Radiation Detector 2018/19 (SPA6309), Tutorial 1

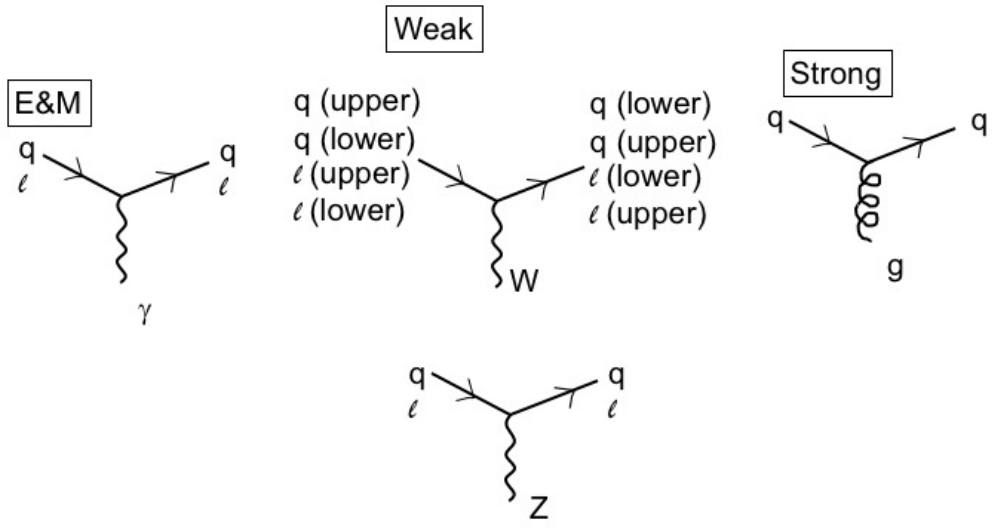
Name:
ID:

To draw Feynman diagrams;

1. memorize all possible vertex types
2. time flows from left to right, virtual particles propagate vertically
3. anti-particles go backward with time

1. Vertex rules

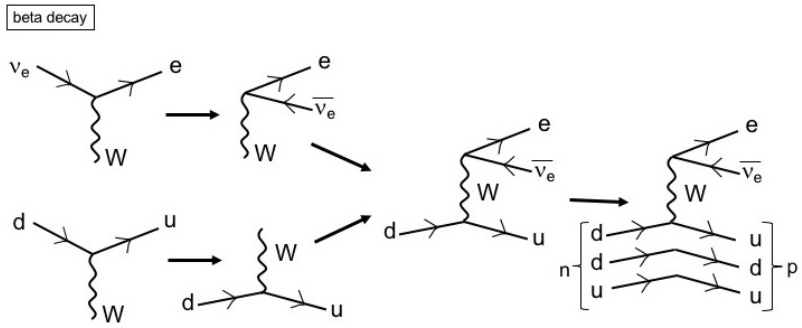
As you see weak interaction is way more complicated than others. By exchange of W bosons, flavours of quarks or leptons change. In the lepton sector, this change is strictly within the generation. An electron (lower 1st generation lepton) becomes electron neutrino (upper 1st generation lepton), and electron neutrino becomes electron). For quarks, the majority of transformation is within the generation, but the small transformation to beyond same generation is allowed.



2. flow of particles

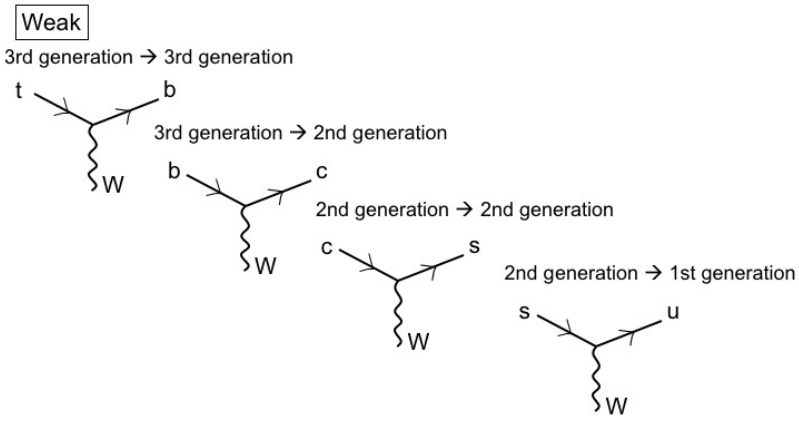
Let's make a Feynman diagram of beta decay ($n \rightarrow p + e^- + \bar{\nu_e}$ or $d \rightarrow u + e^- + \bar{\nu_e}$), first we pick 2 vertices for lepton and quark. Then, "bend" the leg of electron neutrino to another side, but now electron neutrino flows to the opposite direction, so it is electron anti-neutrino. By combining with quark side, add other lines, you can make the beta decay Feynman diagram!

Note, "arrow" attached on the lines are just conventions to keep track particles and anti-particles. It is common to omit arrows on lines. In fact, some textbooks use different conventions. The important thing is which one is particle and anti-particle.



3. Quark transition beyond the same generation

Although leptons only transform by weak interaction within a same generation, heavy quarks can transform to different generations, this can happen mostly from lower quark→upper quark, like $b \rightarrow c$ and $s \rightarrow u$ (this is because $m_t > m_b$, so $t \rightarrow b$ instead of more difficult $t \rightarrow s$. Same is true for for c and s.). Therefore, a standard transformation chain of a quark is $t \rightarrow b \rightarrow c \rightarrow s \rightarrow u$.

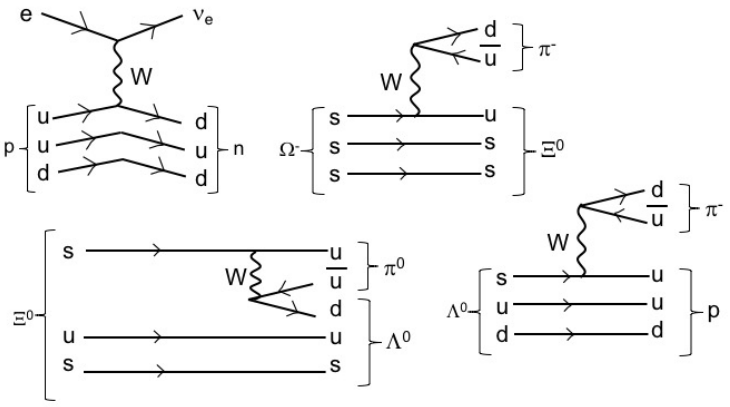


problem 1

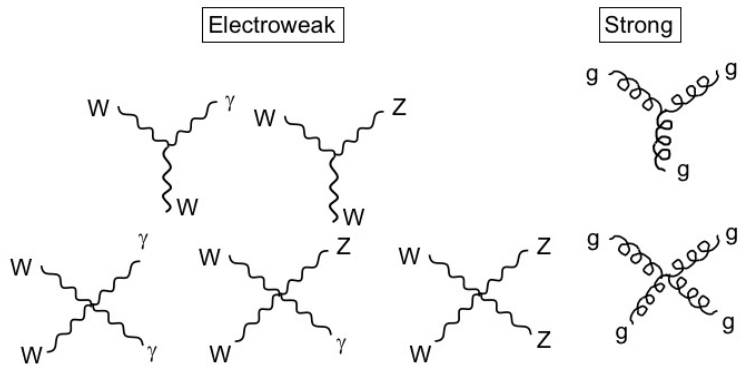
Draw Feynman diagram of electron capture ($e + p \rightarrow \nu_e + n$)

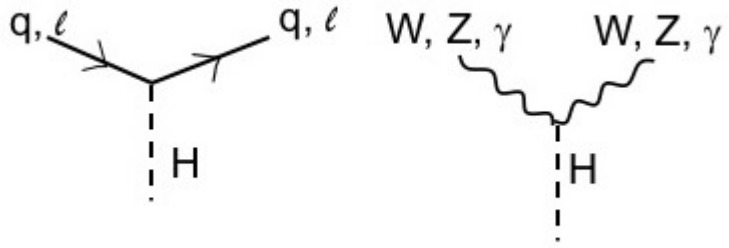
problem 2

Draw Feynman diagram of Ω decay chain ($\Omega \rightarrow \Xi^0 + \pi^-$, $\Xi^0 \rightarrow \Lambda^0 + \pi^\circ$, $\Lambda^0 \rightarrow p + \pi^-$), here, Ω=sss, Ξ^0=ssu ,Λ^0=uds.



Vertex rules for gauge bosons





Notice γ cannot interact with γ, but it can interacts with W and Z bosons. There are many types of interactions for γ, W, and Z, but gluon only interact with gluon. Higgs boson couple with any fermions and weak bosons.

problem 3

Draw Feynman diagram of photon-photon interaction ($\gamma + \gamma \rightarrow \gamma + \gamma$).

problem 4

Draw Feynman diagram of gluon-gluon fusion Higgs production, then Higgs boson decays to two photons from the proton-proton collision (this is the channel used for the discovery of Higgs boson).