Particle Physics 2 : Exercise 10

1) Gauge bosons polarisation

By considering the form of the polarisation four-vector for a longitudinally polarised massive gauge bosons, explain why the t-channel neutrino-exchange diagram for $e^+e^- \to W^+W^-$, when taken in isolation, is badly behaved at high centre-of-mass energies.

2) Euler-Lagrange equation

The Lagrangian for the Dirac equation is :

$$\mathcal{L} = i\bar{\psi}\gamma_\mu\partial^\mu\psi - m\bar{\psi}\psi,$$

Treating the eight fields ψ_i and $\bar{\psi}_i$ as independent, show that the Euler-Lagrange equation for the component ψ_i leads to

$$i\partial_\mu\bar{\psi}\gamma^\mu + m\bar{\psi} = 0$$

3) Higgs production cross section

Assuming a total Higgs production cross section of 20 pb and an integrated luminosity of 10 fb^{-1}, how many $\mathrm{H} \to \gamma\gamma$ and $\mathrm{H} \to \mu^+\mu^-\mu^+\mu^-$ events are expected in each of the ATLAS and CMS experiments ?
Use the predicted branching ratios of the Higgs boson at $m_\mathrm{H} = 125$ GeV : $BR(\mathrm{Z} \to \mu^+\mu^-) \approx 0.035$, $BR(\mathrm{H} \to \mathrm{ZZ}^*) \approx 0.027$ and $BR(\mathrm{H} \to \gamma\gamma) \approx 0.002$.

4) Higgs diagrams

Draw the lowest-order Feynman diagrams for the processes $e^+e^- \to \mathrm{HZ}$ and $e^+e^- \to \mathrm{H}\nu_e\bar{\nu}_e$, which are the main Higgs production mechanism at a future high-energy linear collider.

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