Übungen zur Vorlesung

Theoretische Teilchenphysik

SS 08

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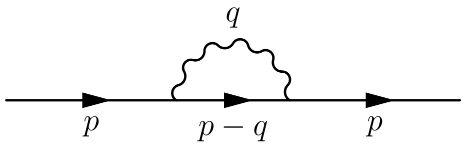
Blatt 11
07.07.08

Präsenz-Aufgabe 17 Electron Self-Energy

Calculate the electron self-energy at one loop

$$\Sigma^{\bar{e}e}(p) \;=$$



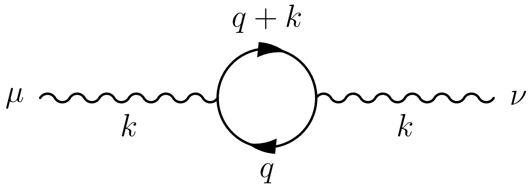
$$= \; ie^2\mu^{4-D}\int\frac{d^Dq}{(2\pi)^D}\frac{\gamma_\mu\left(\not{q}+m\right)\gamma^\mu}{\left[q^2-\lambda^2\right]\left[(q-p)^2-m^2\right]}. \qquad (1)$$

λ denotes in this context a photon mass which is introduced in order to regularize the soft divergence of this diagram. It does not appear in physical observables.

Hausaufgabe 12 Photon self-energy

Calculate the photon self-energy at one-loop level

$$\Sigma^{AA}_{\mu\nu}(k) \;=$$



$$= \; -ie^2\mu^{4-D}\int\frac{d^Dq}{(2\pi)^D}\frac{\mathrm{tr}\left[\gamma_\mu\left(\not{q}+m\right)\gamma_\nu\left(\not{q}+\not{k}+m\right)\right]}{\left[q^2-m^2\right]\left[(q+k)^2-m^2\right]}. \qquad (2)$$

(a) Evaluate the trace in the numerator and use the reduction formulas for the tensor integrals to show that

$$\Sigma^{AA}_{\mu\nu}(k) \;=\; \frac{\alpha}{\pi}\left\{g_{\mu\nu}\left[2B_{00}-A_0(M)+\frac{1}{2}k^2B_0\right]+k_\mu k_\nu\left[2B_{11}+2B_1\right]\right\}.$$

(b) Separate $\Sigma^{AA}_{\mu\nu}(k)$ into its longitudinal and transverse part

$$\Sigma^{AA}_{\mu\nu}(k) \;=\; \left(g_{\mu\nu}-\frac{k_\mu k_\nu}{k^2}\right)\Sigma^{AA}_T(k^2)+\frac{k_\mu k_\nu}{k^2}\Sigma^{AA}_L(k^2)$$

and show that

$$\Sigma^{AA}_T(k^2) \;=\; \frac{\alpha}{\pi}\left[(k^2+2m^2)B_0(k^2,m,m)-\frac{1}{3}k^2-2m^2B_0(0,m,m)\right] \qquad (3)$$

$$\Sigma^{AA}_L(k^2) \;=\; 0 \qquad (4)$$