Modern Experimental Particle Physics (FYST17) - Problems 2013

Chapters 8-12; return by March 1

1) In the lowest order weak interactions, decays proceed via single W-boson exchange. Explain why the decay $\Sigma^- \rightarrow n + e^- + \bar{\nu}_e$ have been observed, while $\Sigma^+ \rightarrow n + e^+ + \nu_e$ - never. Σ^- has quark contents of (dds), and Σ^+ - (uus). Plot the quark diagram for the Σ^- decay.

2) Which of the following processes are allowed in electromagnetic, and which - in weak interactions? Consider only single boson exchange processes.

1. $\Sigma^- \rightarrow \pi^- + n$
2. $\Sigma^0 \rightarrow \Lambda + \gamma$
3. $B^+ \rightarrow K^+ + e^+ + e^-$
4. $K^+ \rightarrow \pi^0 + \mu^+ + \nu_\mu$

3) Using Feynman diagrams, show that the neutral meson mixing can occur not only in the case of neutral kaons, but also for neutral D mesons (D^0 ($\bar{u}c$) and $\bar{D}^0$ ($u\bar{c}$)) and neutral B mesons (B^0 ($d\bar{b}$) and $\bar{B}^0$ ($\bar{d}b$), as well as B_s^0 ($s\bar{b}$) and $\bar{B}_s^0$ ($\bar{s}b$)).

4) In February 1987, bursts of neutrino interactions associated with $\bar{\nu}_e$ were observed at both the *Kamioka* and the *IMB* detectors, which were built to detect proton decay. A few hours later, astronomers reported visual observation of the supernova SN1987A, approximately 1.5×10^5 light years away. Assuming that this event was the source of registered neutrino bursts, estimate an upper limit of the electron antineutrino mass, knowing that the incident neutrino energies covered the range 10-40 MeV and the interactions were observed to occur over a ~ 10 second period.