PHY 801: SUSY - Spring 2008

Homework 3

Due March 28, 2008

1. Show that the Wess Zumino Model corresponds to the superpotential:

$$f(\hat{\mathcal{S}}_L) = \frac{1}{2} m \hat{\mathcal{S}}_L^2 + \frac{1}{3} g \hat{\mathcal{S}}_L^3$$

a) Derive the Lagrangian in terms of the component fields $\mathcal{S}, \psi_L, \mathcal{F}$.

b) Next rewrite the Lagrangian in terms of the fields A, B, ψ, F, G, where

$$\begin{aligned} \mathcal{S} &= \frac{1}{\sqrt{2}} (A + iB) \\ \psi_L &= \frac{1-\gamma_5}{2} \psi \\ \mathcal{F} &= \frac{1}{\sqrt{2}} (F + iG) \end{aligned}$$

where ψ is Majarona. Show that you reproduce Eqs. (3.1c) and (3.43) of Baer and Tata.

c) Going back to part (a), find the equations of motion for $\mathcal{F}$, $\mathcal{F}^\dagger$, and eliminate them from the Lagrangian. This yields the analogue of Baer and Tata (3.45).

2. Starting from the curl superfield $\hat{W}_A$ in the Wess Zumino gauge, Eq. (6.31) in Baer and Tata, show that $\overline{\hat{W}_A^c}$ is given by their Eq. (6.32).

3. Show that the term that we drop in the derivation of the gauge kinetic term, i.e.,

$$\frac{1}{4} \epsilon^{\nu\mu\mu'\nu'} F_{A\mu\nu} F_{A,\mu'\nu'}$$

is a total derivative.

4. Consider a simple model with a single left-chiral superfield $\hat{\mathcal{S}}_L$ with a superpotential

$$f(\hat{\mathcal{S}}_L) = \alpha + \beta \hat{\mathcal{S}}_L + \gamma \hat{\mathcal{S}}_L^2 + \delta \hat{\mathcal{S}}_L^3$$

where $\alpha, \beta, \gamma, \delta$ are real constants.

a) Evaluate the scalar potential $V(\mathcal{S})$. Find the value of $< \mathcal{S} >$ that minimizes the potential. What is $V(< \mathcal{S} >)$? Is SUSY broken or unbroken?

b) Expand around the minimum of the potential $s \equiv \mathcal{S} - < \mathcal{S} >$. What is the mass of the s particle?

c) Evaluate the mass of ψ_L. Is it the same as the mass of s? Why does this make sense?