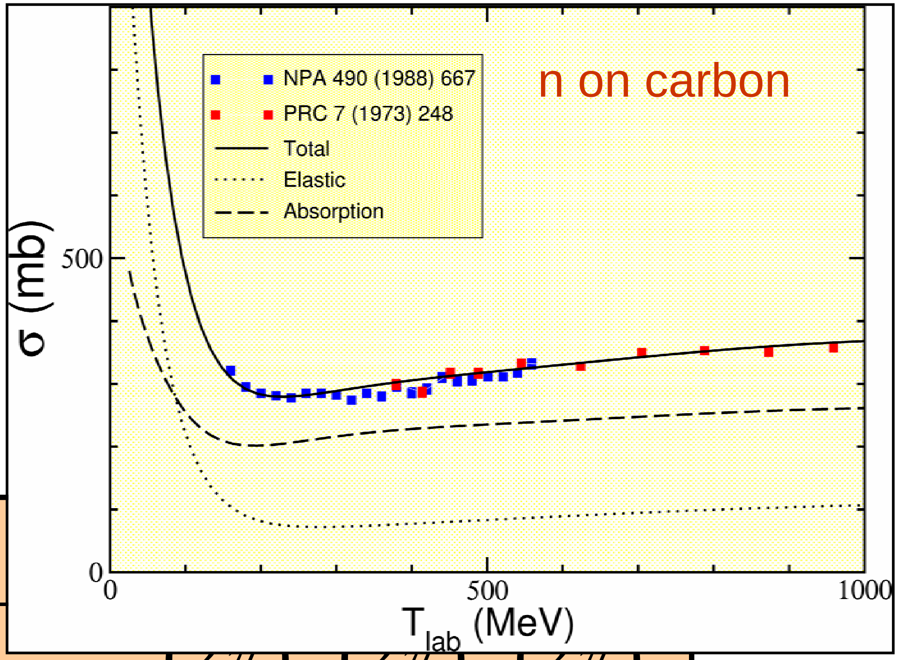
Regla de oro de Fermi

Reacciones de fragmentación en blancos ligeros (No Coulomb)

$$\frac{d^6\sigma^{(0i)}}{d\vec{p}'_{i,jk}\,d\vec{p}'_{jk}} \propto \sum \left| \left\langle \Phi^{(jk)}_{p'_{jk} s_{jk} \sigma_{jk}} \, e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}} \, \chi_{s_i \sigma_i} \middle| \Psi^{JM} \right\rangle \right|^2$$

Pure sudden approximation





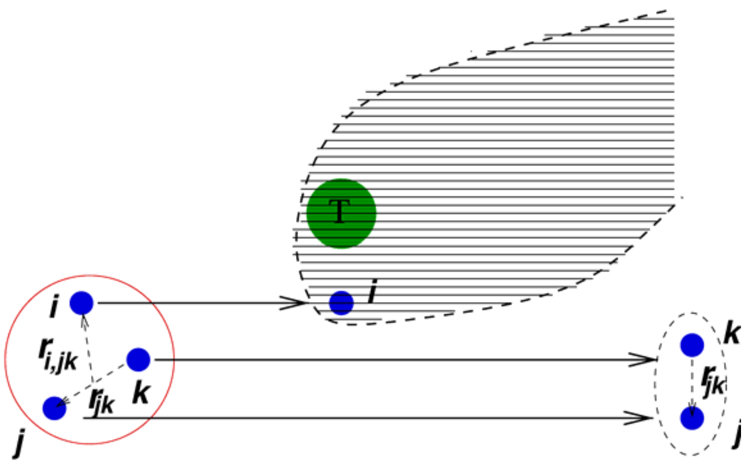
$$d\sigma^{(i)} = \frac{2\pi}{v}\left|T^{(i)}\right|^2 \delta(E'_{0i} - \ldots \quad (2\pi)^3 \quad (2\pi)^3 \quad (2\pi)^3$$

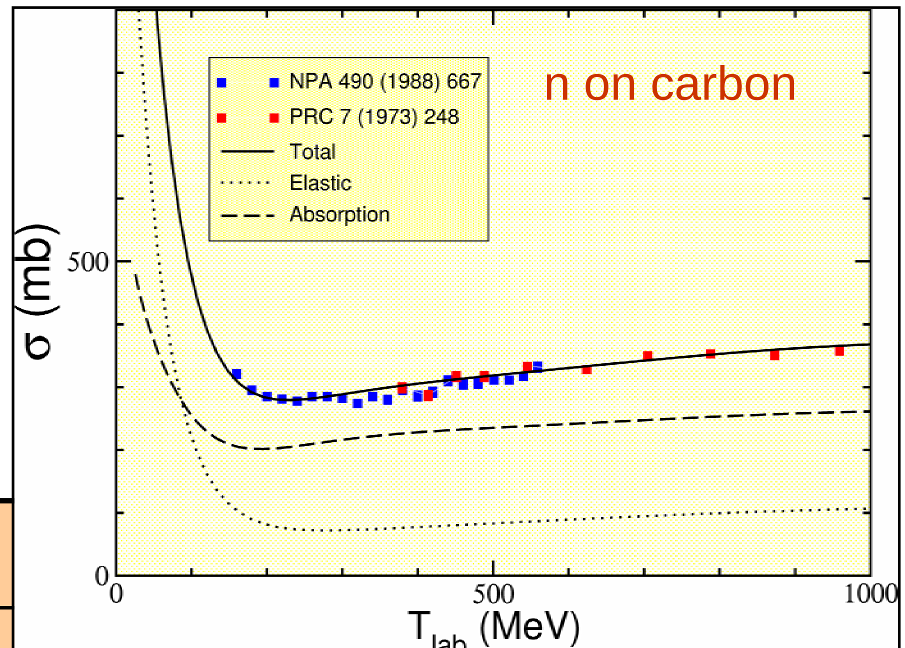
Regla de oro de Fermi

Reacciones de fragmentación en blancos ligeros (No Coulomb)

$$\frac{d^6\sigma^{(0i)}}{d\vec{p}'_{i,jk}\,d\vec{p}'_{jk}} \propto \sum \left| \left\langle \Phi^{(jk)}_{p'_{jk} s_{jk} \sigma_{jk}} \, e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}} \chi_{s_i \sigma_i} \middle| \Psi^{JM} \right\rangle \right|^2$$

Pure sudden approximation





$$d\sigma^{(i)} = \frac{2\pi}{v}\left|T^{(i)}\right|^2 \delta(E'_{0i} - \ldots$$

(2π) (2π) (2π)

Regla de oro de Fermi

Reacciones de fragmentación en blancos ligeros (No Coulomb)

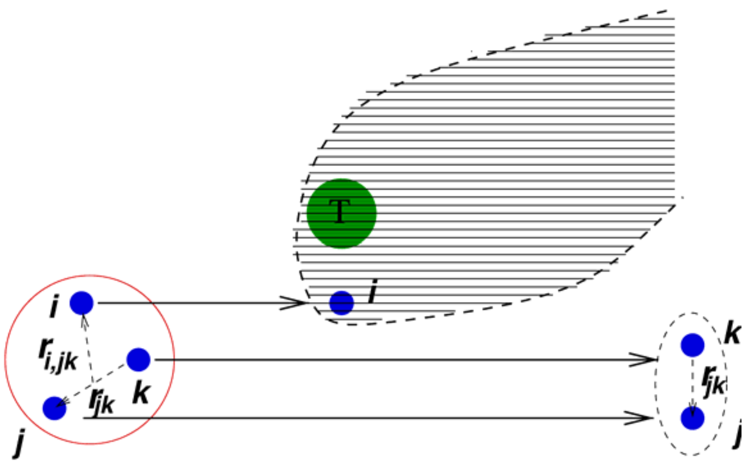
$$\frac{d^6\sigma^{(0i)}}{d\vec{p}'_{i,jk}\,d\vec{p}'_{jk}} \propto \sum \left| \left\langle \Phi^{(jk)}_{p'_{jk}s_{jk}\sigma_{jk}}\, e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}}\, \chi_{s_i\sigma_i} \middle| \Psi^{JM} \right\rangle \right|^2$$

Pure sudden approximation

Si no FSI

$$\Phi^{(jk)}_{p'_{jk}s_{jk}\sigma_{jk}} = e^{i\vec{p}_{jk}\cdot r_{jk}}$$

Transformada de Fourier

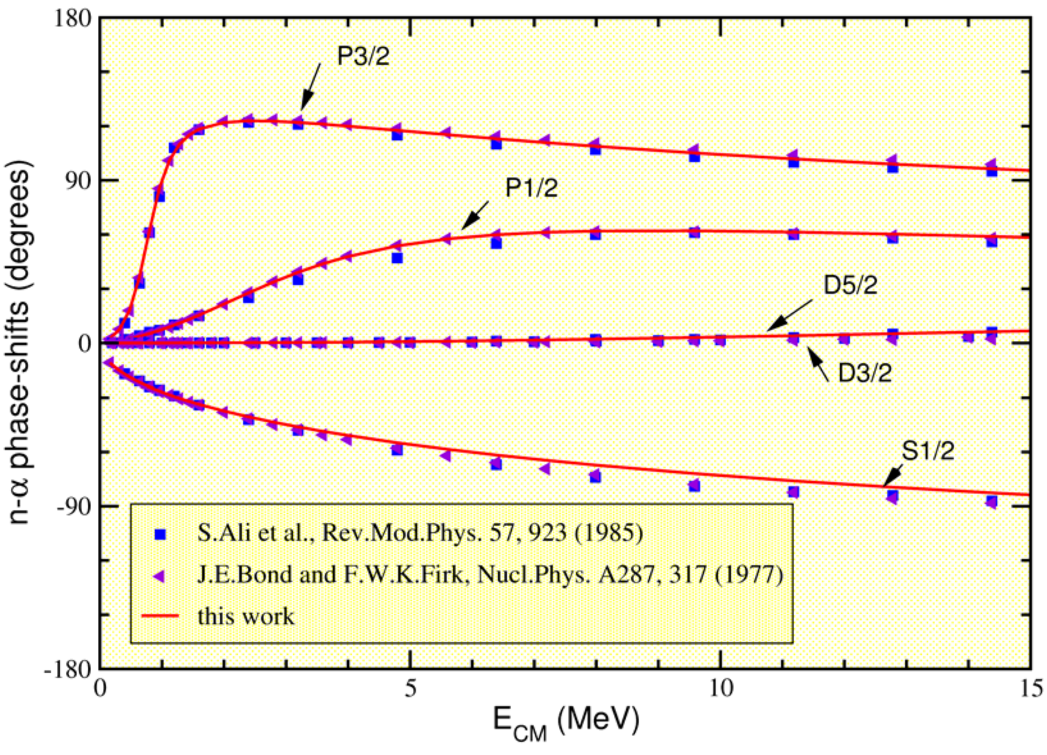


$$d\sigma^{(i)} = \frac{2\pi}{v}\left|T^{(i)}\right|^2 \delta(E'_{0i}-E_{0i})\,\frac{d\vec{p}'_{0i}}{(2\pi)^3}\,\frac{d\vec{p}'_{jk}}{(2\pi)^3}\,\frac{d\vec{P}'}{(2\pi)^3}$$

Regla de oro de Fermi

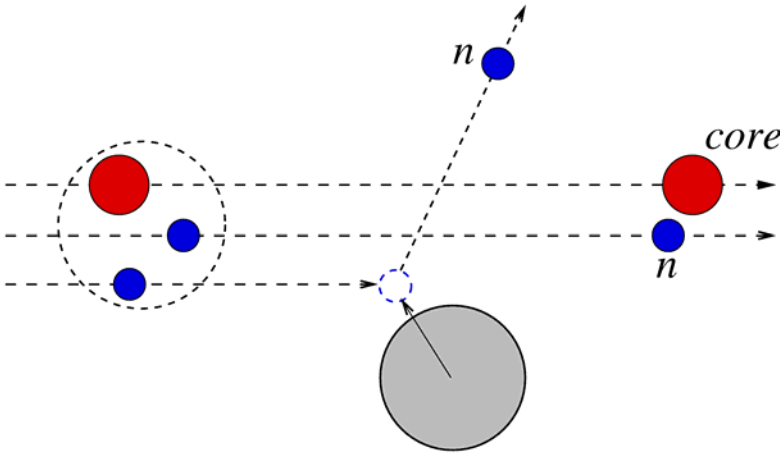
El caso del ^{6}He: $n+n+\alpha$

Interacción ^{4}He-neutrón: $$V_{n\alpha}^{(\ell)}(r) = V_c^{(\ell)}(r) + V_{so}^{(\ell)}(r)\vec{\ell}_{n\alpha}\cdot\vec{s}_n$$



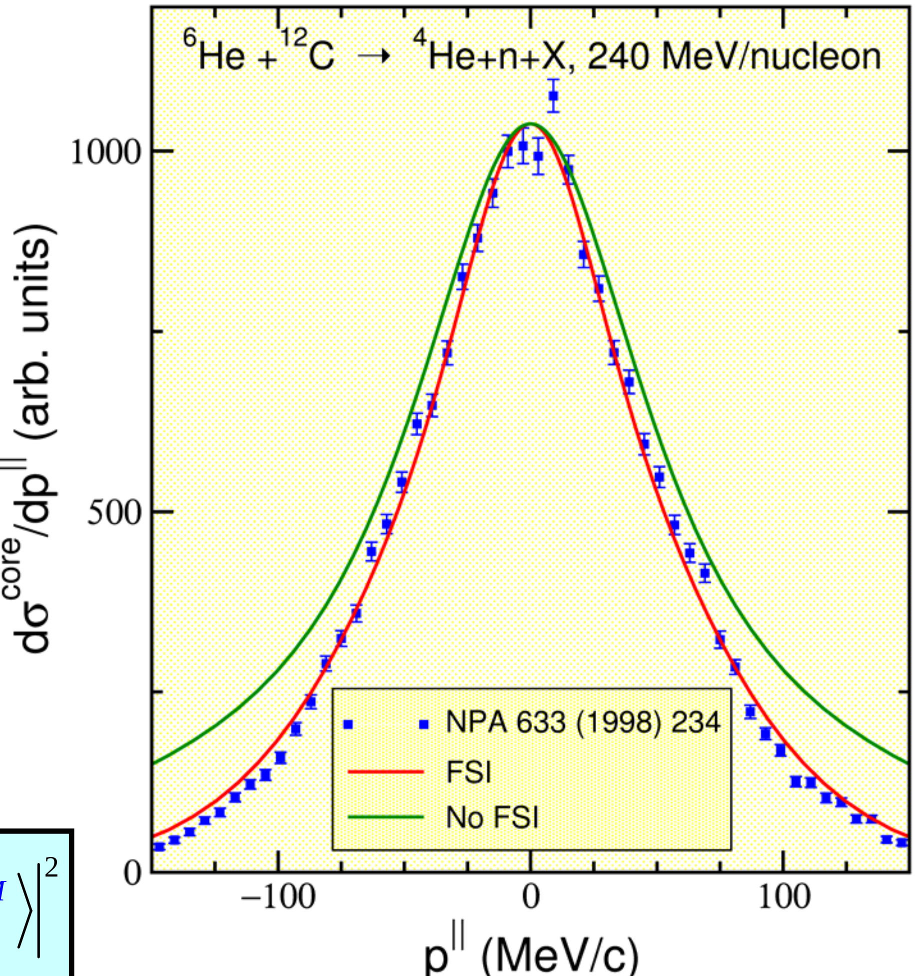
		Calc.	Exp.
^{5}He (n+α)	$E\,(p_{3/2})$	0.77	0.77
	$\Gamma\,(p_{3/2})$	0.68	0.64
	$E\,(p_{1/2})$	1.94	1.97
	$\Gamma\,(p_{1/2})$	4.02	5.22
^{6}He	B (MeV)	-0.97	-0.97±0.04
	rms (fm)	2.53	2.47±0.10

El caso del ^{6}He: n+n+α

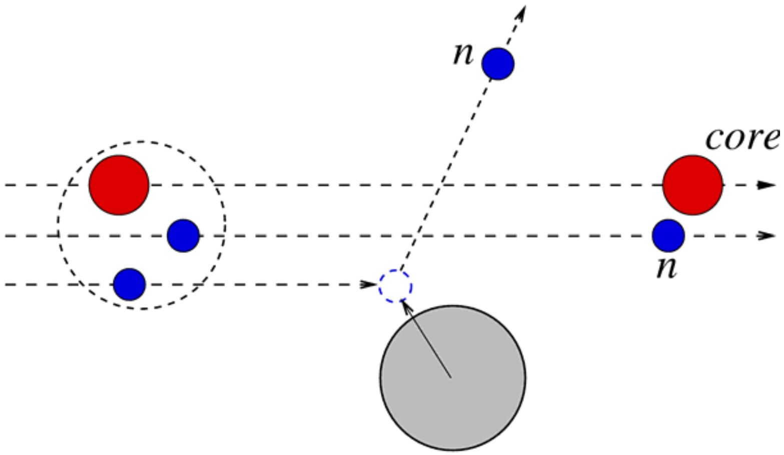


Distribución de momentos del "core"

$$\frac{d^6\sigma^{(0i)}}{d\vec{p}'_{i,jk}d\vec{p}'_{jk}} \propto \sum \left| \left\langle \Phi^{(jk)}_{p'_{jk}s_{jk}\sigma_{jk}} e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}} \chi_{s_i\sigma_i} \middle| \Psi^{JM} \right\rangle \right|^2$$

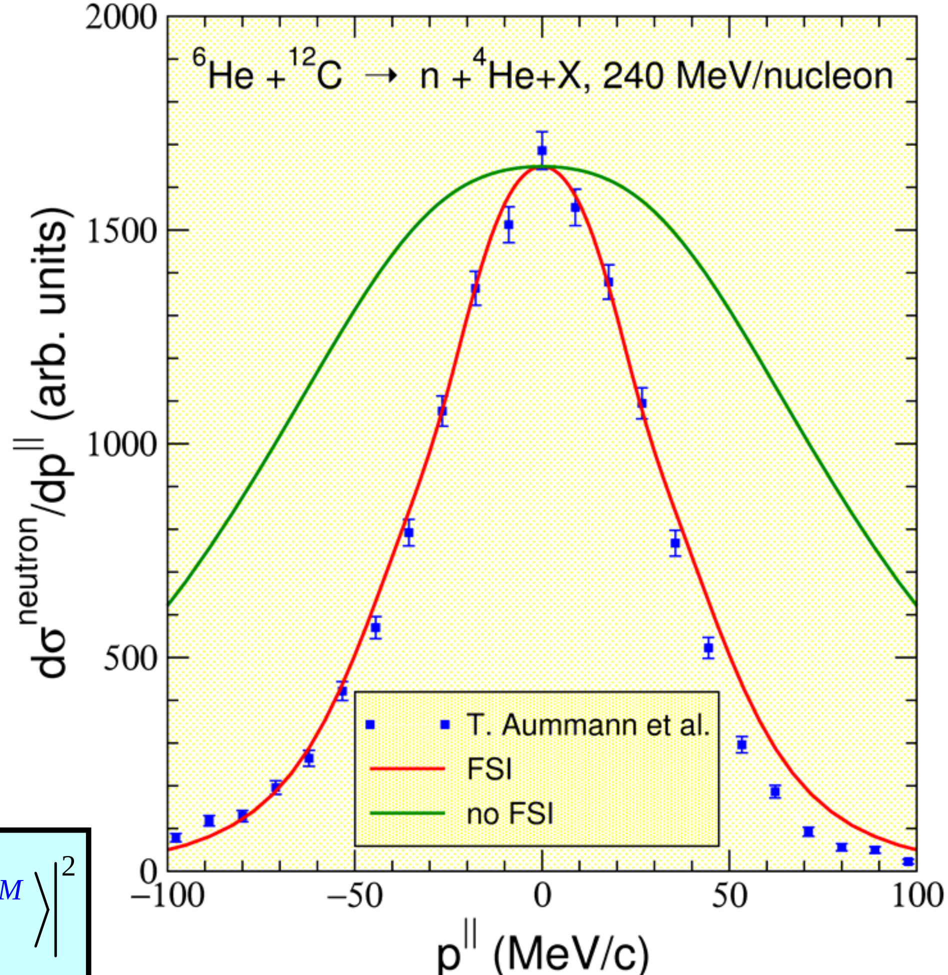


El caso del ^{6}He: $n+n+\alpha$

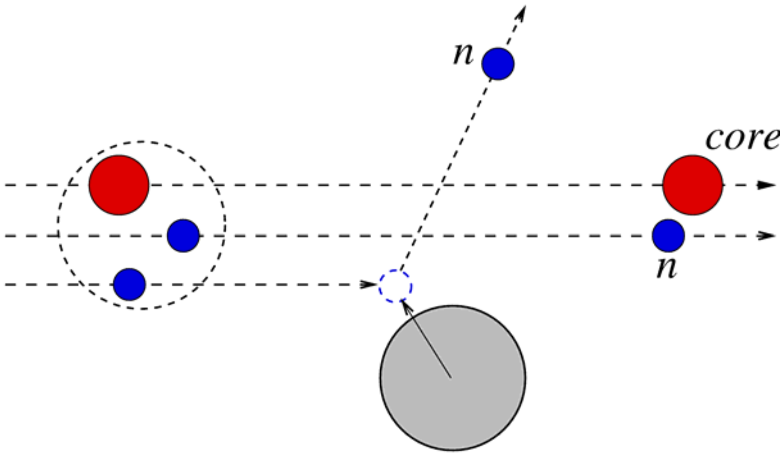


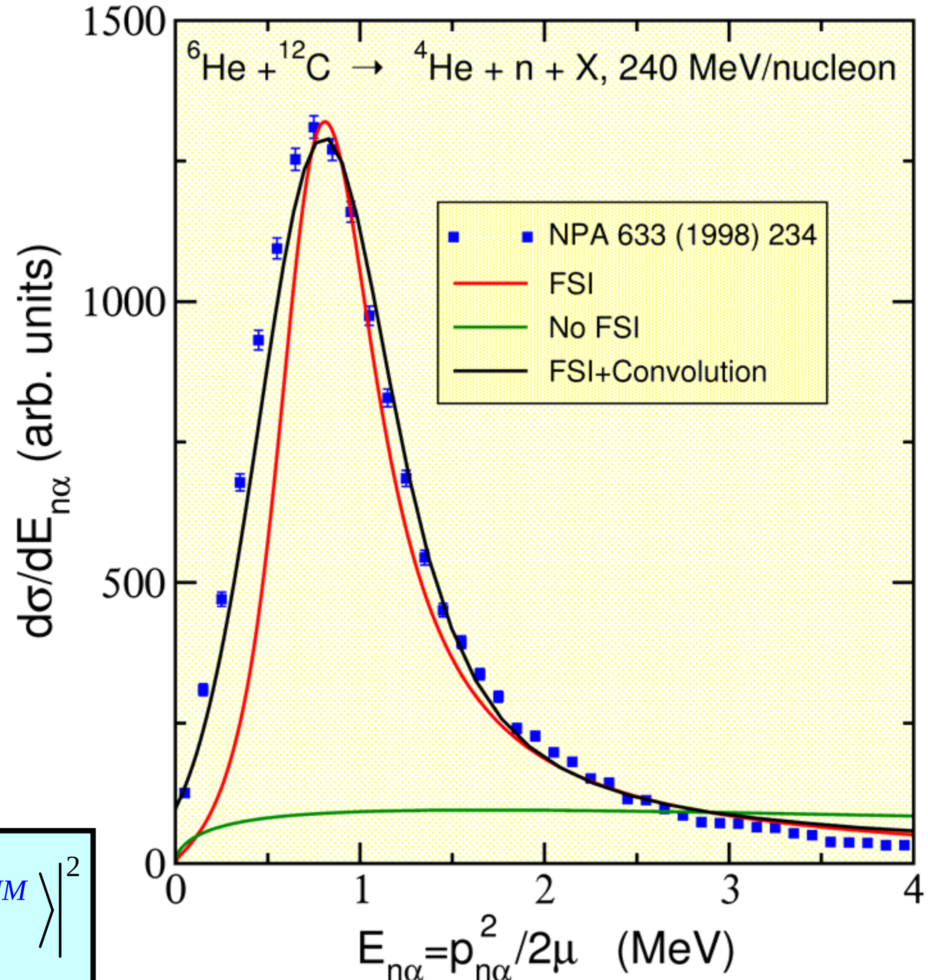
Distribución de momentos del neutrón

$$\frac{d^6\sigma^{(0i)}}{d\vec{p}'_{i,jk}\,d\vec{p}'_{jk}} \propto \sum \left| \left\langle \Phi^{(jk)}_{p'_{jk}s_{jk}\sigma_{jk}} \, e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}} \chi_{s_i\sigma_i} \middle| \Psi^{JM} \right\rangle \right|^2$$



El caso del ^{6}He: $n+n+\alpha$

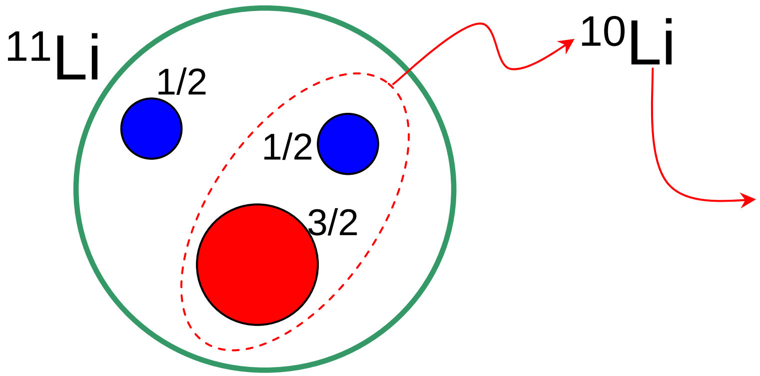




Distribución de momentos del energías en ^{5}He

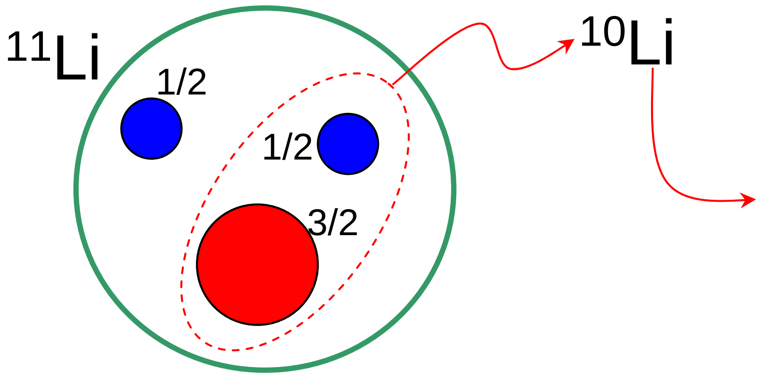
$$\frac{d^6\sigma^{(0i)}}{d\vec{p}\,'_{i,jk}\,d\vec{p}\,'_{jk}} \propto \sum \left| \left\langle \Phi^{(jk)}_{p'_{jk} s_{jk} \sigma_{jk}} \, e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}} \chi_{s_i \sigma_i} \,\middle|\, \Psi^{JM} \right\rangle \right|^2$$

El caso del ^{11}Li: $n+n+{}^9Li$



1) $E_s < 200$ keV
2) $E_p \sim 0.5$ MeV
3) Contenido en onda *p*??

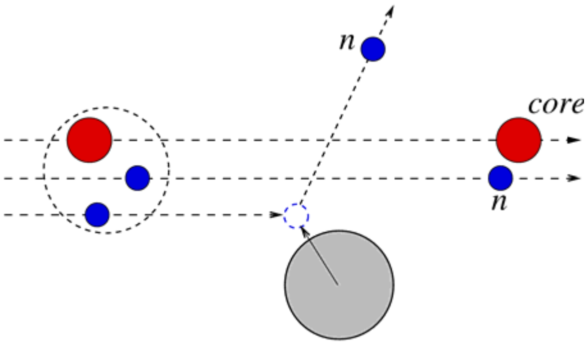
El caso del ^{11}Li: $n+n+^{9}Li$

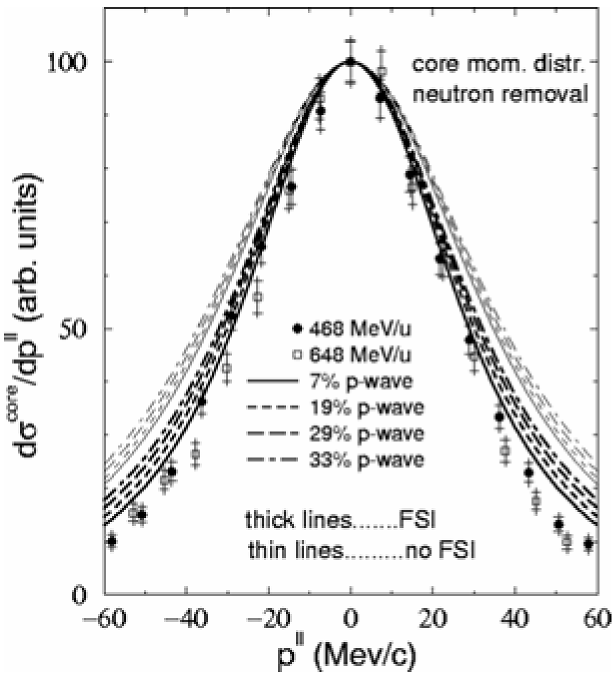


1) E_s < 200 keV
2) E_p ~ 0.5 MeV
3) Contenido en onda *p*??

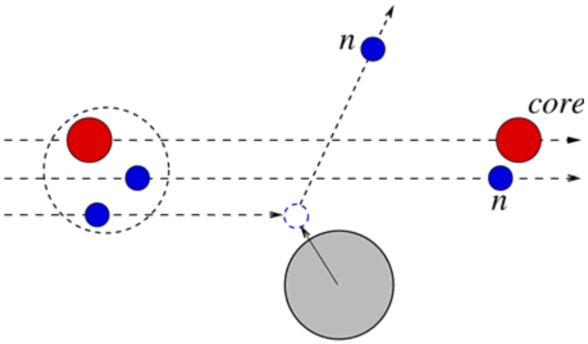
$$\boxed{V^{(\ell)}_{^9Li-n}(r) = V_c^{(\ell)}(r) + V_{so}^{(\ell)}(r)\vec{\ell}_{^9Li-n}\cdot\vec{s}_n + V_{ss}^{(\ell)}(r)\vec{s}_c\cdot\vec{s}_n}$$

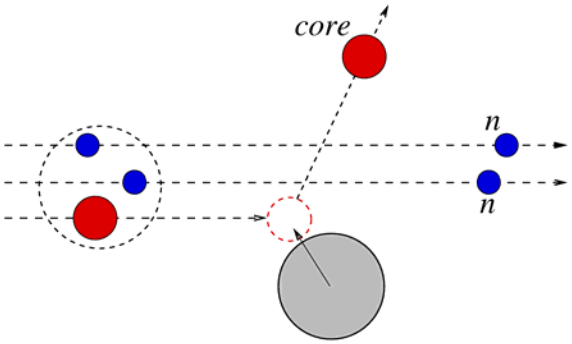
El caso del ^{11}Li: $n+n+{}^9Li$

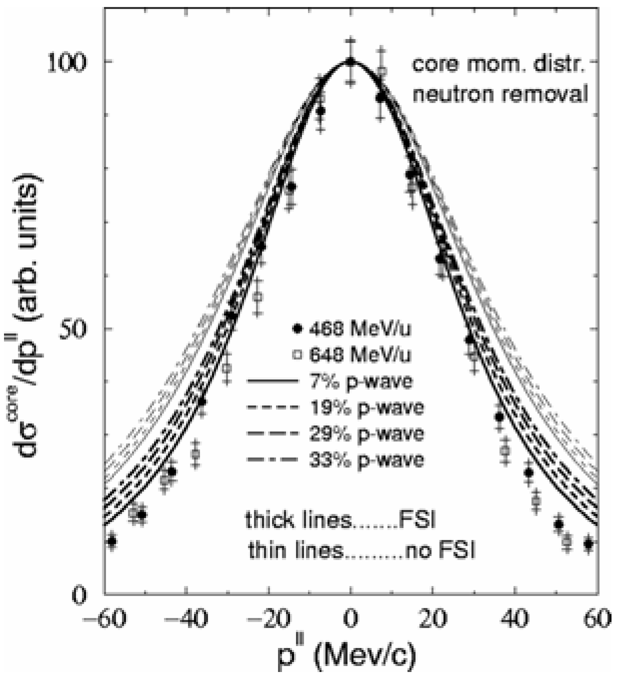


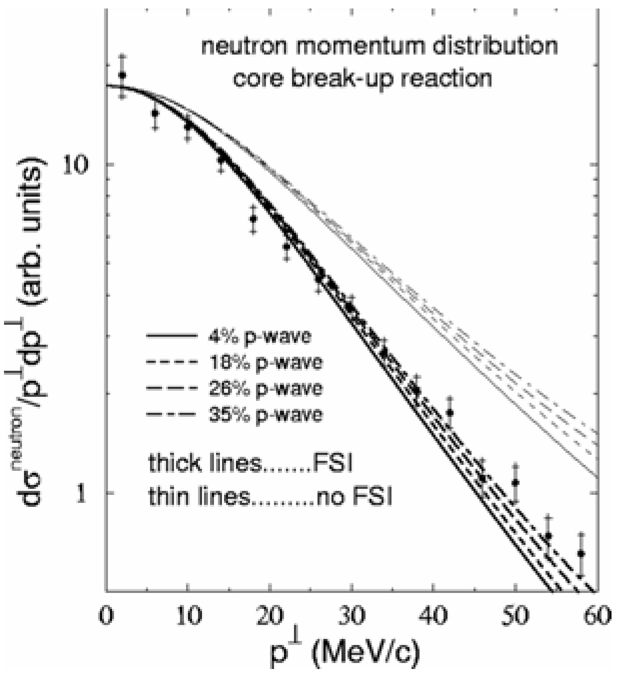


El caso del ^{11}Li: n+n+^{9}Li

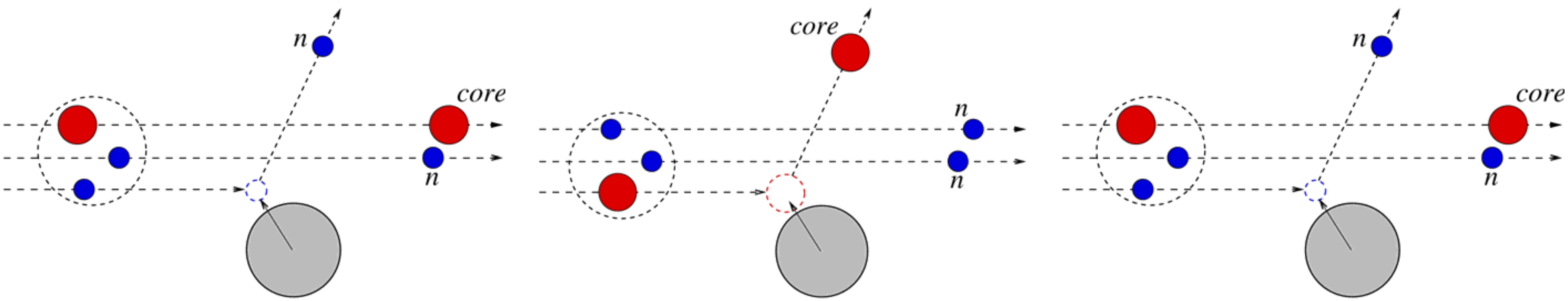


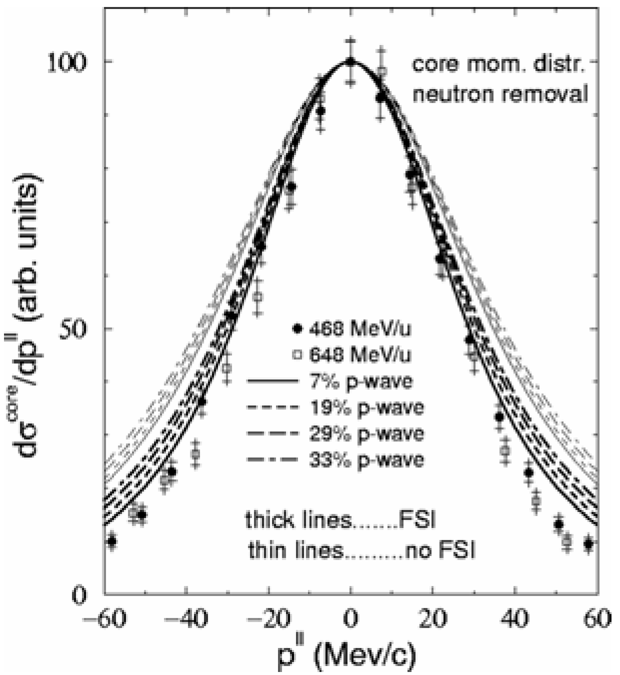


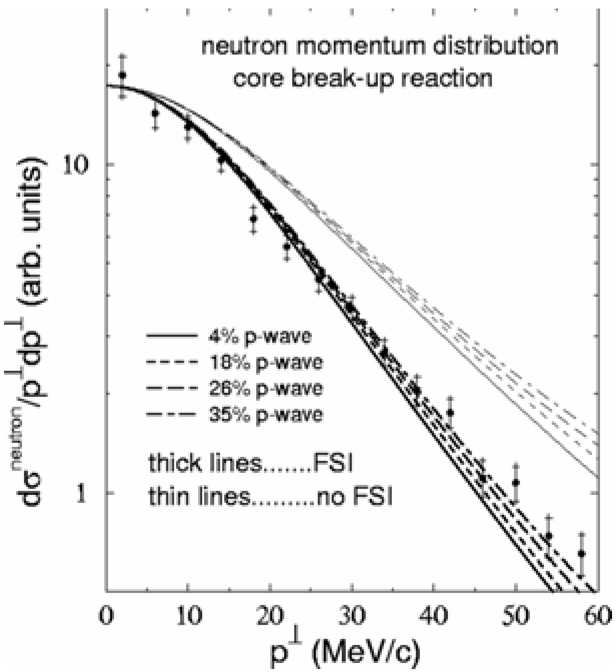


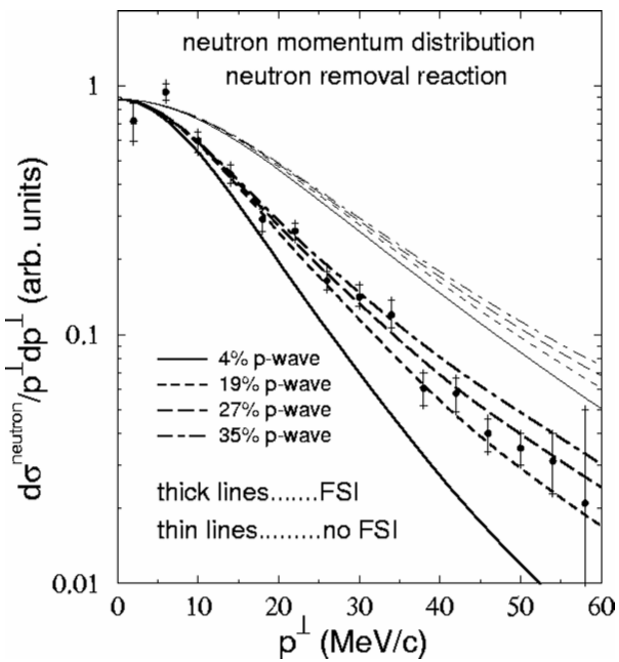


El caso del ^{11}Li: $n+n+^{9}Li$

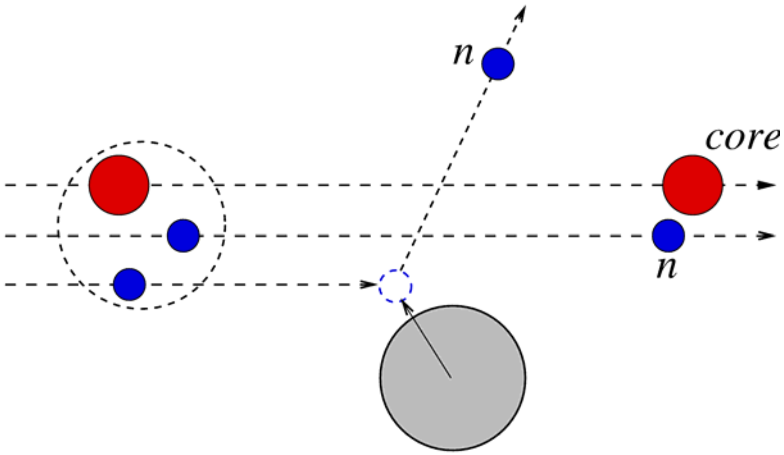




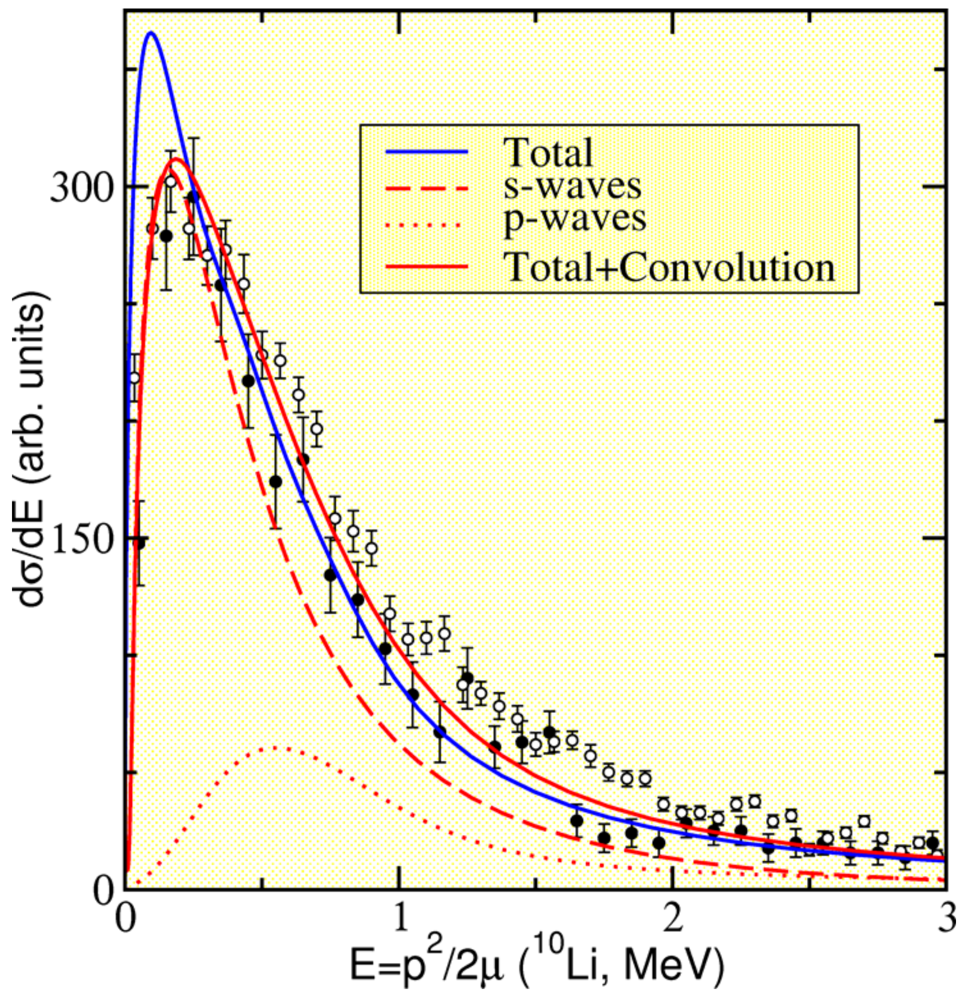




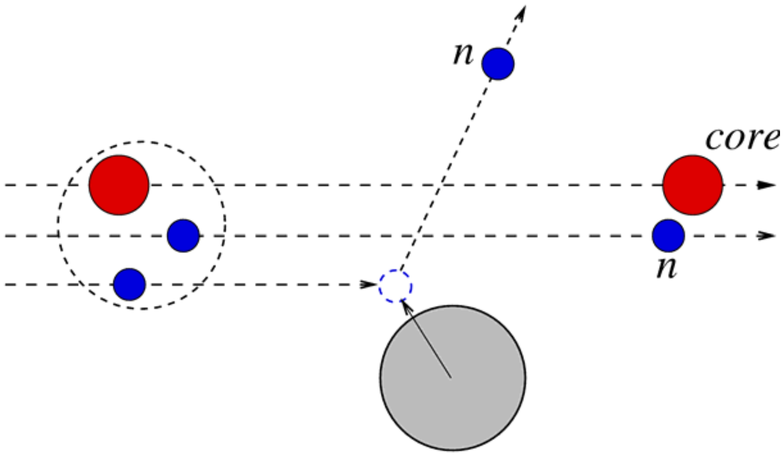
El caso del ^{11}Li: $n+n+^{9}Li$

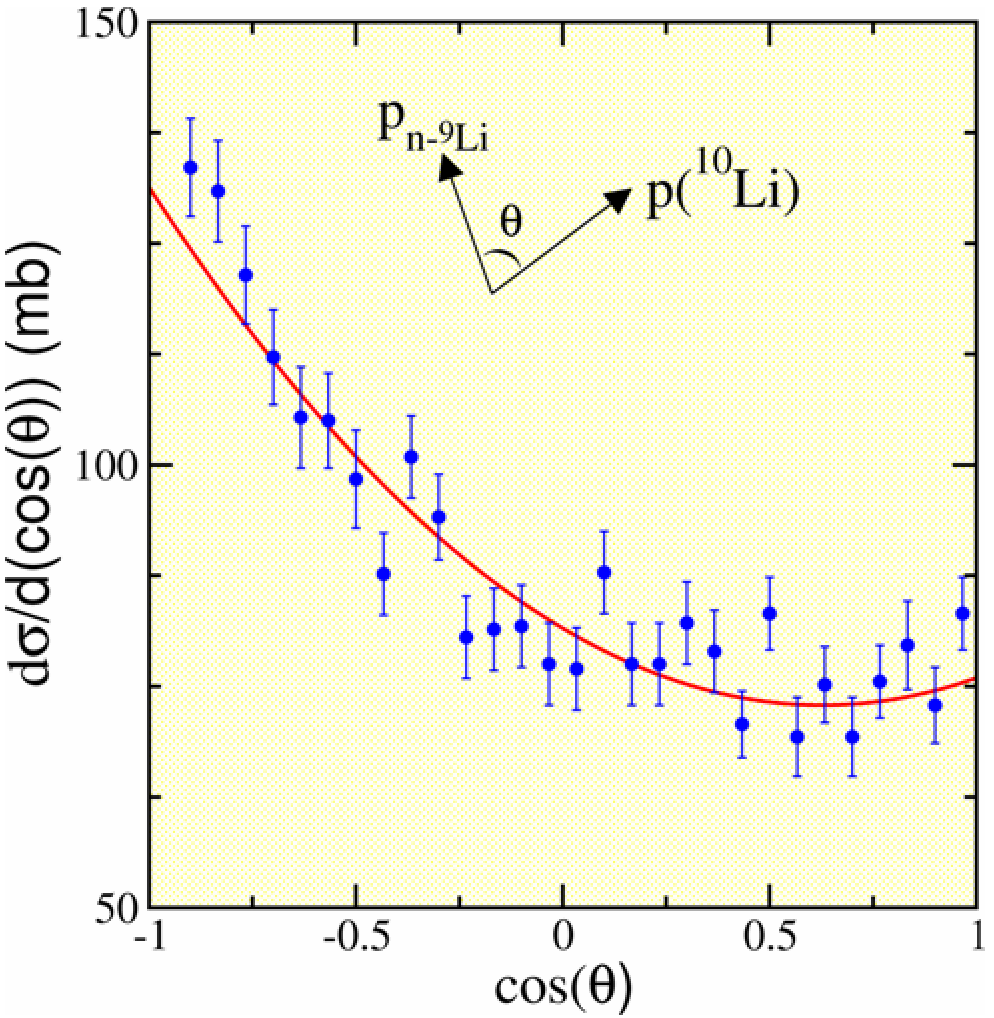


Distribución de momentos del energías en ^{10}Li



El caso del ^{11}Li: $n+n+^{9}Li$





Distribución angular del ^{10}Li

Ángulo entre el momento relativo ^{9}Li-neutrón y el momento del ^{10}Li

En la "sudden approximation"……

$$\frac{d^6\sigma^{(0i)}}{d\vec{p}'_{i,jk}\, d\vec{p}'_{jk}} \propto \sum \left| \left\langle \Phi^{(jk)}_{p'_{jk} s_{jk} \sigma_{jk}} \, e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}} \, \chi_{s_i \sigma_i} \middle| \Psi^{JM} \right\rangle \right|^2$$

- ✓¿Dependencia en la energía del haz?
- ✓¿Dependencia en el blanco empleado?
- ✓¿Distribuciones longitudinales y transversales?
- ✓¿Valores absolutos de las secciones eficaces?

En la “sudden approximation”……

$$\frac{d^6\sigma^{(0i)}}{d\vec{p}'_{i,jk}\,d\vec{p}'_{jk}} \propto \sum \left| \left\langle \Phi^{(jk)}_{p'_{jk} s_{jk} \sigma_{jk}} e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}} \chi_{s_i\sigma_i} \middle| \Psi^{JM} \right\rangle \right|^2$$

- ✓¿Dependencia en la energía del haz?
- ✓¿Dependencia en el blanco empleado?
- ✓¿Distribuciones longitudinales y transversales?
- ✓¿Valores absolutos de las secciones eficaces?

$$\frac{d^6\sigma^{(0i)}_{(\text{elas,abs})}}{d\vec{p}'_{i,jk}\,d\vec{p}'_{jk}} = \sigma^{(0i)}_{(\text{elas,abs})} \frac{1}{2J+1} \sum \left| \left\langle \Phi^{(jk)}_{p'_{jk} s_{jk} \sigma_{jk}} e^{i\vec{p}_{i,jk}\cdot\vec{r}_{i,jk}} \chi_{s_i\sigma_i} \middle| \Psi^{JM} \right\rangle \right|^2$$

Resumiendo….

- ✓Los núcleos ligeros próximos a la “dripline” de neutrones pueden presentar una estructura de halo: ^{6}He, ^{11}Li, ^{11}Be, ^{19}C….

- ✓Además de poder describirse como sistemas de pocos cuerpos los neutrones del halo residen preferentemente en la zona clásicamente prohibida.

- ✓Experimentalmente se observa que estos núcleos presentan un comportamiento anómalo: Radios de interacción, disociación Coulombiana, distribuciones de momentos…

- ✓La descripción de estos núcleos como sistemas de pocos cuerpos permite reproducir datos experimentales, no sólo de su estructura, sino también de procesos de fragmentación.