

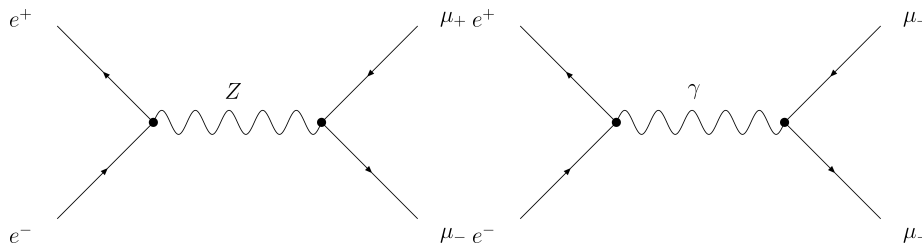
# Particle Physics Phenomenology II

FS 11, Series 5

Due date: 28.03.2011, 1 pm

**Exercise 1**  $e^+e^- \rightarrow \mu^+\mu^-$  with the Z-boson revisited

In the electroweak standard model, the following two diagrams contribute to  $e^+e^- \rightarrow \mu^+\mu^-$  at tree level:



Use your results of **Series 1** to compute the forward-backward asymmetry for this process for  $m_\mu^2 \ll s$ . Take into account the fact that the Z-boson is unstable, therefore  $p^2 - M_Z^2 \rightarrow p^2 - M_Z^2 + iM_Z\Gamma_Z$  in the propagator of the Z-boson.

Proceed as follows:

- i) Write the differential cross section  $\frac{d\sigma}{d\Omega}$  as

$$\frac{d\sigma}{d\Omega} = \frac{\alpha^2}{4s} [A_0 (1 + \cos^2 \Theta) + A_1 \cos \theta].$$

- ii) Show that the forward-backward asymmetry is given by

$$A = \frac{F - B}{F + B} = \frac{3A_1}{8A_0}$$

where

$$F = \int_{\cos\theta=0}^{\cos\theta=1} \frac{d\sigma}{d\Omega} d\Omega, \quad B = \int_{\cos\theta=-1}^{\cos\theta=0} \frac{d\sigma}{d\Omega} d\Omega.$$