Physikalisches Institut
Universität Bonn
Theoretische Physik

Exercise 10
29. Jun 2006
SS 06

Exercises on Elementary Particle Physics II

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Final exam: Monday July, 10th 2006 from 11.15 to 13.00 in HS1 PI

1. *Supergravity definitions*

   The Kähler potential $K(\Phi^i, \Phi_j^*)$ and the superpotential $W(\Phi^i)$ are combined to

   $$G(\Phi^i, \Phi_j^*) = -\frac{K(\Phi^i, \Phi_j^*)}{M^2} - \log\left(\frac{|W(\Phi^i)|^2}{M^6}\right).$$

   The F-term part of the scalar potential is given by:

   $$V_{\text{scalar}}(\phi^i, \phi_j^*) = -e^G \left[3 + G_k \left(G^{-1}\right)_l^k G^l\right] M^4,$$

   where ϕ denotes the scalar component of Φ and the derivatives are defined as

   $$G_i = \frac{\partial G}{\partial \phi^{*i}}, \quad G^j = \frac{\partial G}{\partial \phi_j}, \quad G_i^j = \frac{\partial^2 G}{\partial \phi^{*i} \partial \phi_j}$$

   Furthermore, the F^i component of the chiral superfield Φ^i (for constant gauge kinetic function f_{AB}) reads:

   $$F^i = W^i + \frac{1}{M^2} K^i W$$

2. *The Polonyi superpotential*

   Assume a minimal form for the Kähler potential $K(\Phi, \Phi^*) = \Phi^* \Phi$ and the following superpotential

   $$W(\Phi) = m^2(\Phi + \beta)$$

   with β a dimensionful parameter which we will use later to adjust the vacuum energy to zero.

   (a) Determine the F-term of Φ. For which values of β is SUSY definitely broken?

   (b) For which values of β is there a non-SUSY vacuum with zero energy?
   Calculate the vev of ϕ at those vacua.
   Hint: The solution should be $\langle \phi \rangle_\pm = \pm(\sqrt{3} - 1)M$ and $\beta_\pm = \pm(2 - \sqrt{3})M$.

   (c) Calculate the gravitino mass $m_{3/2} = e^{-G/2} M$. Express it in terms of the SUSY breaking scale $M_{\text{SUSY}}^2 = \langle e^{-G/2} \left(G^{-1}\right)_l^k G_k M \rangle$.