Quantenfeldtheorie

Vorlesung: A. Lenz **SS 2010**

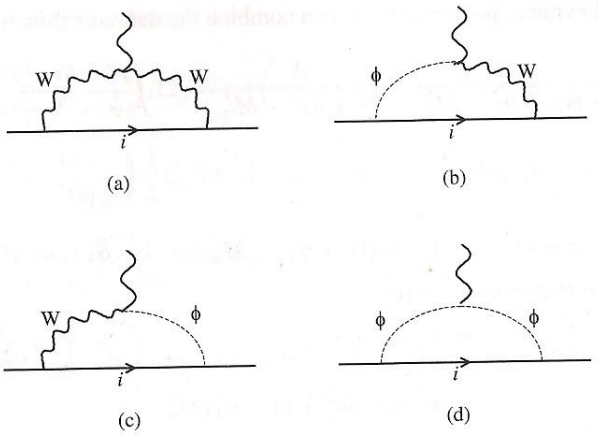
Übungen: C. Gross, S. Schacht **Blatt 13**

Aufgabe 21: *Branching ratio for $\mu \to e\gamma$ in the Standard Model with massive neutrinos*

a) Show that, in the approximation $m_e = 0$, the on-shell amplitude T for the process $\mu \to e\gamma$ has the form

$$T(\mu \to e\gamma) = A\bar{u}_e(p-q)(1+\gamma_5)(2p_\alpha \epsilon^\alpha - m_\mu \gamma_\alpha \epsilon^\alpha)u_\mu(p) \ .$$

b) Using the Feynman rules for spontaneously broken weak interaction gauge theory (these can be found in appendix B of the textbook *"Gauge theory of elementary particle physics"* by Cheng and Li), calculate the function A. Use Feynman–'t Hooft gauge $\xi = 1$. The following four diagrams contribute to A (the index i labels the 3 neutrinos):



c) Use the result you get to determine $BR(\mu \to e\gamma) \equiv \Gamma(\mu \to e\gamma)/\Gamma(\mu \to e\nu\bar{\nu})$. You should find

$$BR(\mu \to e\gamma) = \frac{3\alpha}{32\pi^2}(\delta_\nu)^2$$

where

$$\delta_\nu \equiv 2\sum_i U^*_{ei}U_{\mu i}\ g(m_i^2/m_W^2) \ .$$

Here, U is the PMNS matrix, α is the fine-structure constant and the function g is defined as

$$g(x) \equiv \frac{18\log(x)x^3 + (x-1)(x(x(4x-45)+33)-10)}{6(x-1)^4} \left(= \frac{5}{3} - \frac{x}{2} + \mathcal{O}(x^2)\right) \ .$$