AKT II - Übung

Übungen Atom-, Kern- und Teilchenphysik II

H. Abele, J. Schieck, R. Schöfbeck, M. Zawisky

Übungstermine: Di FH – HS 3 12:30 – 14:00

VB: 5. 3. ab 12 Uhr
12. 3. , 19. 3., 26. 3., 2. 4., 9. 4., 30. 4., 7. 5., 14. 5., 21. 5., 28. 5,
4. 6., 18. 6., 25. 6

Übungsablauf:
Die Übungen dienen zur Vertiefung und Ergänzung des Stoffes der Vorlesung Atom-, Kern- und Teilchenphysik II. Die Übungsbeispiele werden vom Übungsleiter an der Tafel vorgestellt und von den Übungsteilnehmern als Hausaufgabe gerechnet.
Die Beurteilung erfolgt nach der Anzahl der gerechneten Beispiele und der Mitarbeit an der Tafel.

Buch: Thomson – Modern particle physics

Beispiele für die Übung am 12.3.2019

Feynman Diagramme:

1.1

1.4

Einheiten:

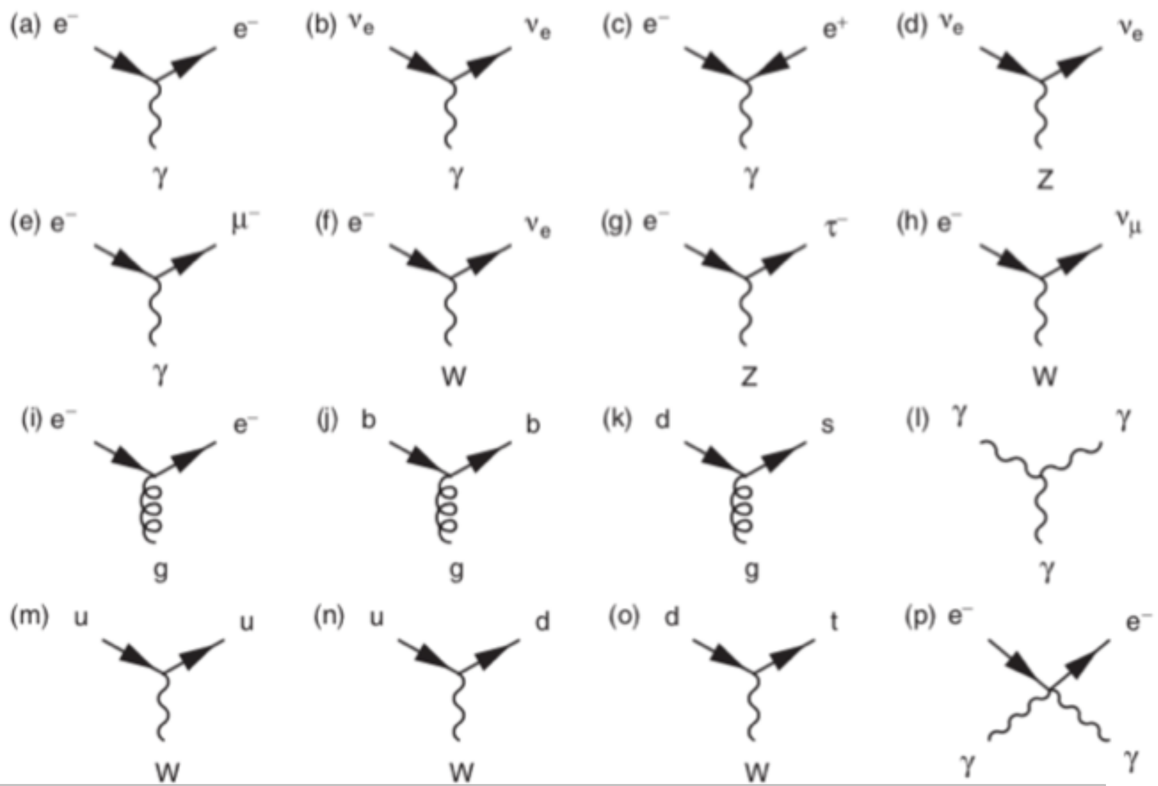
2.1

2.2

Spezielle Relativitaetstheorie:

2.3, 2..4, 2.6, 2.12, 2.13, 2.14

1.1 Feynman diagrams are constructed out of the Standard Model vertices shown in Figure 1.4. Only the weak charged-current ($W^{\pm}$) interaction can change the flavour of the particle at the interaction vertex. Explaining your reasoning, state whether each of the sixteen diagrams below represents a valid Standard Model vertex.



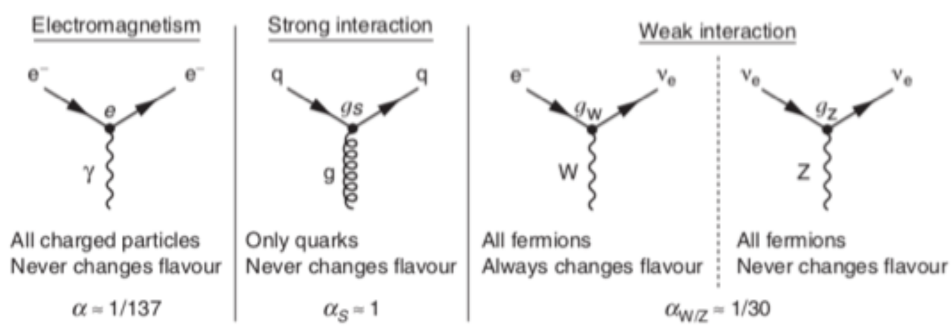


Fig. 1.4 The Standard Model interaction vertices.

1.4 Draw the Feynman diagrams for the decays:

(a) $\Delta^+(\mathrm{uud}) \to \mathrm{n}(\mathrm{udd})\,\pi^+(\mathrm{u\bar{d}})$,
(b) $\Sigma^0(\mathrm{uds}) \to \Lambda(\mathrm{uds})\,\gamma$,
(c) $\pi^+(\mathrm{u\bar{d}}) \to \mu^+\nu_\mu$,

and place them in order of increasing lifetime.

2.1 When expressed in natural units the lifetime of the W boson is approximately $\tau \approx 0.5\,\mathrm{GeV}^{-1}$. What is the corresponding value in S.I. units?

2.2 A cross section is measured to be 1 pb; convert this to natural units.

2.3 Show that the process $\gamma \to e^+e^-$ can not occur in the vacuum.

2.4 A particle of mass 3 GeV is travelling in the positive z-direction with momentum 4 GeV; what are its energy and velocity?

2.6 For the decay $a \to 1 + 2$, show that the mass of the particle a can be expressed as

$$m_a^2 = m_1^2 + m_2^2 + 2E_1E_2(1 - \beta_1\beta_2\cos\theta),$$

where β_1 and β_2 are the velocities of the daughter particles ($\beta_i = v_i/c$) and θ is the angle between them.

2.12 For the process $1+2 \to 3+4$, the Mandelstam variables s, t and u are defined as $s=(p_1+p_2)^2$, $t=(p_1-p_3)^2$ and $u=(p_1-p_4)^2$. Show that

$$s + u + t = m_1^2 + m_2^2 + m_3^2 + m_4^2.$$

2.13 At the HERA collider, 27.5 GeV electrons were collided head-on with 820 GeV protons. Calculate the centre-of-mass energy.

2.14 Consider the Compton scattering of a photon of momentum $\mathbf{k}$ and energy $E = |\mathbf{k}| = \mathrm{k}$ from an electron *at rest*. Writing the four-momenta of the scattered photon and electron respectively as k' and p', conservation of four-momentum is expressed as $k + p = k' + p'$. Use the relation $p'^2 = m_e^2$ to show that the energy of the scattered photon is given by

$$E' = \frac{E}{1 + (E/m_e)(1 - \cos\theta)},$$

where θ is the angle through which the photon is scattered.