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Hydrogen-lithium Low Energy Resonant Electron-Capture and Bethe's Solar Energy Model

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Content:

1. **3-parameter formula**

2. **Selective Resonance Tunneling**

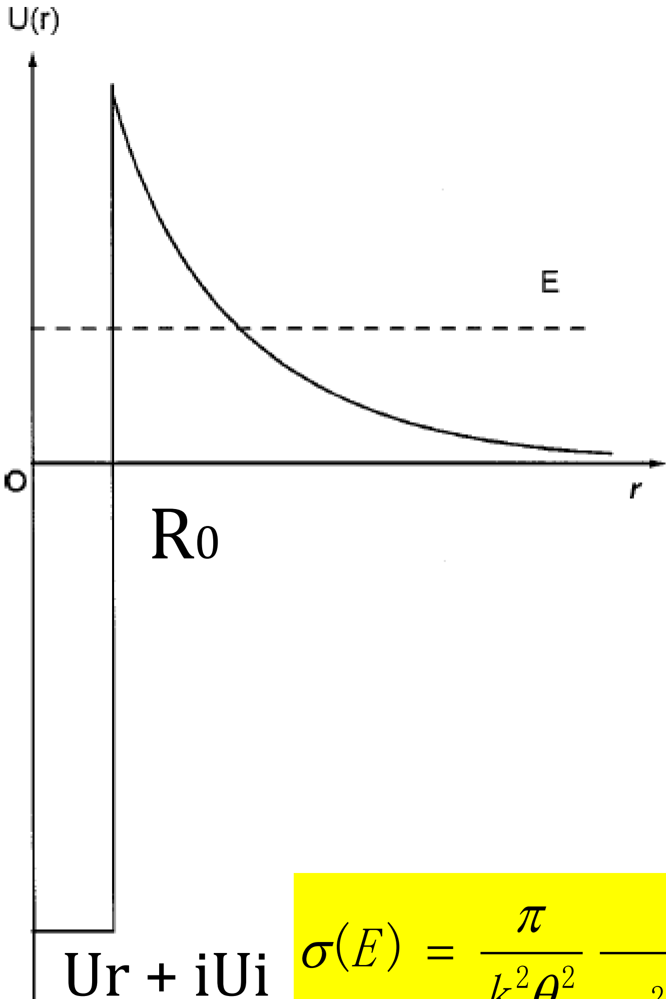
3. **Bethe's Solar Model**

Who participate the reaction ?

How the reaction happen?

What's reaction probability ?

1. 3-parameter formula for fusion cross-section of light nucleus



3 parameters for light nucleus fusion model (non-elastic scattering):

R0: the radius of target nucleus

Ur: the depth of nuclear potential well

Ui: the imaginary part of nuclear potential well (describes the absorption of the well)

C1, C2, wi

$$\sigma(E) = \frac{\pi}{k^2\theta^2}\frac{-4w_i}{w_r^2 + (w_i + \frac{1}{\theta^2})^2} \approx \frac{\pi}{k^2\theta^2}\frac{-4w_i}{(C_1 + C_2E)^2 + (w_i + \frac{1}{\theta^2})^2}$$

1. 3-parameter formula for fusion cross-section of light nucleus

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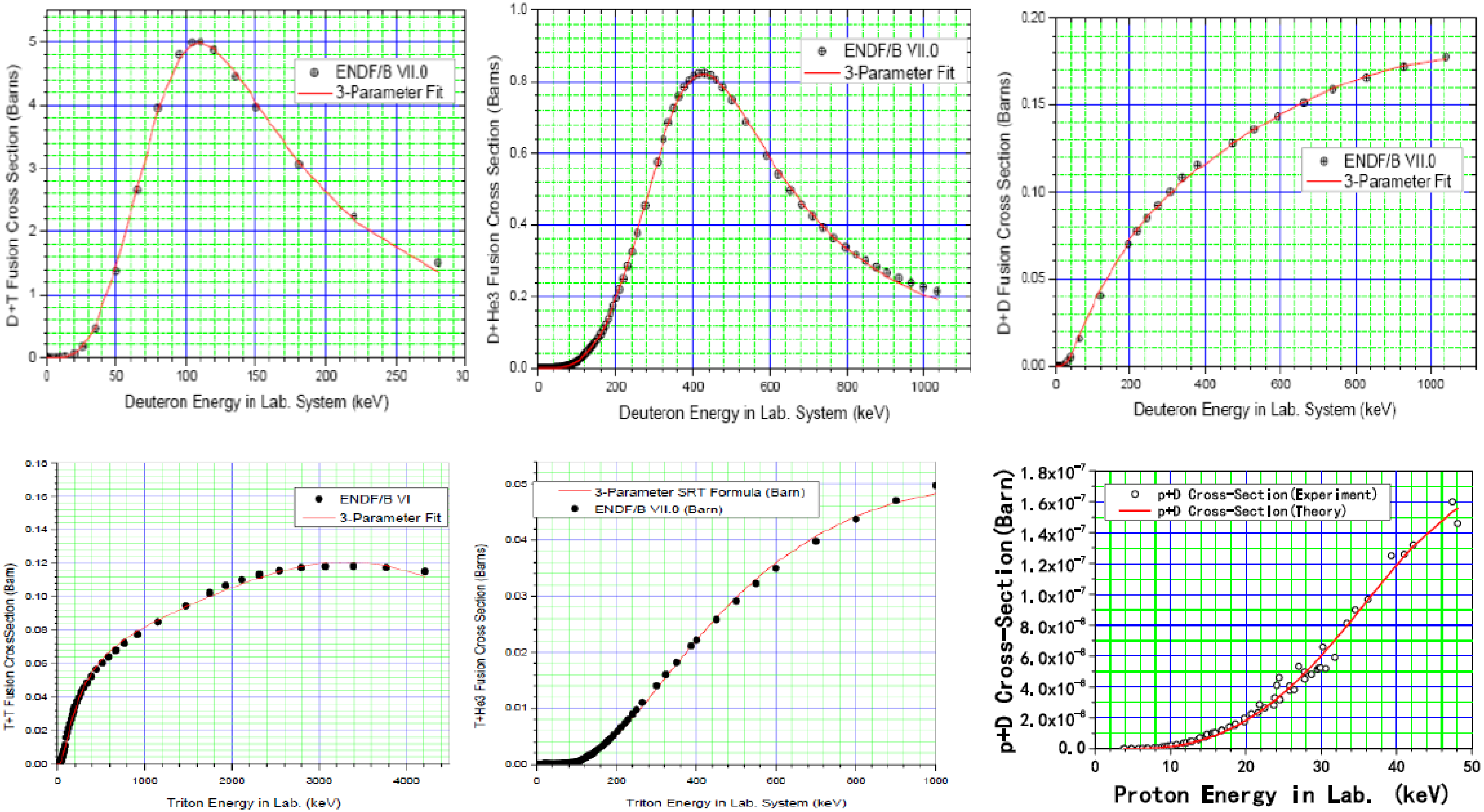
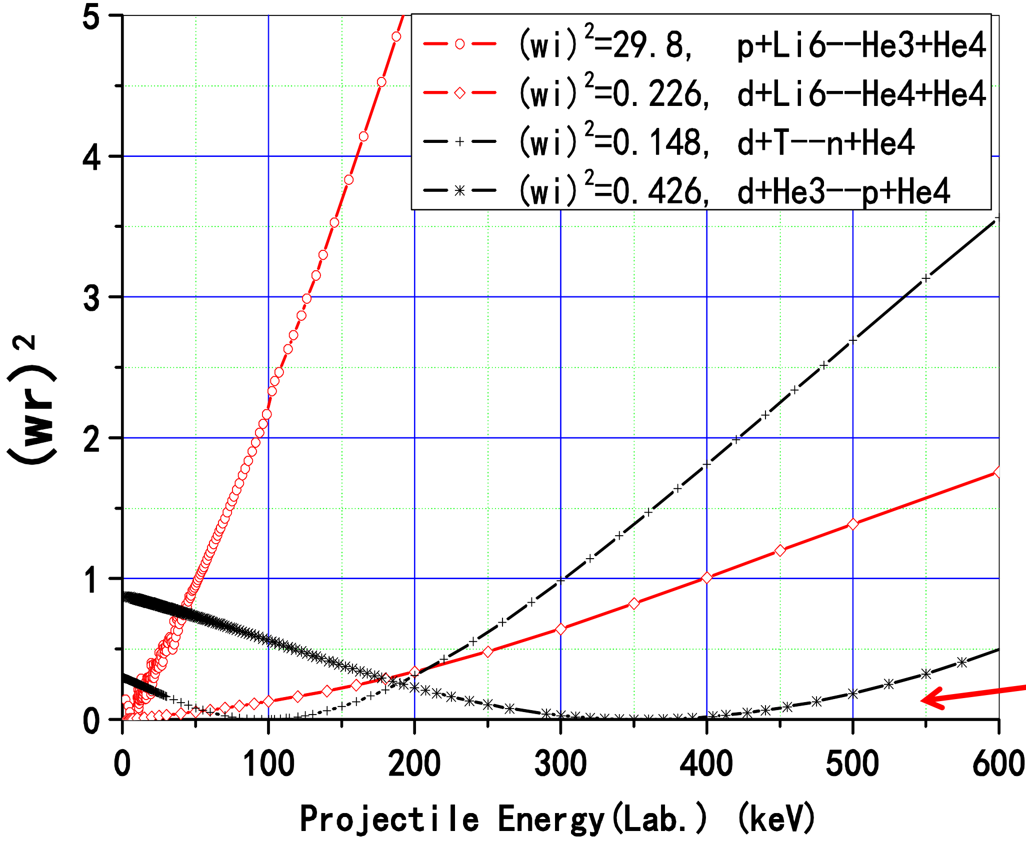


3-parameter formula was supported by hot fusion data: D+T, D+He3, D+D, T+T, T+ ^{3}He, p+D, etc

1. 3-parameter formula for fusion cross-section of light nucleus



$$\sigma(E) = \frac{\pi}{k^2\theta^2} \frac{-4w_i}{w_r^{\ 2} + (w_i - 1/\theta^2)^2}$$

$$w_r^2 = \frac{\pi}{k^2} \frac{(-4w_i)}{\theta[E]^2 \sigma_0[E]} - (w_i - \frac{1}{\theta[E]^2})^2$$

d+T resonance at 95keV, d+ ^{3}He resonance at 375keV

- describes resonance
- **p +** ^{6}**Li**, and **d +** ^{6}**Li** resonance at **E~0**

2. Selective Resonant Tunneling

Can we expect

$^{6}Li + p \Rightarrow {}^{3}He + {}^{4}He$

At E~0 ?

No!

2. Selective Resonant Tunneling

$$\sigma(E) = \frac{\pi}{k^2\theta^2}\frac{-4w_i}{w_r^2 + (w_i + 1/\theta^2)^2}$$

At resonance $w_r = 0$,

$$\sigma(E) = \frac{\pi}{k^2\theta^2}\frac{4}{(-w_i)}$$

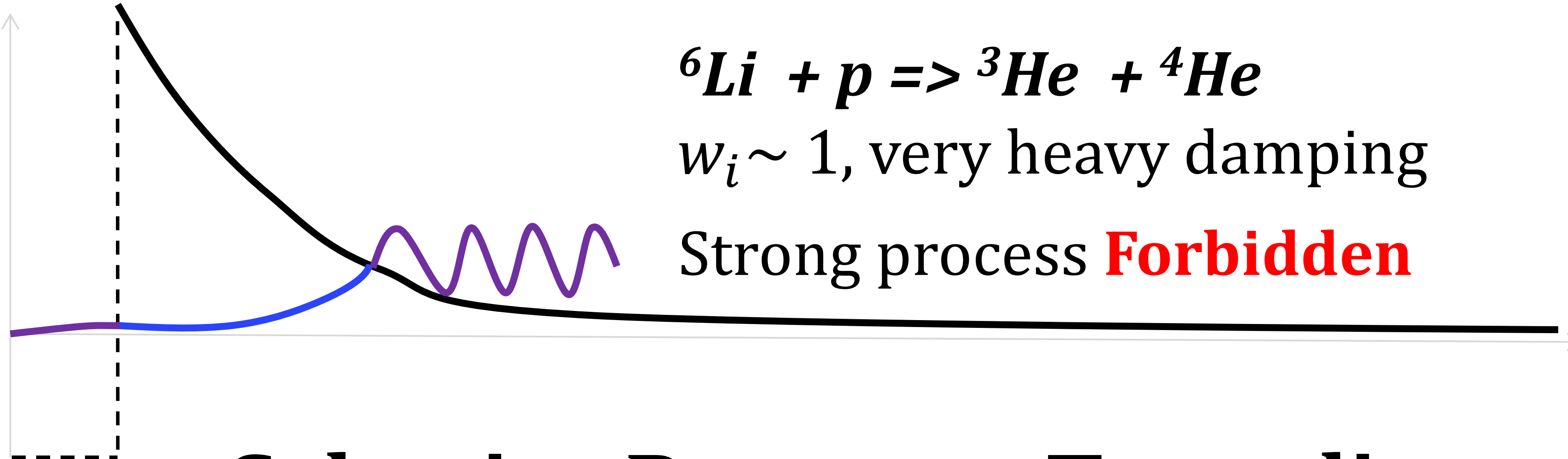
wi represent absorption of nuclear well

- $\theta^2 \approx \frac{1}{2\pi} Exp\left(\frac{Z_a Z_b e^2}{2\varepsilon_0}\sqrt{\frac{m}{E}}\right)$ is Gamow factor, that is an extreme large number ($> 10^{30}$)at low Energy.

- Strong interaction ⇨ $-w_i \sim 1$
- Weak interaction ⇨ $-w_i \sim 10^{-30}$

Only weak interaction will happen

2. Selective Resonant Tunneling

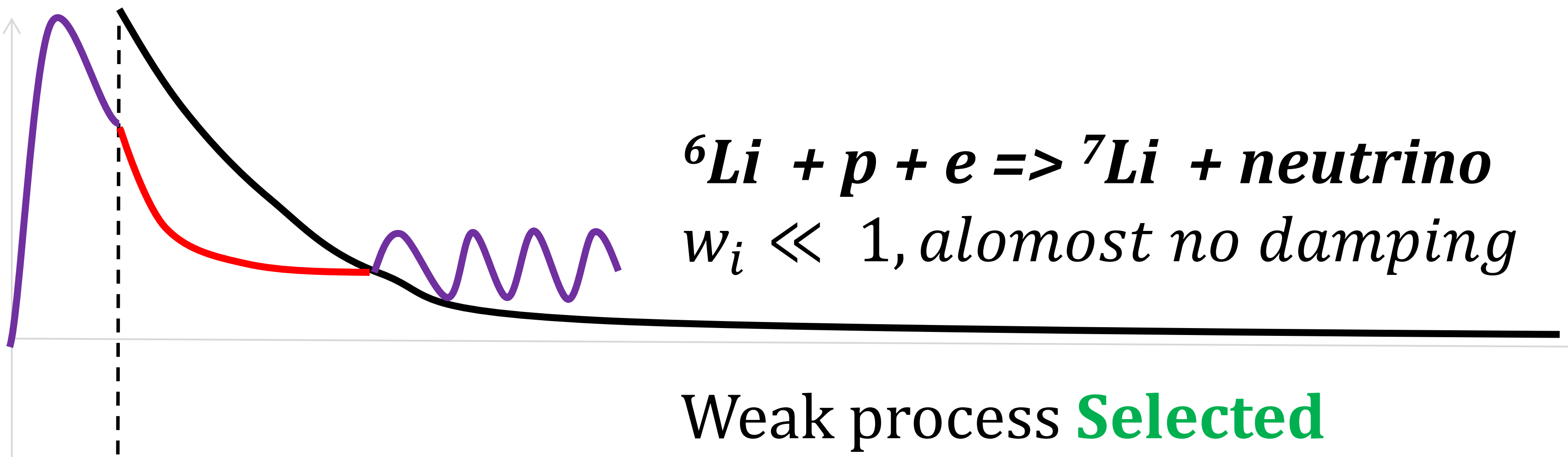


$^{6}Li + p => {}^{3}He + {}^{4}He$

$w_i \sim 1$, very heavy damping

Strong process **Forbidden**

Selective Resonant Tunneling



$^{6}Li + p + e => {}^{7}Li + neutrino$

$w_i \ll 1, alomost\ no\ damping$

Weak process **Selected**

Next Questions:

1. What's the energy width of the resonance? Does the energy width go to zero at **E~0**?

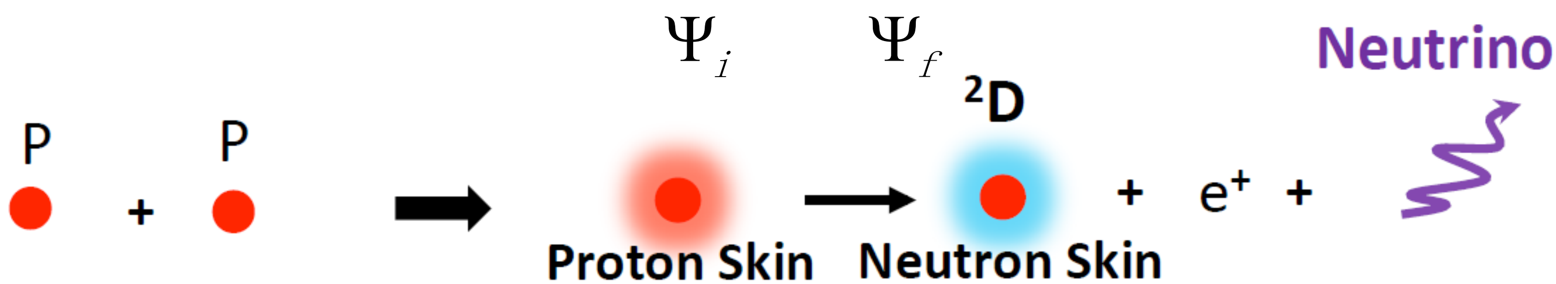
2. Imaginary potential well can't describe weak interaction. How to calculate the probability?

Method in **Bethe's Solar Energy model**

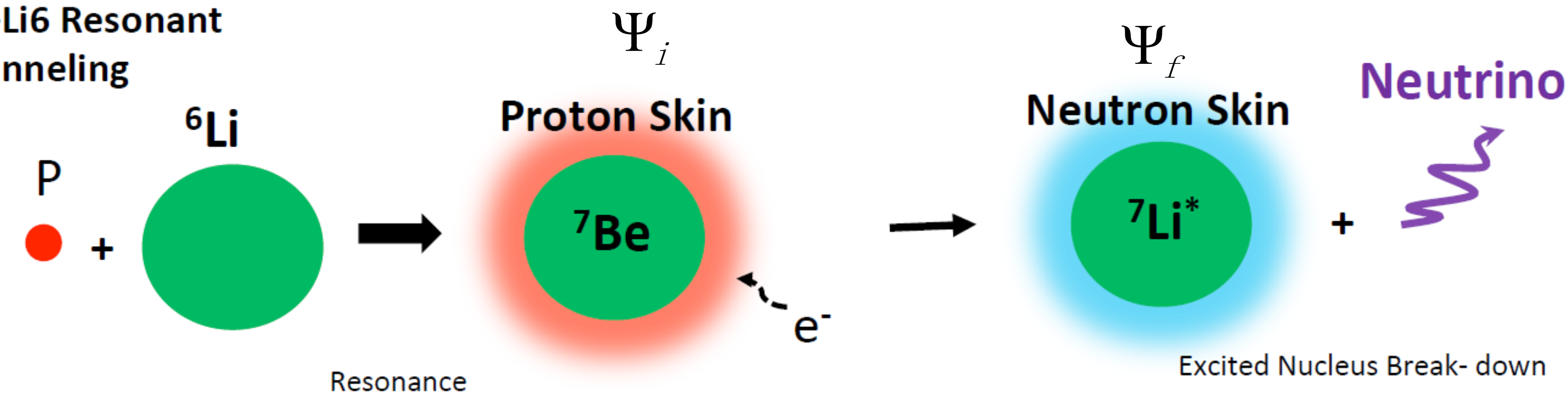
3. Bethe's Solar Energy Model

Elastic Scattering--Weak Interaction

Bethe
Solar Energy

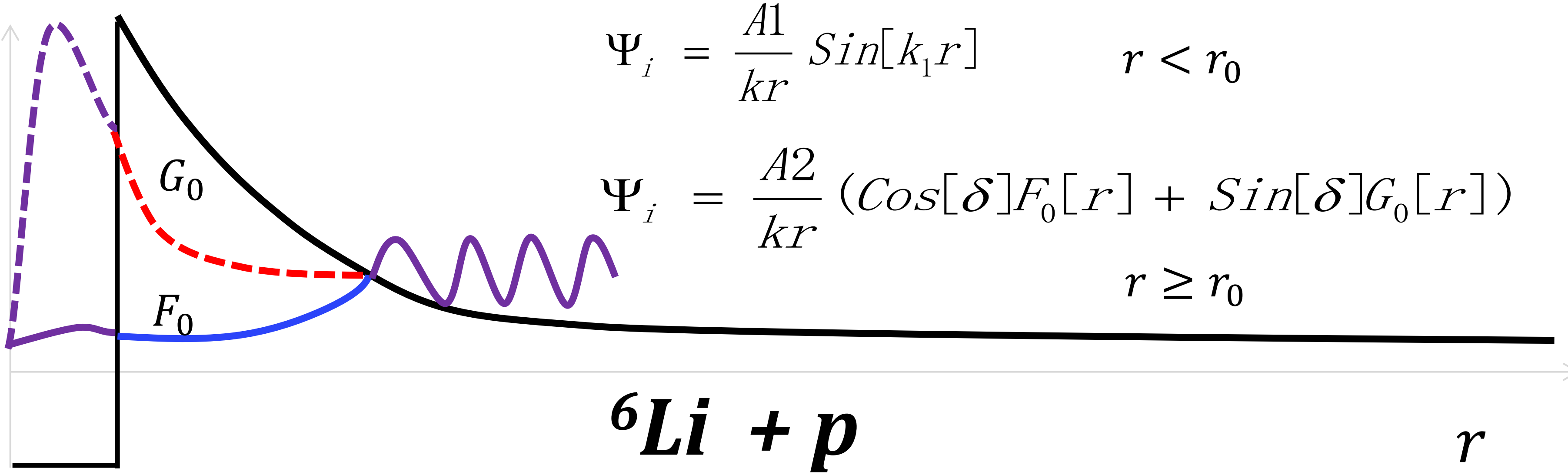


P+Li6 Resonant Tunneling



$$\sigma(E) = \frac{gF(W)}{v}\left|\int \Psi_f \Psi_i d\tau\right|^2$$

3. Bethe's Solar Energy Model

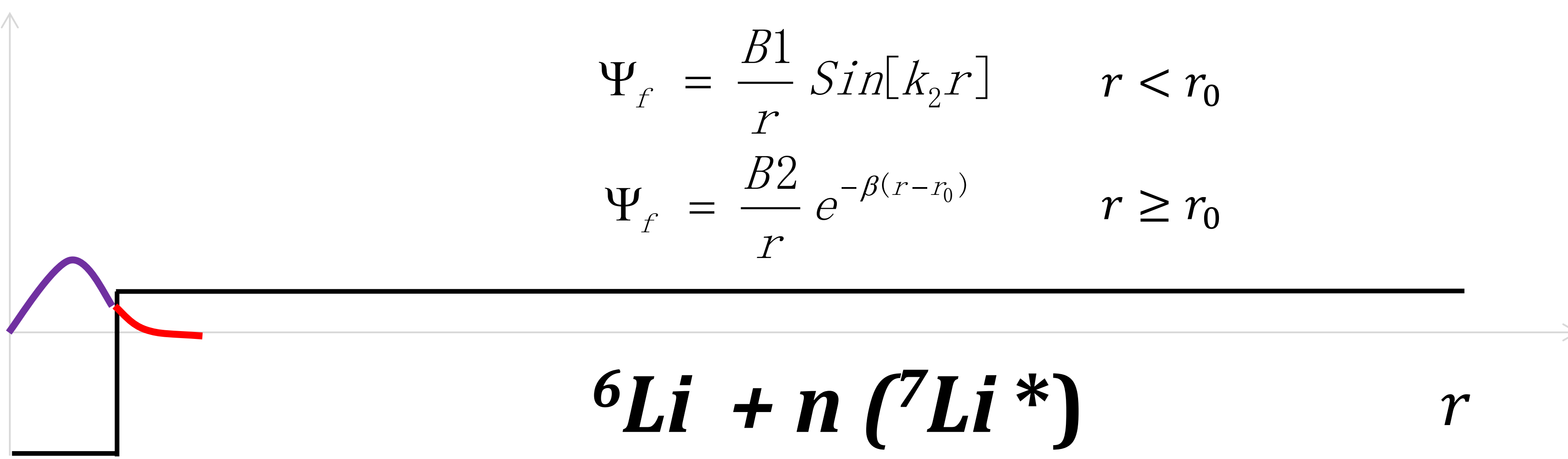


$$\Psi_i = \frac{A1}{kr} Sin[k_1 r] \qquad r < r_0$$

$$\Psi_i = \frac{A2}{kr} (Cos[\delta] F_0[r] + Sin[\delta] G_0[r])$$

$$r \geq r_0$$

$^6Li + p$



$$\Psi_f = \frac{B1}{r} Sin[k_2 r] \qquad r < r_0$$

$$\Psi_f = \frac{B2}{r} e^{-\beta(r - r_0)} \qquad r \geq r_0$$

$^6Li + n\ (^7Li^*)$

3. Bethe's Solar Energy Model

Reaction cross section from Ψ_i to Ψ_f is (in unit of m^2):

$$\sigma(E) = \frac{gF(W)}{v} \left| \int \Psi_f \Psi_i d\tau \right|^2$$

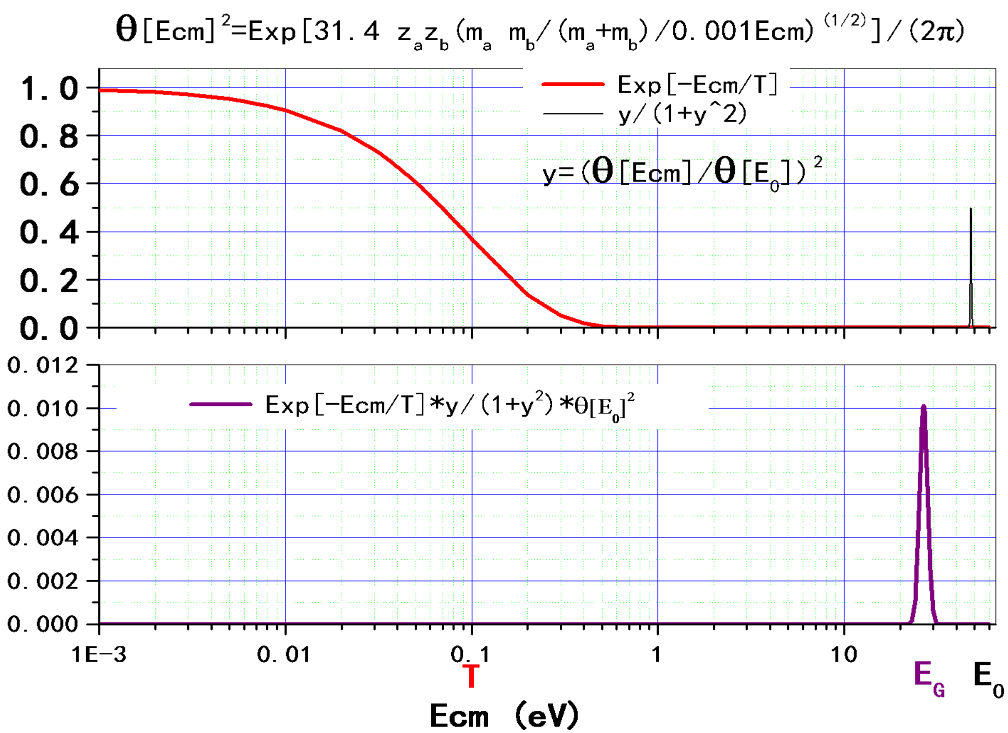
At temperature *T*, average over Maxwell distribution, the reaction probability as below (in unit of m^3/sec):

$$< \sigma[E] v >= (\frac{\mu}{2\pi T})^{3/2} \int_0^\infty gF(W) \left| \int \Psi_f \Psi_i d\tau \right|^2 Exp[-\frac{\mu v^2}{2T}] 4\pi v^2 dv$$

3. Bethe's Solar Energy Model

Resonance peak and resonance width:

$$< \sigma[E]\, v >= C(T)\, (w_r)^2 \int_0^\infty \frac{\theta[E]^2}{1+(w_r \theta[E]^2)^2} Exp[-\frac{E}{T}] dE$$



$$\theta[E_0]^2 w_r = 1$$

$$E_G = (\frac{\pi \hbar T}{\sqrt{2\mu a_c}})^{2/3}$$

$$\Delta E = 2\sqrt{\frac{2Log[2]}{|f''[E_G]|}};$$

3. Bethe's Solar Energy Model

We assume $E_0 = 50eV^*$ And $T = 1300\ k$

$$\frac{1}{W_r} = \theta[E_0]^2$$

$$E_G = \left(\frac{\pi\hbar T}{\sqrt{2\mu a_c}}\right)^{2/3} = 28.4eV$$

$$\Delta E = 2\sqrt{\frac{2Log[2]}{\left|f''[E_G]\right|}} = 3.4eV$$

It is a very broad way to proton tunneling !

* In Lipinski's patent , he claimed that he was able to detect the helium when a low energy (50eV) proton beam was injected into the lithium vapor.

3. Bethe's Solar Energy Model

Reaction probability and Temperature dependence:

With parameters of ^{6}***Li*** and ***p***, and assumed E0 = 50eV, the reaction probability as below:

A is independent with T, and T in Kelvin

$$< \sigma v >= A \cdot (\frac{1}{T})^{2/3} \cdot Exp[-\frac{8416}{T^{1/3}}]$$

It is heavily dependent on Temperature !

This would have a **positive feed-back** effect as an exothermic process.

3. Bethe's Solar Energy Model

The energy releasing

$$^{6}Li + p + e \Rightarrow {}^{7}Li^{*} + neutrino + 6.468MeV$$

$$\hookrightarrow {}^{7}Li^{*} \Rightarrow T + {}^{4}He + 4.001MeV$$

The final reaction product may ***^{7}Li*** or ***T and ^{4}He,*** The energy would be released by the kinetic of these particles.

The END

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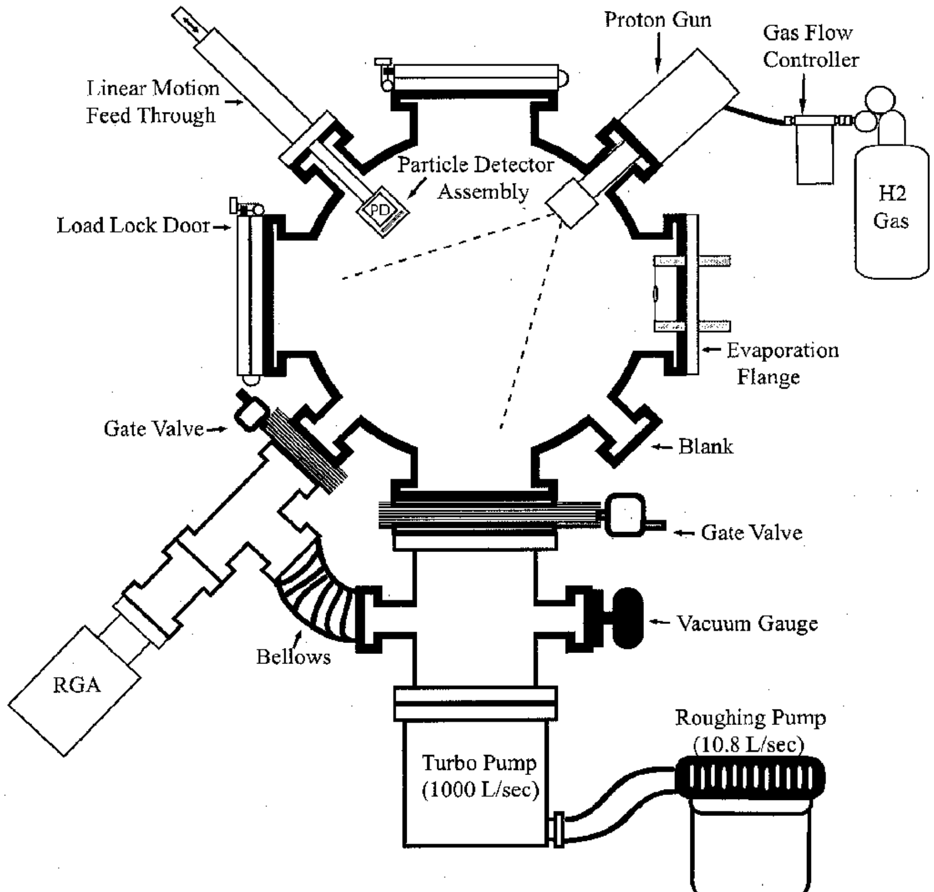
SERIES 23 & 24 REACTION CHAMBER COMPONENTS



(57) Abstract: The Hydrogen-Lithium Fusion Device (HLFD) includes a plasma generator that generates proton-lithium plasma within a reaction chamber. The plasma generator includes a proton source and lithium source. In one implementation, bias voltage is applied within the reaction chamber. The bias voltage enables protons to fuse with lithium ions in the proton-lithium plasma, whereby energetic helium ion fusion byproducts are produced. Multiple configurations of reaction chambers containing protons and lithium ions under conditions that yield proton-lithium fusion are disclosed.

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