Physics Beyond the Standard Model — Exercise Sheet 5

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1. **SUSY QED** The Lagrangian of SUSY QED takes a particularly compact form if superspace notation is used. It can be written as

$$\begin{aligned}\mathcal{L}_{\mathrm{SQED}} &= \int d^4\theta \Big\{ \overline{\Phi}_L e^{2eQ_L V} \Phi_L + \overline{\Phi}_R e^{2eQ_R V} \Phi_R \\ &\quad + \Big[\Big(W + \frac{1}{16e^2} W^\alpha W_\alpha \Big) \delta^2(\overline{\theta}) + h.c. \Big] \Big\} \end{aligned} \tag{1}$$

where the so-called superpotential is given as

$$W = m\Phi_L \Phi_R \,. \tag{2}$$

Your task: Compute the Lagrangian in terms of component fields, starting from the superfield version above. The result is given on the lecture slides.

Use the following definitions:

A general chiral superfield Φ with component fields (A, ψ_α, F) has the expansion

$$\begin{aligned}\Phi(x,\theta,\overline{\theta}) &= A(x) + \sqrt{2}\;\theta\psi(x) + \theta\theta F(x) \\ &\quad - i\theta\sigma^\mu\overline{\theta}\partial_\mu A(x) - \frac{1}{4}\theta\theta\overline{\theta\theta}\partial^\mu\partial_\mu A(x) \\ &\quad - \frac{i}{\sqrt{2}}\;\theta\theta\overline{\theta}\overline{\sigma}^\mu\partial_\mu\psi(x). \end{aligned} \tag{3}$$

In SUSY QED, there are two concrete chiral superfields Φ_L and Φ_R; their component fields are denoted as $(\tilde{e}_L, \psi_{L\alpha})$ und $(\tilde{e}_R^\dagger, \psi_{R\alpha})$ (Note the "dagger" in $\tilde{e}_R^\dagger$).

The corresponding electric charges are $Q_L = -Q_R = -1$.

The vector superfield V has the component field expansion

$$V(x,\theta,\overline{\theta}) = \theta\sigma^\mu\overline{\theta}A_\mu + i\theta\theta\overline{\theta}\overline{\lambda}(x) - i\overline{\theta\theta}\theta\lambda(x) + \frac{1}{2}\theta\theta\overline{\theta\theta}D(x) \tag{4}$$

The field strength superfield W_α has the component field expansion

$$W_\alpha = -2ie\lambda_\alpha + 2e\theta_\alpha D - \;{}_\alpha(\sigma^\mu\overline{\sigma}^\nu\theta)ieF_{\mu\nu} - 2e\theta\theta\;{}_\alpha(\sigma^\mu\partial_\mu\overline{\lambda}). \tag{5}$$