PHY 484 : Week 4

Decays & Scattering.

Decays: Collection of particles $N(t)$ decaying over time

with probability Γ: $\quad dN = -\Gamma N \, dt$.

It follows that $N(t) = N_0 e^{-\Gamma t}$.

Γ is the decay rate, but can be expressed in terms

of half-life $\Gamma = \frac{1}{\tau}$.

For multiple decays, the total decay is the sum

of all individual decays

$$\Gamma_{tot} = \sum_i \Gamma_i .$$

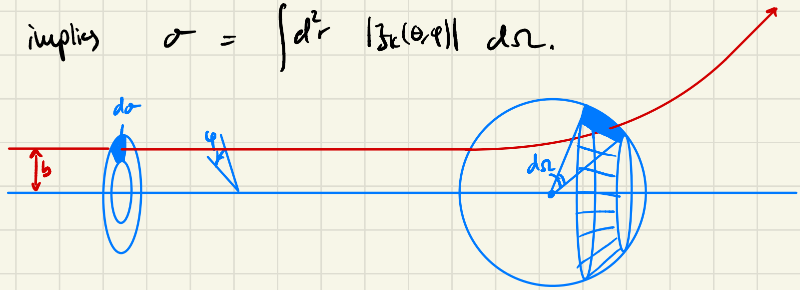
Then $\quad \tau = \frac{1}{\Gamma_{tot}}$,

and the term $\frac{\Gamma_i}{\Gamma_{tot}}$ is called the "Branching Ratio"

Cross-Sections: See PHY456.

$d\Omega = \sin\theta \, d\theta \, d\varphi$

Particles passing through $d\sigma$ scatter through $d\Omega$ with probability $|f_k(\theta,\varphi)|^2$, hence $\frac{d\sigma}{d\Omega} = |f_k(\theta,\varphi)|^2$ implies $\sigma = \int d^2r \; |f_k(\theta,\varphi)| \, d\Omega$.



Final State energy distribution for scattering: Breit-Wigner

For $\Gamma = \sum_i \Gamma_i$,

$$N_f(W) \propto \frac{\Gamma_f}{(W-M)^2 c^4 + \Gamma^2/4}$$

where W is the invariant mass and M is the mass of the unstable state.

This leads to the scattering resonances

$$\sigma_f \propto \frac{\Gamma_i \Gamma_f}{(E - Mc^2)^2 + \Gamma^2/4}$$

where E is the total CM energy, M is the rest mass of resonance (?), Γ_i is the partial width of resonance (?) to decay to initial state (?) and Γ_f is the partial width of resonance to decay to final state (?), and Γ is the full width of resonance (?).

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σ has units $[L^2]$ usually in 'barns' $= 10^{-24}\ cm^2$.

$\sigma \propto |A|^2$; $|A|$ is scattering amplitude.

Collider Physics Terminology:

Luminosity $= L =$ measure of intensity of colliding beams

$$L = N_1 N_2 \frac{f}{A}$$

where N_1, N_2 = number of particles in each beam,

f = particle collision frequency (?)

A = cross-sectional size of collision spot (? not σ?)