Some Decays are Not Allowed

We've already seen some instances where decays don't happen:

1) not enough Q
2) doesn't satisfy our lepton number rules
3) doesn't satisfy charge conservation

But there are some other rules we need to consider

Why can't we have the decay $p \to e^+ \nu_e$?

i) it isn't seen

ii) baryon number is conserved $\begin{pmatrix} = +1 & \text{baryon} \\ -1 & \text{anti-baryon} \end{pmatrix}$

why we've always seen a proton – neutron or neutron – proton

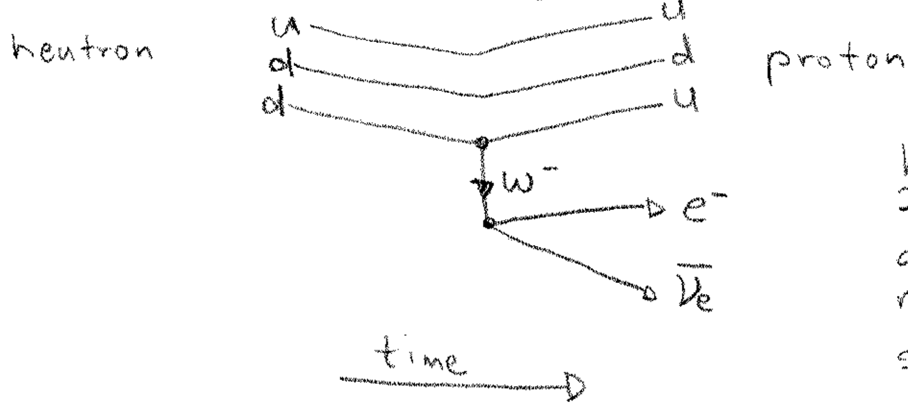
Recall from last time baryons have 3 quarks
mesons have a quark $\overline{\text{quark}}$

Some other conservation Laws depend on the interaction

⇒ Only the weak interaction can change one kind of quark into another

A neutron $\begin{pmatrix} d \\ d \\ u \end{pmatrix}$ can change into a proton $\begin{pmatrix} u \\ u \\ d \end{pmatrix}$ and an electron e^- and a $\overline{\nu}_e$ through a virtual W^- emission

diagramatically



Notice: 2 quarks are along for the ride (called spectators)

So, the • of the W^- can only effect one "line" of quarks at a time.

If you look at the quarks we have

$$\begin{pmatrix} u \\ d \end{pmatrix} \quad \begin{pmatrix} c \\ s \end{pmatrix} \quad \begin{pmatrix} t \\ b \end{pmatrix}$$

& any quark in the top row can mix with any in the bottom row. It is, however, much more likely for quarks to stay in their "generation"

This has implications for the strong force and the electromagnetic force:

"Quarkness" is conserved for these forces

$\Rightarrow$ no way to get rid of an up quark or $\overline{\text{up}}$ quark

you can make $q\bar{q}$ pairs or anhiliate them though

Consider

$$K^+ \to \pi^+ \pi^0$$

$$\bar{s}u \to \begin{matrix} u\bar{d} \\ (u\bar{u}+d\bar{d}) \end{matrix}$$ can occur only via the weak force

$K^{*+} \to K^+ \pi^-$ is ok, but $K^{*+} \to K^- \pi^+$ is not

excited K^+ (changed $\bar{s} \to s$)

You have to be a little careful

$K^{*+} \to K^+ \gamma$ is possible but unlikely unless $K^{*+} - K^+$ is very small

$$t_{weak} \sim 10^{-10}, \quad t_{EM} \sim 10^{-16}, \quad t_{strong} \sim 10^{-23}$$

$\longleftarrow$ order of preference