Universität Bonn
Physikalisches Institut
Theoretische Physik

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Example sheet 6
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Elementary Particle Physics II

Prof. Dr. H.-P. Nilles

Supergravity definitions

The Kähler potential

$$G(\Phi^*, \Phi) = -\frac{K(\Phi^*, \Phi)}{M^2} - \log\left(\frac{|W(\Phi)|^2}{M^6}\right), \tag{1}$$

the F-term part of the scalar potential

$$\mathcal{V}_{scal} = -e^{-G}\left[3 + G_k \left(G^{-1}\right)^k_l G^l\right] \cdot M^4, \tag{2}$$

and the F-terms themselves (for constant gauge kinetic function f_{AB}):

$$F^i \propto W^i + \frac{1}{M^2} K^i W. \tag{3}$$

The derivatives are defined as

$$G_i \equiv \frac{\partial G}{\partial \phi^{*i}}, \qquad G^j \equiv \frac{\partial G}{\partial \phi_j}, \qquad G^j_i \equiv \frac{\partial^2 G}{\partial \phi^{*i} \partial \phi_j}. \tag{4}$$

1. **Polonyi superpotential**

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

   $$W(\Phi) = m^2 (\Phi + \beta). \tag{5}$$

   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.
   (You should find $\langle\phi\rangle_\pm = \pm(\sqrt{3} - 1)M$ *and* $\beta_\pm = \pm(2 - \sqrt{3})M$*.)*

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