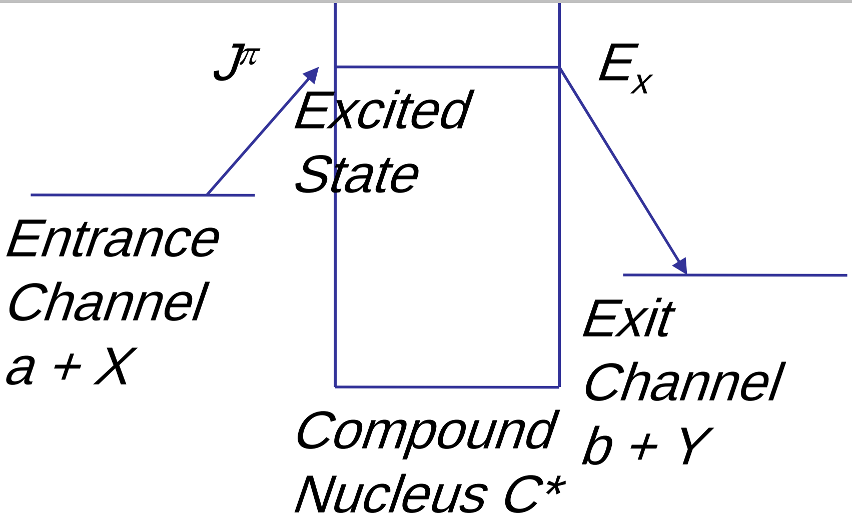
Reaction Cross Section



$a + X \rightarrow Y + b \quad Q > 0$

$b + Y \rightarrow X + a \quad Q < 0$

Inverse Reaction

More Generalization

$$\sigma_{aX} = \pi\lambda\!\!\!^{-}{}_{aX}^{2} \frac{2J+1}{(2J_a+1)(2J_X+1)} (1+\delta_{aX}) \left| \langle Y+b | H_{II} | C \rangle \langle C | H_I | a+X \rangle \right|^2$$

QM

Statistical Factor (ω)

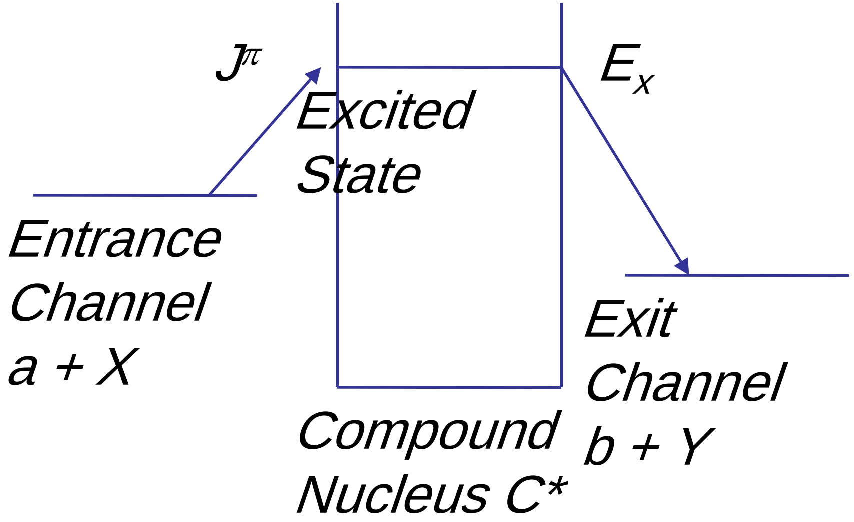
Identical particles

- Nature of force(s).
- Time-reversal invariance.

$$\sigma_{bY} = \pi\lambda\!\!\!^{-}{}_{bY}^{2} \frac{2J+1}{(2J_b+1)(2J_Y+1)} (1+\delta_{bY}) \left| \langle a+X | H_I | C \rangle \langle C | H_{II} | b+Y \rangle \right|^2$$

$$\frac{\sigma_{aX}}{\sigma_{bY}} = ??$$

Resonance Reactions

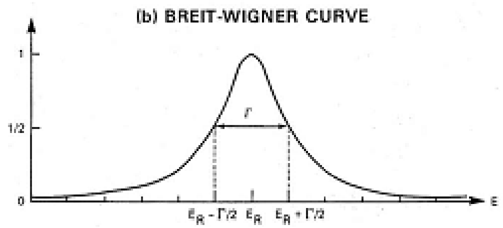


HW 6

In the $^{19}F(p,\alpha\gamma)$ reaction:

- The Q-value is 8.??? MeV.
- The Q-value for the formation of the C.N. is 12.??? MeV.
- For a proton resonance at 668 keV in the lab system, the corresponding energy level in the C.N. is at 13.??? MeV.
- If for this resonance the observed gamma energy is 6.13 MeV, what is the corresponding alpha particle energy?
- If for this resonance there has been no gamma emission observed, what would then be the alpha particle energy?

Resonance Reactions



$$\sigma(E) = \pi \lambda\!\!\!^{-}{}_{aX}^{\;2} \frac{2J+1}{(2J_a+1)(2J_X+1)}(1+\delta_{aX})\frac{\Gamma_a\Gamma_b}{(E-E_R)^2+(\frac{\Gamma}{2})^2}$$

Breit-Wigner formula

$$\Gamma = \Gamma_a + \Gamma_b$$

- All quantities in CM system
- Only for isolated resonances.

$\sigma_R \propto \Gamma_a\Gamma_b$ ← Reaction

$\sigma_e \propto \Gamma_a\Gamma_a$ ← Elastic scattering

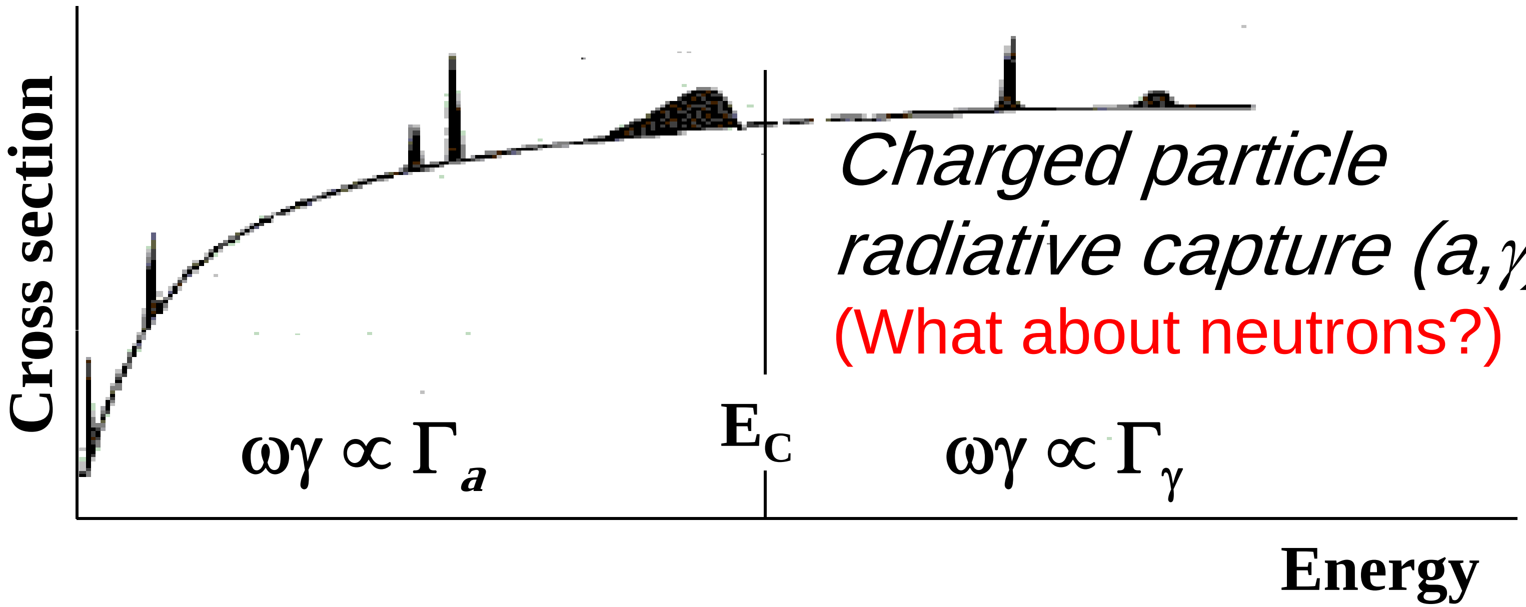
Usually $\Gamma_a >> \Gamma_b$.

$$\frac{\sigma_R}{\sigma_e} = \frac{\Gamma_b}{\Gamma_a}$$

Resonance Reactions

Resonance Strength

$$\omega\gamma = \frac{2J+1}{(2J_a+1)(2J_X+1)}(1+\delta_{aX})\frac{\Gamma_a\Gamma_b}{\Gamma}$$

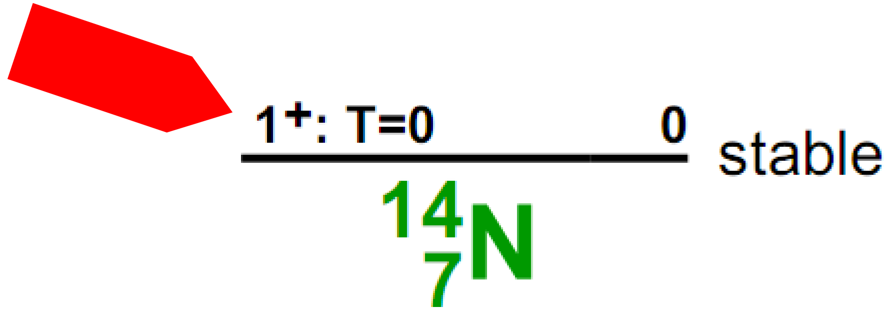


Charged particle radiative capture (a,γ)

(What about neutrons?)

Resonance Reactions

^{14}N(p,γ) **HW 7**



- Q = ??
- E_C = ??
- $E_R^{\,C.M.}$ = 2.0 MeV

  Formation via *s*-wave protons, Take $J = ½$, $\Gamma_p = 0.1$ MeV, dipole radiation $E_\gamma = 9.3$ MeV, $\Gamma_\gamma = 1$ eV.
  Show that $\omega\gamma = 0.33$ eV.
- If same resonance but at $E_R = 10$ keV

  Γ_p = ?? E_γ = ?? Γ_γ (dipole) = ??
  Show that $\omega\gamma = 3.3\times10^{-23}$ eV.

$$\Gamma_L(E_\gamma) = \alpha_L E_\gamma^{2L+1}$$

$$\Gamma_{Dipole}(E_\gamma) = \alpha_1 E_\gamma^{3}$$

Huge challenge to experimentalists