Problem Solving Class: Van Quark tot Biomaterie

Problem Set 13: Elementary Particles Hand-in on paper Monday 9 December (before 12:00 h) in Mailbox Madhu Talluri (Mailboxes W&N building) Hand-in digitally, email to: <u>m.t.talluri@vu.nl</u>; All documents in a single file [file: YourName-WC-P5] All answers in English

1) Feynman diagram for a reaction with elementary particles

Draw a Feynman-diagram for the reaction:

$$n + \nu_{\mu} \rightarrow p + \mu^{-}$$

at the quark level. Explain what the role of weakly interacting bosons is, and what boson is involved.

2) Particle reactions; forbidden or allowed

Specify (with reasons) what reactions are forbidden or allowed

$$\begin{aligned} \pi^- + p &\rightarrow K^+ + \Sigma^- \\ \pi^+ + p &\rightarrow K^+ + \Sigma^+ \\ \pi^- + p &\rightarrow \Lambda^0 + K^0 + \pi^0 \\ \pi^+ + p &\rightarrow \Sigma^0 + \pi^0 \\ \pi^- + p &\rightarrow p + e^- + \overline{\nu}_e \end{aligned}$$

3) Indentification of particles

Identify the missing particle in the reactions (and explain how and why):

$$p + p \rightarrow p + n + \pi^+ + ?$$

 $p + ? \rightarrow n + \mu^+$

4) Quark structure of particles

a) Show how to construct the 3/2+ Baryon multiplet of Gell-Mann in a symmetric manner using u, d and s quarks with properties as in the Table shown below. Use the Total amount of charge q, strangeness s. Note that baryons carry baryon number B=1.



q	=	_	1
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TABLE 43–3 Pro	operties of Quarks	(Antiquarks have opposite sign	Q, B, S, c, t, b)
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Quarks									
Name	Symbol	Mass (MeV/c ²)	Charge Q	Baryon Number B	Strangeness S	Charm c	Bottomness b	Topness t	
Up	u	2	$+\frac{2}{3}e$	$\frac{1}{3}$	0	0	0	0	
Down	d	5	$-\frac{1}{3}e$	$\frac{1}{3}$	0	0	0	0	
Strange	S	95	$-\frac{1}{3}e$	$\frac{1}{3}$	-1	0	0	0	
Charmed	с	1250	$+\frac{2}{3}e$	$\frac{1}{3}$	0	+1	0	0	
Bottom	b	4200	$-\frac{1}{3}e$	$\frac{1}{3}$	0	0	-1	0	
Тор	t	173,000	$+\frac{2}{3}e$	$\frac{1}{3}$	0	0	0	+1	

b) The quarks are Fermi-Dirac particles (fermions) so they obey the Pauli-principle. How then is it possible that some baryons are built from 3 equal quarks; what is the solution to this enigma ?