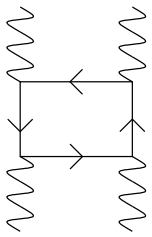
Physics 721, Fall 2006 Josh Erlich

Problem Set 6: Scattering

Due Thursday, November 30.

1. *Light-by-Light Scattering*

A phenomenon in QED that does not occur classically is light-by-light scattering. Label the quantum numbers of the ingoing and outgoing photons in the diagram below, and using the QED Feynman rules evaluate its contribution to the photon-photon scattering amplitude. You do not need to perform the loop integral.



How many independent Feynman diagrams contribute to light-by-light scattering at $\mathcal{O}(e^4)$ in the scattering amplitude?

2. *If the Photon Were a Scalar*

Imagine that electrons ψ_e and muons ψ_μ coupled to a massless scalar field ϕ instead of a massless photon, via an interaction term in the Lagrangian,

$$\mathcal{L} \supset -e\,\overline{\psi}_e\psi_e\phi - e\,\overline{\psi}_\mu\psi_\mu\phi.$$

a) What are the Feynman rules for this theory?

b) Calculate the differential cross section $d\sigma/d\Omega$ for unpolarized $e^+ + e^- \to \mu^+ + \mu^-$ scattering to lowest nontrivial order in the coupling e, summed over final state muon spins and averaged over initial state electron spins. Since the muon is around 200 times heavier than the electron, you may simplify your calculation by approximating the electron as being massless.

You may find it useful to follow the calculation of the cross section for the same reaction in QED, as in Peskin & Schroeder, section 5.1.

c) Simply by measuring this cross section could you determine the spin of the particle exchanged by the fermions?