- p. 10
  vector supermultiplet 是否有 chirality?
  Ans:

- p. 10
  Define chirality
  Ans: 見 backup p. 51

- p.12
  為什麼 Higgs mass 的修正來自於 fermions 和 scalars?
  Ans:

- p. 14
  change slope $\sim 10^4$ GeV 的原因是什麼?
  Ans: 使用不同的 model. Baer 回答：The RGEs change when one transitions from the SM to the MSSM. See Ch. 9.2 of Weak Scale Supersymmetry

- p. 19
  ϵ is a spinor and $\epsilon^\dagger$ is the hermitian conjugate of ϵ ，那麼為什麼 $\delta\phi^* = \epsilon^\dagger\psi^\dagger$ 而不是 $\psi^\dagger\epsilon^\dagger$?
  Ans:

$$\underbrace{\Psi^\dagger_{\dot\alpha}}_{R} \equiv (\underbrace{\Psi_\alpha}_{L})^\dagger = (\Psi^\dagger)_\alpha, \quad (\underbrace{\Psi^{\dagger\dot\alpha}}_{R})^\dagger = \Psi^\alpha, \quad \overline{\Psi}_{\dot\alpha} = (\Psi_\alpha)^*$$

$$\xi^\dagger\chi^\dagger = \chi^\dagger\xi^\dagger = (\xi\chi)^*$$

$$\xi^\dagger\overline{\sigma}^\mu\chi = -\chi\sigma^\mu\xi^\dagger = (\chi^\dagger\overline{\sigma}^\mu\xi)^* = -(\xi\sigma^\mu\chi^\dagger)^*$$

只是使用 complex conjugate，若是量子場時才使用 hermitian conjugage.

$$(\psi\chi)^\dagger = \overline{\chi}_{\dot\alpha}\overline{\psi}^{\dot\alpha} = (\chi\psi)^* = \overline{\chi}\overline{\psi} = \overline{\psi}\overline{\chi}$$

$$\delta\phi = \epsilon\psi \to (\delta\phi)^* = (\epsilon\psi)^* = \epsilon^\dagger\psi^\dagger$$

- p. 20
  $\delta\psi_\alpha = -i(\sigma^\mu\epsilon^\dagger)_\alpha\partial_\mu\phi + \epsilon_\alpha\mathcal{F}$
  $\delta\psi^\dagger_{\dot\alpha} = i(\epsilon\sigma^\mu)_{\dot\alpha}\partial_\mu\phi^* + \epsilon^\dagger_{\dot\alpha}\mathcal{F}^*$

  其中的 $\sigma^\mu\epsilon^\dagger$ 和 $\epsilon\sigma^\mu$ 的順序為什麼不同？
  Ans:

$$\begin{aligned}\delta\psi_\alpha &= -i(\sigma^\mu\epsilon^\dagger)_\alpha\partial_\mu\phi + \epsilon_\alpha\mathcal{F}\\ \Rightarrow (\delta\psi_\alpha)^\dagger &= \big[-i(\sigma^\mu\epsilon^\dagger)_\alpha\partial_\mu\phi + \epsilon_\alpha\mathcal{F}\big]^\dagger\\ &= +i\big[(\sigma^\mu\epsilon^\dagger)_\alpha\partial_\mu\phi\big]^\dagger + (\epsilon_\alpha\mathcal{F})^\dagger\end{aligned}$$

其中 $(\epsilon_\alpha \mathcal{F})^\dagger = \mathcal{F}^\dagger (\epsilon_\alpha)^\dagger = \mathcal{F}^\dagger \epsilon^\dagger_{\dot\alpha} = \epsilon^\dagger_{\dot\alpha} \mathcal{F}^\dagger = \epsilon^\dagger_{\dot\alpha} \mathcal{F}^*$ (因為 $\mathcal{F}$ 是 scalar field，所以 $\mathcal{F}^\dagger = \mathcal{F}^*$)

$$\begin{aligned}\left[(\sigma^\mu \epsilon^\dagger)_\alpha \partial_\mu \phi\right]^\dagger &= (\partial_\mu \phi)^\dagger \left[(\sigma^\mu \epsilon^\dagger)_\alpha\right]^\dagger \\ &= \partial_\mu \phi^* (\sigma^\mu \epsilon^\dagger)^\dagger_{\dot\alpha} \\ &= (\sigma^\mu \epsilon^\dagger)^\dagger_{\dot\alpha} \partial_\mu \phi^* \\ &= \left[\epsilon (\sigma^\mu)^\dagger\right]_{\dot\alpha} \partial_\mu \phi^* \\ &= (\epsilon \sigma^\mu)_{\dot\alpha} \partial_\mu \phi^*\end{aligned}$$

其中 $(\sigma^\mu)^\dagger = \sigma^\mu$，列出 $\mu = 0, 1, 2, 3, 4$ 就知道了.
所以 $(\delta\psi_\alpha)^\dagger = \delta\psi^\dagger_{\dot\alpha} = i(\epsilon\sigma^\mu)_{\dot\alpha} \partial_\mu \phi^* + \epsilon^\dagger_{\dot\alpha} \mathcal{F}^*$

- p. 21
  查 closure 的定義.
  Ans:

- p. 26
  $\overline{\theta}\overline{\sigma}^\mu \theta v_\mu$ 項，為什麼要有 $\overline{\sigma}^\mu$？v_μ 是什麼？
  建議用 θ^2 取代 $\theta\theta$.
  Ans:

$$\overline{\theta}\overline{\sigma}^\mu \theta = \overline{\theta}_{\dot\alpha} (\overline{\sigma}^\mu)^{\dot\alpha\alpha} \theta_\alpha$$

  其中 $(\overline{\sigma}^\mu)^{\dot\alpha\alpha} = (1, +\sigma_i)^{\dot\alpha\alpha}$，不能直接乘，因為一個是 $\dot\alpha$ 另一個是 α.
  v_μ 是 A_μ (gauge boson field).

- p. 27
  為什麼 Q 中會有 σ?
  Ans: 見 Theis P9 的推導.

- p. 32
  $\sqrt{2}$ 一直出現，為什麼？
  Ans: Bilal P.21: normalization of fields and the definition of $\delta\phi$
  Martin P.20: Historical reason. Lykken P.20: convension.

- p. 33
  Define C, D, M, .
  real scalars 用 real scalar fields 取代.
  Ans: C 是 scalar field, D 是 real 的輔助場 D_a (gauge auxiliary field), λ 是 gaugino field. $\frac{i}{2}(M + iN)$ 是 $\mathcal{F}$, $-\frac{i}{2}(M - iN)$ 是 $\mathcal{F}^*$.

- p. 35
  V_{WZ} 是否仍然是 invariant？
  Ans:

- p. 41
  M, m 是什麼？

Ans: M is mass.
Fermion mass term:

$$-\frac{1}{2}\psi_i\langle\frac{\partial^2 W}{\partial\phi_i\partial\phi_j}\rangle\psi_j$$

e.g. $\langle\phi_1\rangle = 0 \Rightarrow M_{\psi 2} = M_{\psi 3} = M, \quad M_{\psi 1} = 0$.
scalar mass $V = W^i W_i^* \Rightarrow M_{\phi 1} = 0, M_{\phi 2} = M$，$\phi_3$ 是 complex field $\frac{1}{\sqrt{2}}(a+ib)$.

$$m_a^2 = M^2 - 2g^2m^2, m_b^2 = M^2 + 2g^2m^2.$$

- p. 44
  有兩個 Higgs doublet，那麼哪一個是 Standard Model 的 Higgs?
  Ans: 是 h_0.
  8 個 Higgs state 在 symmetry breaking 後，其中 3 個形成 $W^\pm$, Z^0, 5 個形成 A_0, h_0，H_0，$H^\pm$.
  A_0: pseudoscalar，由 $(\Im\frac{H_u^0}{\sqrt{2}}, \Im\frac{H_d^0}{\sqrt{2}})$ 形成,
  h_0, H_0: neutral scalar，由 $(\Re\frac{H_u^0}{\sqrt{2}}, \Re\frac{H_d^0}{\sqrt{2}})$ 形成,
  h_0 是接近 SM Higgs 質量的.

- p. 60
  查 W^0 和 B^0 如何 mix 成 Z^0 和 γ? (Griffiths 的粒子物理課本可能有答案)
  Ans:

$$A_\mu = B_\mu \cos\theta_W + W_\mu^3 \sin\theta_W$$
$$Z_\mu = -B_\mu \sin\theta_W + W_\mu^3 \cos\theta_W$$

  其中 $\theta_W = 28.75°$ is weak mixing angle.

- p. 61
  Hypercharge 的定義是什麼?
  Ans: Y = S + A, S = strangeness, A = baryon number, 見 backup 66, $H_u : Y = \frac{1}{2}, H_d : Y = -\frac{1}{2}, T_3 = \frac{1}{2}$ or $-\frac{1}{2}$.

- p. 63
  $\tilde{\bar{t}}\tilde{t}H_u^0 - \tilde{\bar{t}}_L\tilde{b}_L H_u^+$ 第二項代表什麼？
  Ans: 是 stop 和 sbottom 的 coupling term. H_u^0 only neutral Higgs has VEV $\neq$ 0.