Particle Physics, Autumn 2014 CMI

Problem set 3

Due by beginning of lecture on Monday Oct 20, 2014

Diagrams for particle reactions

1. ⟨**27**⟩ Draw leading order quark/lepton level Feynman diagrams to depict the following processes. In each case, state whether it is an EM, strong or weak process. You may choose the direction of time (to the right or upwards) according to your convenience in each case, but indicate it.

   (a) ⟨**2**⟩ Dominant decay mode of π^-.

   (b) ⟨**1**⟩ μ^- decay.

   (c) ⟨**2**⟩ The strangeness changing 'semi-leptonic' decay $K^+ \to e^+\nu_e$.

   (d) ⟨**3**⟩ The strangeness changing 'semi-leptonic' decay $K^- \to \pi^0\mu^-\bar{\nu}_\mu$, taking π^0 as $\bar{u}u$.

   (e) ⟨**3**⟩ Anti-muon-neutrino electron elastic scattering $\bar{\nu}_\mu + e^- \to \bar{\nu}_\mu + e^-$. Why did this reaction become famous when it was first seen in the Gargamelle bubble chamber?

   (f) ⟨**3**⟩ Anti-neutrino proton inelastic elastic scattering $\bar{\nu}_e p \to e^+ n$.

   (g) ⟨**3**⟩ The hadronic scattering process $p(uud)\pi^+(u\bar{d}) \to \Delta^{++}(uuu)\pi^0(u\bar{u})$.

   (h) ⟨**3**⟩ The strangeness-conserving hadronic scattering process $p\pi^+ \to \Sigma^+ K^+$.

   (i) ⟨**3**⟩ The virtual hadronic 'dissociation' process $p \to n\pi^+$. Why can't the proton really decay in this way?

   (j) ⟨**4**⟩ Combine the diagrams for the virtual processes $p \to n\pi^+$ and $n\pi^+ \to p$ to arrive at a diagram showing the real scattering process $pn \to np$. First draw the diagram at the hadron level and then re-draw it at the quark level. At an intermediate time, there should be a π^+ among the intermediate particles. This gives a quark-level indication of the sense in which the inter-nucleon force may be approximated by pion exchange. Note that the pion must be exchanged between the incoming particles and not merely emitted and reabsorbed.

2. ⟨**9**⟩ Give brief answers. A few (3-4) sentences will do.

   (a) ⟨**3**⟩ What was Prout's hypothesis? What was it based on? What was the name of the hypothetical object and roughly when was it proposed?

   (b) ⟨**3**⟩ What did Philip Lenard discover about atomic structure, roughly when and in what scattering experiment?

   (c) ⟨**3**⟩ What is a super-heated liquid?