

Problem Set 2

Physics 487

Due May 27

Some abbreviations: WB - Wess and Bagger

1. WB p.49 problem 4.
2. WB p.50 problem 7 (It's good for the spirit!).
3. WB p.60 problem 6.
4. WB p.238 problem 3, 4 and 5.
5. We have seen that supersymmetry breaking can only occur if the superpotential is nongeneric, meaning that a generic small change will restore supersymmetry. In this exercise you show that adding nonrenormalizable terms to the superpotential of the O'Raifeartaigh model leaves supersymmetry broken, as long as they respect the symmetries of the model. Find the general (not necessarily renormalizable) superpotential with three superfields Φ_1, Φ_2, Φ_3 , where there is an R symmetry with respective charges 2, 2, 0 and a discrete symmetry that flips the sign of Φ_2 and Φ_3 . Show that generically it does break supersymmetry. Show that if you add in the nonrenormalizable term $\Phi_2^2\Phi_3^2$ (which does not respect the R symmetry) then supersymmetry is restored.

6. Consider a theory with chiral superfields, Φ_i , no gauge fields, and a superpotential $W(\Phi)$. You can assume that W is renormalizable, cubic, but it is just as easy to leave it general. Suppose that the potential has a minimum at some point \hat{A} in field space. Linearize the field equations for the scalars near that point, and show that you get a Klein-Gordon equation with a mass-squared matrix. Express the matrix in terms of the derivatives of W at \hat{A} . Find the linearized field equation for the fermions. Show that by squaring it, you again get a Klein-Gordon equation with a mass-squared matrix.

Show that if SUSY is unbroken ($\frac{\partial W}{\partial \Phi_i} = 0$ at \hat{A}) then the fermionic and bosonic equations are the same. Show that otherwise they are different. But show that in all cases the eigenvalues satisfy

$$\sum_{\text{bosons}} m^2 = \sum_{\text{fermions}} m^2 .$$