# 1 Particles

1. Can a gluon interact with a photon?
2. Can a gluon interact with a $W^-$?
3. Can a photon interact with itself? Why (not)?
4. What is the only elementary boson that can interact with neutrinos without changing them?
5. Can we have a meson with charge $++$?
6. What is the quark content of:

   $\Lambda^0$ (baryon, strangeness -1)

   $D_s^+$ (meson, strangeness 1, charmness 1)

   $\Omega^-$ (baryon, strangeness -3)

   $\Xi_{cc}^{++}$ (baryon, charmness 2)

# 2 Conservation Laws

Determine if the following processes are possible, and if yes, with which interaction:

$p + \overline{p} \to \pi^+ + \pi^- + \pi^0 + \pi^+ + \pi^-$

$p + K^- \to \Sigma^+ + \pi^- + \pi^+ + \pi^- + \pi^0$

$p \to \Lambda^0 + \overline{\Sigma}^0 + \pi^+$

$\overline{\nu}_\mu + p \to \mu^+ + n$

$\overline{\nu}_e + p \to e^+ + \Lambda^0 + K^0$

$\Sigma^0 \to \Lambda^0 + \gamma$

# 3 Feynman Diagrams

Draw Feynman diagrams for the following processes using the weak interaction:

- $\pi^+ \to \mu^+ + \nu_\mu$
- $\Lambda \to p + e^- + \overline{\nu}_e$
- $K^0 \to \pi^+ + \pi^-$
- $\pi^+ \to \pi^0 + \pi^-$

Draw Feynman diagrams for the following processes using the strong interaction:

- $\omega^0 \to \pi^+ + \pi^- + \pi^0$
- $\rho^0 \to \pi^+ + \pi^-$
- $\Delta^{++} \to p + \pi^+$

# 4 Challenge Exercise

A proton target is hit by a proton beam with momentum $|p| = 12GeV/c$. In one specific event, 6 tracks are observed. Two of these point to the interaction point and from their curvature we know these are positively charged particles. The other tracks form two pair of opposite charge. Both pairs are visible only a few cm past the interaction point. It is hence clear that two neutral particles were produced that later decayed into charged particles.

1. Make a sketch of this event
2. Discuss which mesons and baryons would be possible candidates for these decays (use the particle data - mass and lifetime - from the PDG booklet. Look for decay channels into two charged particles)
3. The measured momenta for the two pairs are:

   a) $|p+| = 0.68GeV/c \quad |p-| = 0.27GeV/c \quad \theta_{+-} = 11^\circ$

   b) $|p+| = 0.25GeV/c \quad |p-| = 2.16GeV/c \quad \theta_{+-} = 16^\circ$

   with a measurement error of 5%. Calculate the total energy to decide with hypothesis from 2. agrees with these measurements
4. Use these results to draw a Feynman diagram. Is this the only possible solution?

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