Beyond the Minimal Composite Higgs Model

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CERN TH

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BMG, A. Pomarol, F. Riva, J. Serra, JHEP 0904:070, arXiv:0902.1483

BMG, JHEP 1002:045, arXiv:0910.1789

Outline

Strong EWSB and its problems

The Minimal Composite Higgs Model

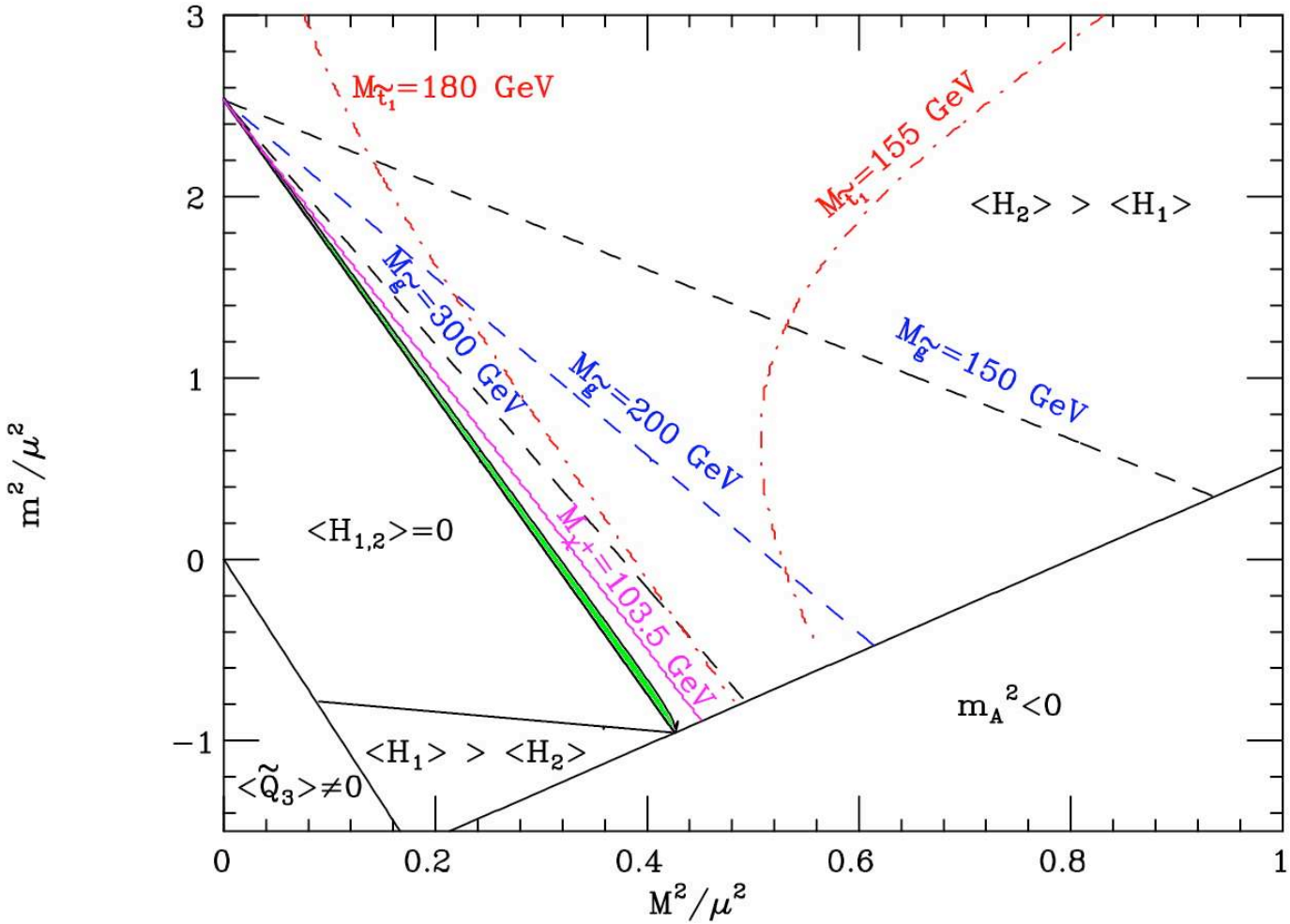
Beyond the Minimal Composite Higgs Model

Why strong EWSB?

Why *not* weak EWSB?

What about the hierarchy?

If SUSY, why haven't we seen any superpartners yet?



Giudice and Rattazzi, 0606105

Why strong EWSB?

- A natural hierarchy, *cf.* QCD

Why *not* strong EWSB?

- Electroweak precision tests
- Flavour changing neutral currents

Strong EWSB and FCNC

Two ways to get fermion masses:

(i) Bi-linearly: $\mathscr{L} \subset \frac{f_L \mathscr{O}_H f_R}{\Lambda_F^{d-1}}$

- $\mathscr{L} \subset \frac{f_L f_R f_L f_R}{\Lambda_F^2}$
- FCNC $\Longrightarrow \Lambda_F \gtrsim 10^{3-4}\, TeV \Longrightarrow d \lesssim 1.2 - 1.3$

Strassler, 0309122

Luty & Okui, 0409274

- This seems to be impossible

Rattazzi, Rychkov & Vichi, 0807.0004

Rychkov & Vichi, 0905.2211

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Two ways to get fermion masses:

(ii) Linearly: $\mathscr{L} \subset y_L f_L \mathscr{O}_R + y_R f_R \mathscr{O}_L + g \mathscr{O}_L \mathscr{O}_H \mathscr{O}_R$

D. B. Kaplan, 1991

- Relevant operators
- Flavour can be decoupled
- RS-GIM

Gherghetta & Pomarol, 0003129

Huber & Shafi, 0010195

Agashe, Perez & Soni, 0406101

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Agashe, Contino & Pomarol, 0412089

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Strong EWSB and EWPT:

Contributions to EWPT $\sim \frac{m_W^2}{m_\rho^2}$ are too large.

Strong EWSB and EWPT:

The lagrangian we know and love:

$$\mathscr{L} = \Pi_{+-} W^+ W^- + \Pi_{33} W^3 W^3 + \Pi_{3Y} W^3 B + \Pi_{YY} BB$$

- $\Pi(q^2) = \Pi(0) + q^2 \Pi'(0) + \ldots$
- $\Pi_{+-} - \Pi_{33} \sim T$
- $\Pi'_{3Y} \sim S$

Peskin & Takeuchi, 1990; 1992

- Can we make these $\ll m_W^2/m_\rho^2$?

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Strong EWSB and EWPT: T

Enlarge the global symmetry of the strong sector:

$$\frac{SU(2)_L \times U(1)_Y}{U(1)_Q} \longrightarrow \frac{SU(2)_L \times SU(2)_R}{SU(2)_V} = \frac{SO(4)}{SO(3)}$$

Sikivie, Susskind, Voloshin & Zakharov, 1980

- $T \sim \Pi_{+-} - \Pi_{33}$ is **5** of $SU(2)_V$

Strong EWSB and EWPT: S

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$\ldots$ except $SU(2)_L \times U(1)_Y$.

Inami, Lim & Yamada, 1992

- $\Longrightarrow S \sim v^2/\Lambda^2$
- Put back Higgs: $SO(4)/SO(3) \to SO(5)/SO(4)$
- v/Λ dynamical

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Global symmetry $SO(5)/SO(4)$ Agashe, Contino & Pomarol, 0412089

- Light d. o. f.: SM Higgs
- $m_\rho \sim 3\,TeV$
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Why stop at the minimal model?

Beyond MCHM

What about $SO(6)/SO(5)$, for example?

BMG, A. Pomarol, F. Riva, J. Serra, 0902.1483

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What else?

- Flavour $\Longrightarrow$ fermion masses arise linearly
- EWSB sector carries colour charge.
- Coloured baryons $\Longrightarrow$ Coloured mesons?
- TeV -scale, composite leptoquarks
- LHC decays: $2b$ or $2t$ and 2τ or 2ν

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- Let the LHC decide

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