Advance topics in particle physics: Assignment #2

Due 24/12/09

1. Assume a 5D theory with a compact extra dim’ on interval with fermion mass given by 
   \[ m^i_X = m_0(y - y_{X_i})/R \] (y is the 5D coordinate, \( 0 \leq y_{X_i} \leq \pi R \) is a flavor dependent constant, \( i = 1, 2, 3 \) being a flavor index and \( X \in Qu, U, D \)). In addition assume that the Higgs is a bulk field with a constant, flat VEV.
   (i) What is the resulting parametric structure for the 4D Yukawa matrices for \( m_0 R \ll 1 \)?
   (ii) Repeat this for \( m_0 R \gg 1 \). Could you identify an approximate low energy symmetry ?
   (iii) Show, in a parametric fashion, that the above set up can address the flavor puzzle.
   (iv) Estimate roughly a lower bound on the KK gluon mass [for case (iii)].
   (v) Can this model be probed directly at the LHC?

2. Assume a Higgsless 5D model where electroweak symmetry is broken via simple, Neumann and Dirichlet boundary conditions (BCs). Here we only refer to the electroweak gauge sector at tree-level.
   (i) First assume BCs which do not mix the 5D fields: What is the spectrum of the theory (match the inverse compactification scale to get the correct \( W \) mass)? What is \( \theta_W \)? What is the \( \rho \)-parameter?
   (ii) Find a set of BCs which results in a correct value for \( \theta_W \).
   (iii) Calculate the \( W, Z \) masses and the \( \rho \)-parameter for this case and compare with the SM tree-level value.
   (iv) Is the above model consistent with direct bounds?
   (v) Do these models preserve an approximate custodial symmetry? If not, could you find a way to incorporate an approximate custodial symmetry (answer qualitatively, no need to provide explicit calculations)?

3. Estimate the RS contribution to \( \epsilon_K \) and obtain a lower bound on the KK mass scale. Compare your result with the flat case.