Composite Lepto-/Di-quarks

Ben Gripaios

CERN TH

September 2010

BMG, arXiv:0910.1789

BMG, Papaefstathiou, Sakurai, & Webber, to appear

Outline

Motivations

Strong EWSB and FCNC

Natural hierarchy $\Longrightarrow$ $d[\mathscr{O}] \gtrsim 4$

Two ways to get fermion masses:

- Bi-linear:
$$\mathscr{L} = y f_L \mathscr{O}_H f_R, \;\; \mathscr{O}_H \sim (1,2)_{\frac{1}{2}}$$
- Linear:
$$\mathscr{L} = y_L f_L \mathscr{O}_R + y_R f_R \mathscr{O}_L + g \mathscr{O}_L \mathscr{O}_H \mathscr{O}_R, \;\; \mathscr{O}_R \sim (3,2)_{\frac{1}{6}}$$

D. B. Kaplan, 1991

Bi-linear fermion masses

$$\mathscr{L} = \frac{f_L \mathscr{O}_H f_R}{\Lambda_F^{d-1}} + \frac{f_L f_R f_L f_R}{\Lambda_F^2}$$

$$\text{FCNC} \implies \Lambda_F \gtrsim 10^{3-4}\, TeV \implies d \lesssim 1.2 - 1.3$$

- RS: $d \to \infty$
- TC: $d \sim 3$
- WTC: $d \sim 2$
- SM: $d \sim 1$ (but then $d[\mathscr{O}_H^\dagger \mathscr{O}_H] \sim 2$)

Strassler, 0309122

Luty & Okui, 0409274

Rattazzi, Rychkov & Vichi, 0807.0004

Rychkov & Vichi, 0905.2211

Linear fermion masses

$$\mathscr{L} = y_L f_L \mathscr{O}_R + y_R f_R \mathscr{O}_L + g \mathscr{O}_{L,R} \mathscr{O}_H \mathscr{O}_{L,R}$$

D. B. Kaplan, 1991

- $\mathscr{O}_{L,R}$ can be relevant
- Flavour can be decoupled
- $y_f \sim \frac{y_L y_R}{g_\rho}$
- RS-GIM

Gherghetta & Pomarol, 0003129

Huber & Shafi, 0010195

Agashe, Perez & Soni, 0406101

Agashe, Perez & Soni, 0408134

Agashe, Contino & Pomarol, 0412089

Linear fermion masses II

- Flavour $\Longrightarrow$ fermion masses arise linearly
$$\mathscr{O}_R \sim (3,2)_{\frac{1}{6}}$$
- EWSB sector coloured
- Coloured 'baryons'. Coloured 'mesons'?
- TeV Lepto- or di-quarks
- Unification $\Longrightarrow$ lepto- or di-quarks

BMG, 0910.1789

Constraints

Aren't TeV leptoquarks already ruled out?

Leptoquark Constraints

- Many stringent constraints on λ_{LQ}^2/M^2

  Bailey, Davidson & Campbell, 9309310

- $\mu \to e\gamma, \tau \to \mu\gamma, B_d \to K\mu\mu$
- Natural suppression $\lambda_{LQ} \sim \frac{y_L y_Q}{g_\rho}$

LQ Constraints II

- Many stringent constraints on λ_{LQ}^2/M^2
- What is M?
- $M \sim TeV$
- or $M \sim 300 GeV$ if PNGB
- Ok if LQs are chiral

Tevatron LQ Constraints

- Searched in $2b2\tau$ and $2b + \not{E}_T$
- $M > 220 GeV$ or $M > m_t$

Di-quark constraints?

Searches

LHC LQ searches

- Leptoquarks pair-produced by gluon interactions
- Decay exclusively to third generation fermions
- $t\tau$ or $t\nu_\tau$ or $b\tau$ or $b\nu_\tau$
- 10 pairwise channels

LHC LQ searches

- Third generation LQs added to Herwig++
- Search strategies suggested in all channels
- Tops/taus/missing energy
- Reconstruction issues

BMG, Papaefstathiou, Sakurai, & Webber, to appear

Di-quark searches?

Summary

- Flavour in strong EWSB
- Composite lepto-/di-quarks
- Natural suppression of flavour
- LHC searches …