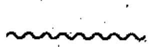
13.1 QED Feynman rules

The Feynman rules for QED can be read directly from the Lagrangian just as in scalar QED. The only subtlety is possible extra minus signs coming from anticommuting spinors within the time ordering. First, we write down the Feynman rules, then derive the supplementary minus sign rules.

A photon propagator is represented with a squiggly line:



$$= \frac{-i}{p^2 + i\varepsilon}\left[g_{\mu\nu} - (1-\xi)\frac{p_\mu p_\nu}{p^2}\right]. \tag{13.10}$$

Unless we are explicitly checking gauge invariance, we will usually work in Feynman gauge, $\xi = 1$, where the propagator is

$$= \frac{-ig_{\mu\nu}}{p^2 + i\varepsilon} \quad \text{(Feynman gauge)}. \tag{13.11}$$

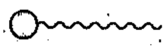
A spinor propagator is a solid line with an arrow:

$$= \frac{i(\not{p} + m)}{p^2 - m^2 + i\varepsilon}. \tag{13.12}$$

The arrow points to the right for particles and to the left for antiparticles. For internal lines, the arrow points with momentum flow.

External photon lines get polarization vectors:

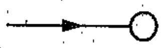
$$= \epsilon_\mu(p) \quad \text{(incoming)}, \tag{13.13}$$



$$= \epsilon^\star_\mu(p) \quad \text{(outgoing)}. \tag{13.14}$$

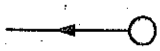
Here the blob means the rest of the diagram.

External fermion lines get spinors, with u spinors for electrons and v spinors for positrons.



$$= u^s(p), \tag{13.15}$$

$$= \bar{u}^s(p), \tag{13.16}$$



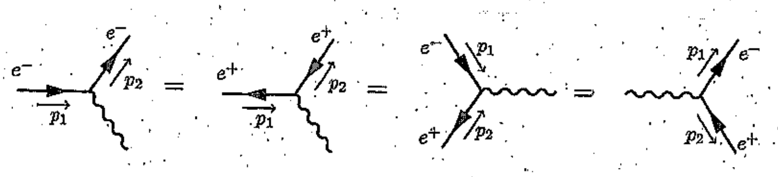
$$= \bar{v}^s(p), \tag{13.17}$$

$$= v^s(p). \tag{13.18}$$

External spinors are on-shell (they are forced to be on-shell by LSZ). So, for external spinors we can use the equations of motion:

$$(\not{p} - m)u^s(p) = \bar{u}^s(p)(\not{p} - m) = 0, \tag{13.19}$$

$$(\not{p} + m)v^s(p) = \bar{v}^s(p)(\not{p} + m) = 0, \tag{13.20}$$



$$= -ie\gamma^\mu.$$

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