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Group:

Problem sheet 1 - Physics V - WS 2006/2007

Due: November 2/3, 2006

Problem 1.1 Particle processes (25P)

Which of the following particle reactions or decays are allowed, which are forbidden. Justify your answer by checking the relevant conservation laws. Are all of the processes kinematically allowed?

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| 1) $\pi^- p \rightarrow \pi^- p$ | 6) $p \rightarrow n e^+ \nu_e$ |
| 2) $\pi^- p \rightarrow \pi^- p n$ | 7) $K^0 \rightarrow \pi^- \pi^+$ |
| 3) $\pi^- p \rightarrow \pi^- p p \bar{n} \pi^-$ | 8) $K^+ \rightarrow \pi^- \pi^+ \pi^+$ |
| 4) $\nu_\mu n \rightarrow \mu^- p$ | 9) $K^0 \rightarrow \pi^- \pi^- \pi^+ \pi^+$ |
| 5) $\bar{\nu}_e p \rightarrow e^- p \pi^+$ | 10) $K^0 \rightarrow \pi^+ e^- \bar{\nu}_e$ |

Problem 1.2 Feynman diagrams (25P)

Draw the Feynman diagrams of lowest order for the following processes:

- $n \rightarrow p e^- \bar{\nu}_e$
- $\nu_e e^- \rightarrow \nu_e e^-$
- $\pi^0 \rightarrow \gamma \gamma$
- $e^+ e^- \rightarrow \mu^+ \mu^-$
- $\pi^- p \rightarrow K^0 \Lambda$

Mark the fermion lines with arrows. For hadrons use the quark level description. For processes 2) and 4) two lowest-order-graphs are possible.

Draw the Feynman diagrams of the process $e^+ e^- \rightarrow \mu^+ \mu^- \gamma$.

Problem 1.3 Discovery of the antiproton (30P)

In 1955 the Antiproton was observed in fixed target pp scattering experiments by the reaction $p + p \rightarrow p + p + p + \bar{p}$. What is the minimal energy (energy threshold) of the incoming proton beam to produce the additional $p\bar{p}$ pair?

Problem 1.4 Cross section (20P)

Consider a fixed target experiment with a proton beam of 10^6 particles per second on a 5 cm thick C_{12} target with a density of $\rho = 2.265 \text{ g cm}^{-3}$. Assume a cross section of $\sigma = 40 \text{ mb}$ for each target nucleon and that the cross section per nucleus is the sum of the cross section per nucleon.

- What is the mean free path length in the carbon target?
- Which percentage of the protons interact in the target?
- What is the interaction rate?