

8.701

Introduction to Nuclear
and Particle Physics

Markus Klute - MIT

4. QED

4.6 Examples



Catalog of basic QED processes

Second-order processes

Elastic



{ Electron-muon scattering ($e + \mu \rightarrow e + \mu$)
(Mott scattering ($M \gg m$) \Rightarrow Rutherford scattering ($v \ll c$))



{ Electron-electron scattering ($e^- + e^- \rightarrow e^- + e^-$)
(Møller scattering)



{ Electron-positron scattering ($e^- + e^+ \rightarrow e^- + e^+$)
(Bhabha scattering)



{ Compton scattering ($\gamma + e^- \rightarrow \gamma + e^-$)

Inelastic



{ Pair annihilation ($e^- + e^+ \rightarrow \gamma + \gamma$)



{ Pair production ($\gamma + \gamma \rightarrow e^- + e^+$)

Most important third-order process

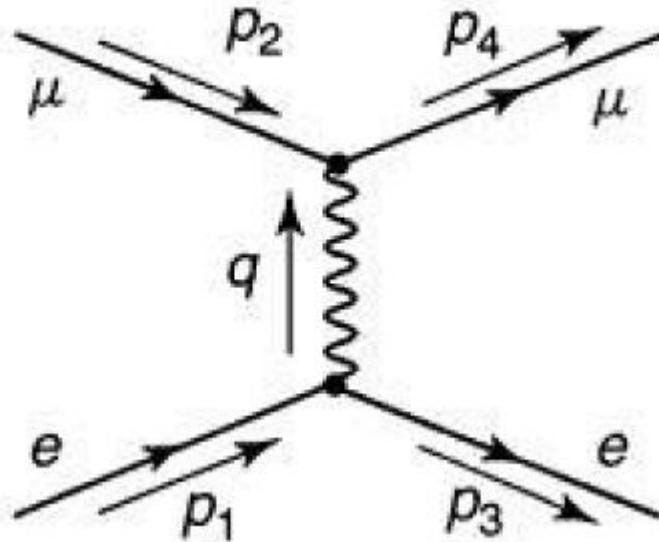


{ \Rightarrow Anomalous magnetic moment of electron

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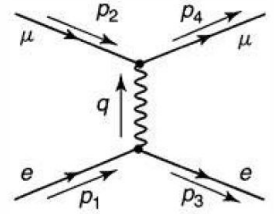
Electron-Muon Scattering

Only one diagram contributes in 2nd order



Electron-Muon Scattering

Applying the Feynman rules



$$(2\pi)^4 \int [\bar{u}^{(s_3)}(p_3)(ig_e\gamma^\mu)u^{(s_1)}(p_1)] \frac{-ig_{\mu\nu}}{q^2} [\bar{u}^{(s_4)}(p_4)(ig_e\gamma^\nu)u^{(s_2)}(p_2)] \\ \times \delta^4(p_1 - p_3 - q)\delta^4(p_2 + q - p_4) d^4q$$

Carrying out the q integration and dropping the delta functions

$$\mathcal{M} = -\frac{g_e^2}{(p_1 - p_3)^2} [\bar{u}^{(s_3)}(p_3)\gamma^\mu u^{(s_1)}(p_1)] [\bar{u}^{(s_4)}(p_4)\gamma_\mu u^{(s_2)}(p_2)]$$

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