Universität Bonn
Physikalisches Institut
Theoretische Physik

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Example sheet 3
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Elementary Particle Physics II

Prof. Dr. H.-P. Nilles

1. **Kinetic terms**

   (a) Write the chiral superfield

   $$\Phi_L(x,\theta) = \varphi(x) + \sqrt{2}\,\theta\psi(x) + \theta\theta\, F(x)\,, \tag{1}$$

   in the $\Phi(x^\mu, \theta, \bar{\theta})$ representation by shifting the coordinates according to this result from the previous sheet: $\Phi(x^\mu, \theta, \bar{\theta}) = \Phi_L(x^\mu + i\,\theta\sigma^\mu\bar{\theta}, \theta, \bar{\theta})$.

   (b) Calculate the $\theta\theta\bar{\theta}\bar{\theta}$ coefficient of $\Phi^\dagger\Phi$.

2. **F-term SUSY breaking**
   Take the superpotential

   $$W(\Phi_1, \Phi_2, \Phi_3) = \lambda\,\Phi_1\left(\Phi_3^2 - M^2\right) + \mu\,\Phi_2\Phi_3\,, \quad \text{with} \left(M^2 > \frac{\mu^2}{2\lambda^2}\right)\,. \tag{2}$$

   (a) Check that supersymmetry is broken because not all F_i can be zero simultaneously. *(Remember:* $F_i^\dagger = -\frac{\partial W}{\partial \phi_i}$*)*

   (b) What is the value of the potential $V = \sum |F_i|^2$ at the global minimum?
   What are the expectation values for the scalar fields at the minimum?

   (c) Identify the goldstino. What are the masses of the other fermions?
   (For a generic superpotential $W = \frac{1}{2}m_{ij}\Phi_i\Phi_j + \frac{1}{3}\lambda_{ijk}\Phi_i\Phi_j\Phi_k$*, the fermion mass part of the Lagrangian is* $\mathcal{L}_{m_f} = \left(-\frac{1}{2}m_{ij} - \lambda_{ijk}\langle\phi_k\rangle\right)\psi_i\psi_k + h.c.$*)*

   (d) What are the masses for the bosons?
   (The boson mass part of the Lagrangian is contained in $\mathcal{L}_b = -V$*.)*