Physikalisches Institut, Albert-Ludwigs-Universität Freiburg

Übungen zur Vorlesung

Supersymmetrie

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Blatt 5

Hausaufgabe 4 Wess-Zumino model

Compute $e^{\hat{V}_{WZ}}$ in the Wess-Zumino gauge with

$$\hat{V}_{WZ}(x,\theta,\bar{\theta}) = \left(\theta\sigma^\mu\bar{\theta}\right) A_\mu(x) + i\,(\theta\theta)\left(\bar{\theta}\bar{\lambda}(x)\right) - i\left(\bar{\theta}\bar{\theta}\right)(\theta\lambda(x)) + \frac{1}{2}(\theta\theta)\left(\bar{\theta}\bar{\theta}\right) D(x).$$

Hausaufgabe 5 Useful Identities

Using the fundamental (anti-) commutators show that

$$\begin{aligned}
[\bar{D}_{\dot{\alpha}}, \{\bar{D}_{\dot{\beta}}, D_\gamma\}] =& 0,\\
\frac{1}{2}[D_\alpha, \bar{D}_{\dot{\beta}}\bar{D}^{\dot{\beta}}] =& -2i\sigma^\mu_{\alpha\dot{\beta}}\partial_\mu \bar{D}^{\dot{\beta}},\\
\frac{1}{8}[D^2, \bar{D}^2] =& -iD^\alpha\sigma^\mu_{\alpha\dot{\alpha}}\bar{D}^{\dot{\alpha}}\partial_\mu - 2\Box\\
=& +i\bar{D}^{\dot{\alpha}}\bar{\sigma}^\mu_{\dot{\alpha}\alpha}D^\alpha\partial_\mu + 2\Box.
\end{aligned}$$

Präsenz-Aufgabe 5 R-Symmetry

Show that a Wess-Zumino model consisting of a single superfield $\hat{\Phi}$ with the superpotential

$$W(\hat{\Phi}) = \frac{m}{2}\hat{\Phi}^2 + \frac{g}{3}\hat{\Phi}^3$$

cannot be R-symmetrical.

Präsenz-Aufgabe 6 SUSY transformations of vector superfields

Let $\xi Q = \xi^\alpha\frac{\partial}{\partial\theta^\alpha} - i\left(\xi\sigma^\mu\bar{\theta}\right)\partial_\mu$ act on $\hat{V}_{WZ}$. Then add its hermitian conjugate in order to show that component fields of $\hat{V}_{WZ}$ transform under the SUSY transformation $\delta_\xi = \left(\xi Q + \bar{\xi}\bar{Q}\right)$ according to

$$\begin{aligned}
\delta_\xi A_\mu(x) &= i\left(\xi\sigma^\mu\bar{\lambda}(x) + \lambda(x)\sigma^\mu\bar{\xi}\right)\\
\delta_\xi\lambda(x) &= i\xi D(x) + (\sigma^{\mu\nu}\xi)\,F_{\mu\nu}(x)\\
\delta_\xi D(x) &= \bar{\xi}\bar{\sigma}^\mu\partial_\mu\lambda(x) - \xi\sigma^\mu\partial\bar{\lambda}(x),
\end{aligned}$$

where

$$\sigma^{\mu\nu} = \frac{1}{4}\left(\sigma^\mu\bar{\sigma}^\nu - \sigma^\nu\bar{\sigma}^\mu\right).$$