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Example sheet 7
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Elementary Particle Physics II

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Supergravity definitions

The Kähler potential

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

the scalar potential

$$\mathcal{V}_{scal} = -e^{-G}\left[3 + G_k\left(G^{-1}\right)_l^k G^l\right] + D\text{-}terms\,, \tag{2}$$

and the F-terms

$$F^i \propto W^i + K^i\, W\,. \tag{3}$$

1. **No-Scale Model**

   Take $N = 1$ supergravity with three chiral superfields S, T and C. The Kähler potential (with $M \equiv 1$) is

   $$K = -\log(S + S^*) - 3\log(T + T^* - C^*C)\,. \tag{4}$$

   The superpotential is

   $$W = C^3 + a\, e^{-\alpha S} + b\,, \tag{5}$$

   where a and b are arbitrary complex numbers and $\alpha > 0$. These additional terms will enable us to fix $\langle S\rangle$.

   (a) Find the auxiliary fields for S, T and C and check that SUSY is broken.

   (b) Calculate the scalar potential.

   (c) What is the value of the vacuum energy? Are there flat directions (where E_{vac} is independent of the VEV of a field)?

   (d) What is the gravitino mass?

2. **Dimensional reduction**

   (a) Reduce the field content of a $10d$ N=1 gauge multiplet to $4d$.
   How many supersymmetries result? What multiplet do you get?

   (b) Reduce the fields of $11d$ Supergravity (g_{MN}, Ψ_M, A_{MNP}) to $4d$.