The nature of the electroweak Higgs sector

Discrete 2008, December 11-16 Valencia (Spain)

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December 13, 2008

Outline

The outline of this talk is

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- The Standard Model
- Supersymmetry
- Little Higgs
- Gauge-Higgs unification
- Unhiggs
- Conclusion

Standard Model

- In the Standard Model the electroweak symmetry is spontaneously broken by the Higgs mechanism where an $SU(2)_L$ doublet Higgs boson is needed

Higgs mechanism

$$H = \begin{pmatrix} H^+ \\ H^0 \end{pmatrix},\ \mathcal{L}_{Higgs} = |D_\mu H|^2 - \frac{\lambda}{2}\left[|H|^2 - \frac{v^2}{2}\right]^2 + \mathcal{L}_Y$$

- The term $|D_\mu H|^2$ gives a mass to gauge bosons W and Z which absorb the Goldstone bosons H^+ and ImH^0
- The term $\mathcal{L}_Y$ gives a mass to SM fermions
- The Higgs can "regularize" the bad UV behaviour of gauge bosons with longitudinal polarization

$$\epsilon_L^\mu \simeq \frac{p^\mu}{M_V}$$

Unitarity bound

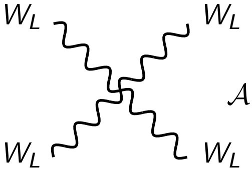
The Higgs unitarizes the scattering of longitudinal gauge bosons

Partial wave decomposition

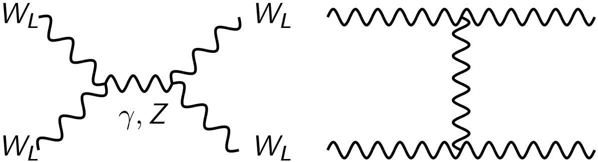
$$\mathcal{A} = 16\pi \sum_{\ell} (2\ell+1) P_\ell(\cos\theta) a_\ell, \quad \sigma = \frac{16}{\pi} \sum_{\ell} (2\ell+1) |a_\ell|^2$$

Optical theorem

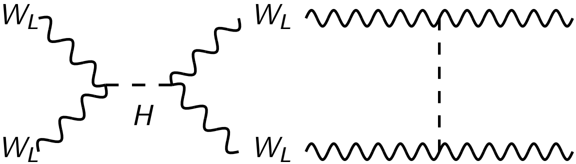
$$\sigma = \frac{1}{s} Im\mathcal{A}(\cos\theta = 1) \Rightarrow Im(a_\ell) = |a_\ell|^2 \Rightarrow Re(a_\ell)| \leq \frac{1}{2}$$



$$\mathcal{A} \propto g^2 \frac{s^2}{M_W^4} \Rightarrow s \leq M_W^2$$

+


$$a_0 = \frac{g^2 s}{16\pi M_W^2} \Rightarrow \sqrt{s} \leq 1.7\, TeV$$

+


$$a_0 = \frac{g^2 m_H^2}{64\pi M_W^2} \Rightarrow m_H \leq 1.2\, TeV$$

Including the ZZ scattering one gets

$$m_H \leq 780 \;\; GeV$$

Theoretical constraints

- The Higgs mass

$m_H^2 = 2\lambda v^2$ is an independent parameter in the SM.

- Loop corrections to the λ parameter

RGE

$$8\pi^2 \frac{d\lambda}{d\log\Lambda} = 3(4\lambda^2 + 2h_t^2\lambda - h_t^2) + \ldots$$

produce two bounds on m_H for a given scale Λ

- For large values of λ (large Higgs masses) there is a Landau pole for some value of Λ: triviality bound
- For small values of λ (small Higgs masses) the quartic coupling becomes negative for some value of Λ: stability bound

Triviality bounds

- For large Higgs masses RGE are dominated by

$$8\pi^2 \frac{d\lambda}{d\log\Lambda} \simeq 12\lambda^2$$

and λ increases with Λ

$$\lambda(\Lambda) \simeq \frac{m_H^2}{2v^2 - \frac{3m_H^2}{2\pi^2} m_H^2 \log\frac{\Lambda}{v}}$$

- For fixed Λ there is a lower bound on the Higgs mass

$$m_H^2 \leq \frac{4\pi^2 v^2}{3\log(\Lambda/v)}$$

- For fixed m_H there is an upper bound on Λ

$$\Lambda \leq v\exp(4\pi^2 v^2/3m_H^2)$$

Stability bounds

- For small Higgs masses RGE are dominated by

$$8\pi^2 \frac{d\lambda}{d\log\Lambda} \simeq -3h_t^4$$

and λ decreases with Λ

$$\lambda(\Lambda) \simeq \lambda - \frac{3}{8\pi^2} h_t^4 \log\frac{\Lambda}{v}$$

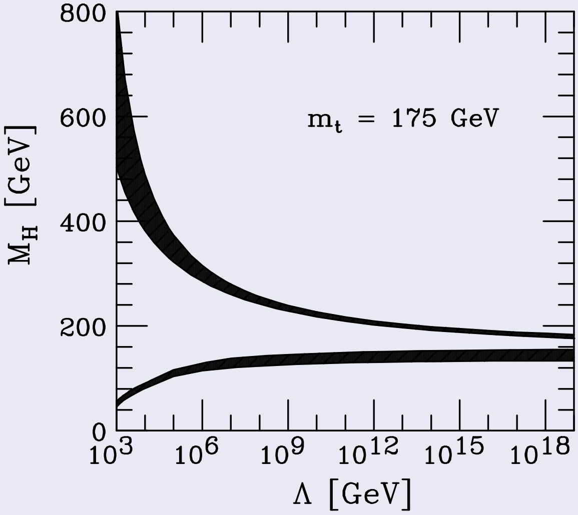
- When $\lambda(\Lambda) < 0$ the potential is unbounded from below
- For fixed Λ there is a lower bound on the Higgs mass

$$m_H^2 \geq \frac{3h_t^2 m_t^2}{2\pi^2} \log\frac{\Lambda}{v}$$

- For fixed m_H there is an upper bound on Λ

$$\Lambda \leq v \exp(2\pi^2 m_H^2 / 3h_t^2 m_t^2)$$

The Standard Model Window



Experimental constraints

- Non-observation of the Higgs at LEP-2 in the process $e^+e^- \to ZH$ imposes the direct lower bound

Direct search limit

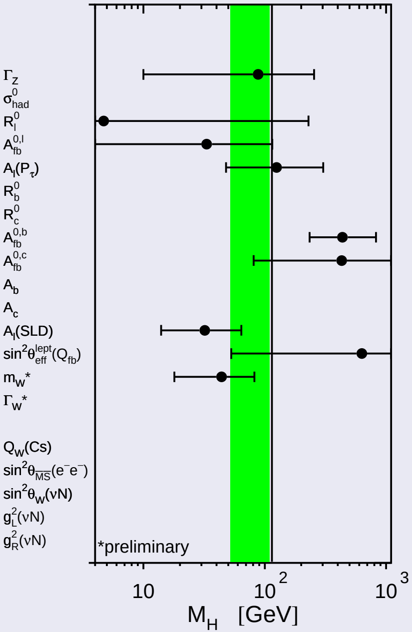
$$m_H > 114.4\ GeV$$

- The Higgs mass enters the quantum corrections of electroweak observables, in particular through the $\rho = 1 + \Delta\rho = 1 + T$ and S parameters

$$T = \frac{\Pi_{33}(0) - \Pi_{+-}(0)}{M_W^2} \simeq \frac{3G_F}{8\pi^2\sqrt{2}}\left[m_t^2 - (M_Z^2 - M_W^2)\log\frac{m_H^2}{M_Z^2}\right]$$

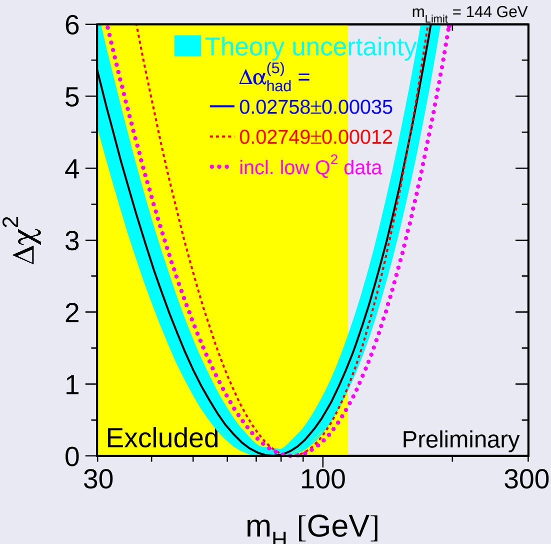
$$S \propto \Pi'_{3B}(0) \simeq \frac{1}{6\pi}\log\frac{m_H}{M_Z}$$

Electroweak observables



Indirect search limit

$$m_H < 144 \ GeV \ 95\% C.L.$$



Standard Model Drawbacks

- Big Hierarchy problem: The Higgs mass is sensitive to UV physics. Quantum corrections are quadratically sensitive to the cutoff Λ

$$\Delta m_H^2(F,B) = \mp \frac{n_{F,B} g_{F,B}^2}{16\pi^2}\Lambda^2$$

They are not protected by any symmetry which is enhanced when $m_H = 0$

- On the contrary fermions masses

$$\Delta m_F \propto \frac{m_F}{16\pi^2}\log\Lambda$$

are protected by chiral symmetry for $m_F = 0$

- Electroweak symmetry breaking requires a tachyonic mass for the Higgs
- Dark Matter: there is no candidate
- There is no gauge coupling unification
- Strong CP-problem: axion required

The Little Hierarchy Problem/LEP paradox

- The leading quantum correction to the Higgs mass parameter is expected to come from the top sector as

$$\Delta m_H^2 = -\frac{3h_t^2}{8\pi^2}\Lambda^2$$

- In the absence of tuning this implies a lower bound on the cutoff scale as

$$\Lambda < 600\; GeV \left(\frac{m_H}{200\; GeV}\right)$$

- Why did LEP not detect any deviation from the SM predictions? (LEP paradox)
- In particular one can parametrize the new effects as non-renormalizable operators ($d = 6$)

$$\mathcal{L}_{eff} = \frac{c_1}{\Lambda^2}\left(\bar{e}\gamma^\mu e\right)^2 + \dots$$

- If $c_i = \mathcal{O}(1) \Rightarrow \Lambda > 10$ TeV $\Rightarrow$ tension

MSSM

Minimal Supersymmetric Extension of the Standard Model

Higgs sector

- An extended Higgs sector

$$H_1 = \begin{pmatrix} H_1^0 \\ H_1^- \end{pmatrix}_{-1/2}, \quad H_2 = \begin{pmatrix} H_2^+ \\ H_2^0 \end{pmatrix}_{1/2}$$

- After the Higgs mechanism $\langle H_1^0 \rangle = v_1$, $\langle H_2^0 \rangle = v_2$, $\tan\beta = v_2/v_1$ there are five Higgses left: two scalar (h, H), one pseudoscalar (A) and two charged $(H^\pm)$
- Supersymmetry has to be broken, e.g. by embedding the MSSM into a local supersymmetry
- The Higgs spectrum is determined by two free parameters: m_A and $\tan\beta$
$m_{H^\pm} = m_A^2 + M_W^2$, $\quad m_{h,H}^2 =$
$\frac{1}{2}\left[m_A^2 + M_Z^2 \mp \sqrt{(m_A^2 + M_Z^2)^2 - 4m_A^2 M_Z^2 \cos^2 2\beta}\right]$

Big Hierarchy problem

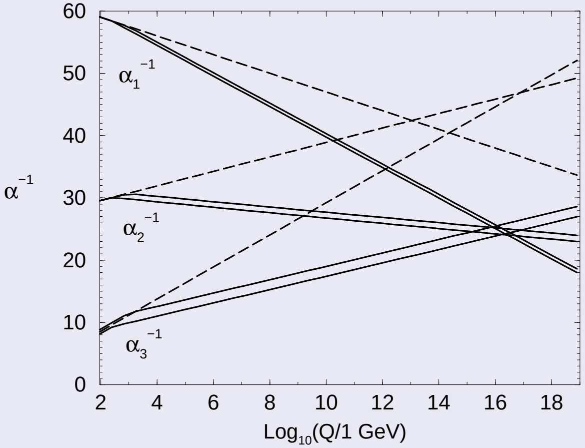
- Because quantum corrections to the Higgs mass from bosonic loops have *opposite* signs there is a cancellation between supersymmetric partners. Supersymmetry protects the Higgs mass
- When supersymmetry is broken by *soft* terms the supersymmetric cancellation holds up to supersymmetry breaking terms
- Quadratic divergences are still absent
- Hierarchy problem is *technically* solved by the *non-renormalization theorems* of supersymmetry

Dark Matter

There is a natural candidate for Cold Dark Mater in the MSSM: the lightest neutralino, provided that R-parity is unbroken

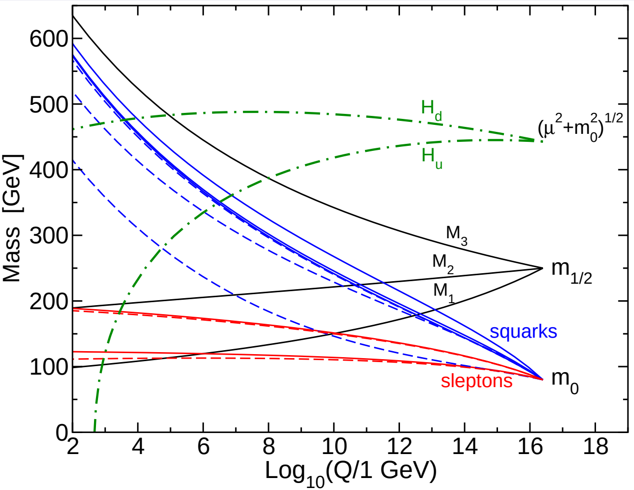
Gauge coupling unification

Consistently with LEP measurements and if superparticles are at $\sim$ TeV scale gauge couplings unify at a scale $M_{GUT} \sim 2 \times 10^{16}$ GeV



Electroweak breaking

If soft breaking parameters are generated at M_{GUT} a tachyonic mass can be triggered by RGE at the weak scale



Stability/triviality problems

- The stability ($\lambda < 0$) and triviality/Landau pole ($\lambda \to \infty$) problems are solved because of the supersymmetric relation

$$\lambda = \frac{1}{8}(g^2 + g'^2)$$

- Because the gauge couplings remain perturbative (and positive) up to M_{GUT} there is no stability and/or triviality problem in the MSSM
- As a consequence: the Higgs mass (unlike in the SM) is NOT a free parameter. For the SM-like Higgs

$$m_h^2 \simeq M_Z^2 \cos^2 2\beta + \frac{3 G_F m_t^4}{\sqrt{2}\pi^2}\left[\log\frac{m_{\tilde{t}}^2}{m_t^2} + \frac{A_t^2}{M_S^2}\left(1 - \frac{A_t^2}{12 M_S^2}\right)\right]$$

- The Higgs mass is a prediction in a supersymmetric theory $\Rightarrow$ theoretical constraints

Theoretical constraints

- The Higgs mass is a prediction in the MSSM
  - At the tree level there is the absolute bound

Tree-level

$$m_h^2 \leq M_Z^2$$

- At one-loop there is an important contribution controlled by the top/stop sector

One-loop

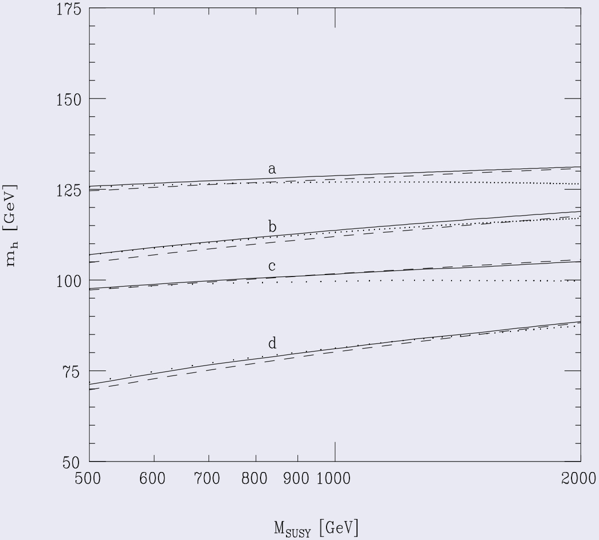
$$\Delta m_h^2 = \frac{3 G_F m_t^4}{\sqrt{2}\pi^2}\left[\log\frac{m_{\tilde{t}}^2}{m_t^2} + \frac{A_t^2}{M_S^2}\left(1 - \frac{A_t^2}{12 M_S^2}\right)\right]$$

- Even if the one-loop contribution can be larger than the tree-level perturbation theory holds

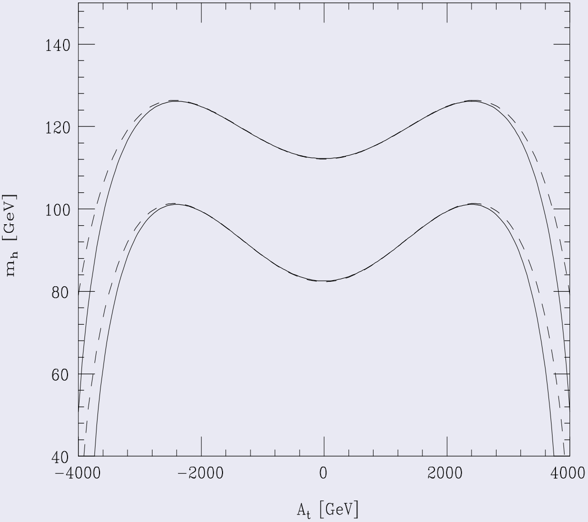
Little fine-tuning problem

To satisfy the experimental bounds a stop around the TeV scale is needed which produces a $\sim 1\%$ fine-tuning in the determination of the Z-mass

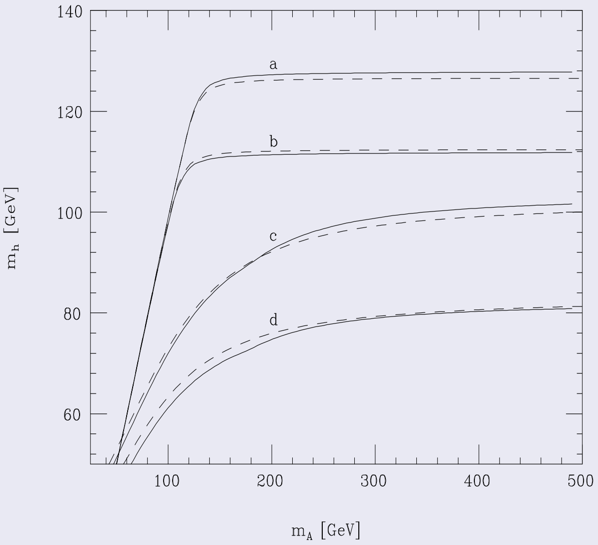
m_h Vs. M_{SUSY} [$m_A \sim 1$ TeV, (a,b) $\tan\beta = 15$ $A_t/M_{SUSY} = (\sqrt{6}, 0)$; (c,d) $\tan\beta = 2$]



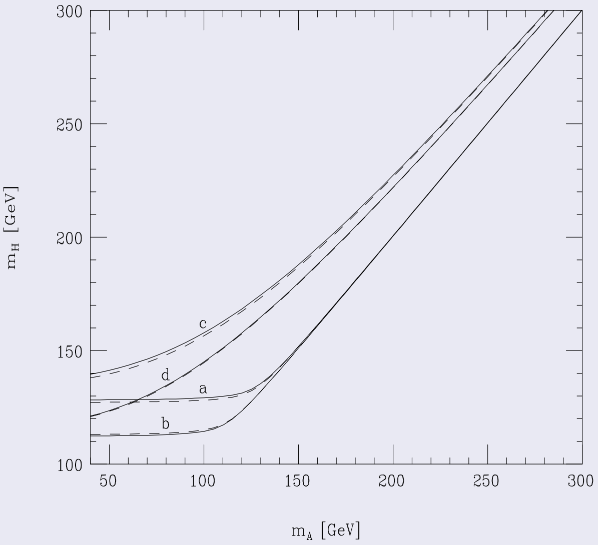
m_h Vs. A_t $[M_{SUSY}, m_A \sim 1$ TeV, $\tan\beta = 15, 2]$



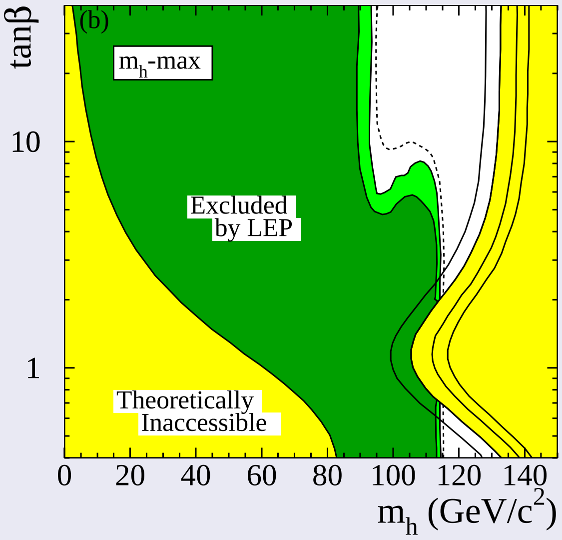
m_h Vs. m_A $[M_{SUSY} \sim 1$ TeV$]$



m_H Vs. m_A [$M_{SUSY} \sim 1$ TeV]



Experimental constraints from LEP-2



Drawbacks of the MSSM

- Little fine tuning: $\sim 1\%$ fine-tuning
- Large number ($\sim 10^2$) of free parameters
- Uncertainty in the mechanism of supersymmetry breaking:
  - Gravity mediation:
    - Universal mechanism solving the $\mu/B\mu$ problem
    - Its minimal version reduces the number of free parameters to a few
    - So-called Supergravity models
  - Gauge mediation
    - It is flavor blind
    - It has $\mu/B\mu$ problems
    - Gravitino is the LSP
  - Anomaly mediation
    - Tachyonic sleptons
- Supersymmetric flavor problem: supersymmetric partners can create FCNC and CP violating operators
- Gravity mediation has to be subdominant ($\sim 0.1\%$ of gauge mediation)

Little Higgs

- Little Higgs models aim to solve the Little Hierarchy problem
- The symmetry that protects the (little) hierarchy is a global symmetry of which the Higgs is an approximate (pseudo) Goldstone boson
- It is inspired from low energy hadronic physics: there $\pi^{\pm 0}$ are Goldstone bosons associated to the spontaneous breaking $SU(2)_L \times SU(2)_R \to SU(2)_I$
- Similarly the Higgs is the Goldstone boson of a global symmetry $G_0 \to H_0$. It is in the coset space $H \in G_0/H_0$
- The symmetry $H \to H + c$ is broken (in particular) by Yukawa interactions

$$\Rightarrow m_H^2 \sim \frac{\alpha_t}{4\pi}\Lambda^2 \Rightarrow LEP\ paradox$$

- LH is a clever construction to avoid the appearance of the lowest order contribution to m_H^2

Collective breaking

- The mass of a Higgs pseudo-Goldstone boson from the different couplings α_i that break the Goldstone symmetry is

$$m_H^2 = \left(c_i \frac{\alpha_i}{4\pi} + c_{ij} \frac{\alpha_i \alpha_j}{(4\pi)^2} \right) \Lambda^2$$

where the coefficients are controlled by selection rules

- If the Goldstone symmetry is restored when any single coupling $\alpha_i = 0$
  $\Rightarrow$ To totally destroy the Goldstone symmetry one requires the combined effect [collective breaking] of at least two non-zero couplings

$$\Rightarrow m_H^2 \sim \left(\frac{\alpha}{4\pi} \right)^2 \Lambda^2 \Rightarrow \Lambda \sim 10 \; TeV$$

- This is a solution to the LEP paradox/Little Hierarchy problem

General structure

- There is a global group G_g which spontaneously breaks to a subgroup H_g at a scale $f \sim 1$ TeV and the theory becomes strong at the scale $\Lambda \sim 4\pi f \sim 10$ TeV [Scales are similar to Λ_{QCD} and f_π in QCD]
- The subgroup $G_l \subset G_g$ is gauged: $G_l \supset SU(2) \times U(1)$
- The combination of spontaneous and collective breaking makes: $G_l \to SU(2) \times U(1)$ leaving heavy vector bosons and fermions with masses

$$M_{Heavy} \sim g\, f \sim 1\ TeV$$

- Higgs is part of the Goldstone multiplet which parametrizes the coset space G_g/H_g

Model	G_g	H_g
Littlest	$SU(5)$	$SO(5)$
Simplest	$SU(3)^2$	$SU(2)^2$

General structure

- The generators of G_l do not commute with the generators of the Higgs and thus gauge and Yukawa couplings collectively break the Goldstone symmetry and induce a Higgs mass
- The global invariance of the SM must be extended according to the different models (Littlest, Simplest,...)
- There are *same spin partners* for every SM field.
- When computing corrections to the Higgs mass these partners enforce the selection rule $c_i = 0$ by cancelling the one-loop quadratic divergent contributions of the Higgs field
- For instance if $SU(3) \subset G_g$
  - The quarks appear in triplets or singlets

$$\begin{pmatrix} t \\ b \\ T \end{pmatrix}_L, t_R, b_R, T_R$$

  - The Higgs boson arises as a pseudo-Goldstone boson from the spontaneous breaking $SU(3) \to SU(2) \times U(1)$

General structure

- The gauge structure is also enlarged

Model	G_g	H_g	G_l
Littlest	$SU(5)$	$SO(5)$	$[SU(2)\times U(1)]^2$
Simplest	$SU(3)^2$	$SU(2)^2$	$SU(3)\times U(1)$

- Littlest:
  - $SU(5)\to SO(5)$: 24-10=14 Goldstone bosons
  - 4 absorbed by the broken gauge group
  - 10 Goldstone bosons= 4 (Higgs doublet)+6 (Higgs triplet)
- The one-loop quadratic divergence from the top quark

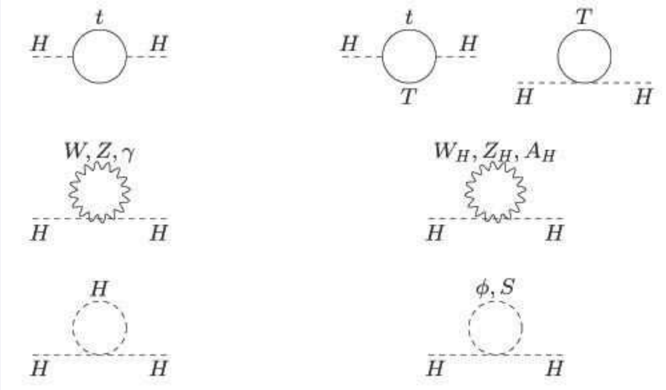
$$\Delta M_H^2 \sim -\frac{\alpha_t}{4\pi}\Lambda^2$$

is cancelled by that from the T quark
- The one-loop quadratic divergence from the W gauge boson

$$\Delta M_H^2 \sim \frac{\alpha_W}{4\pi}\Lambda^2$$

is cancelled by that from the W_H gauge boson

Cancellation of quadratic divergences



Electroweak breaking

It is triggered by the $t - T$ sector analogously to the MSSM

$$\Delta m_H^2 = -\frac{3}{8\pi^2} h_t^2 m_T^2 \log \frac{\Lambda}{m_T}$$

Since $\Delta m_H^2 \sim m_T^2$ electroweak breaking requires some tuning of at least 5% as in the MSSM

Dark Matter

In the Littlest LH models one can introduce a T-parity such that SM particles (extra particles) are T-even (T-odd). In this case the lightest T-odd gauge bososon is a candidate to DM

Electroweak precision tests

T-parity forbids the mixing between T-odd and T-even gauge bosons leading naturally to $S = 0$

Gauge Higgs Unification

- We have explored two symmetries protecting the Higgs from quadratic divergences: supersymmetry and a global symmetry
- In higher dimensional theories there is another symmetry which could do the job: a gauge symmetry
- The gauge bosons of a higher dimensional gauge symmetry decompose as

Lorentz Decomposition

$$A_M^A = A_\mu^A,\ A_i^A\ [\mu = 0, \dots, 3, i = 1, \dots, d]$$

- A_μ^A are gauge bosons in four dimensions
- A_i^A are scalar in the adjoint representation

Orbifold constructions

We need to compactify extra dimensions in an orbifold: e.g. for $d = 1$ (A_μ, A_5)

$$S^1/\mathbb{Z}_2$$

- The orbifold group has to act non trivially on the group generators such that:

Orbifold Decomposition

$$A_\mu^A = A_\mu^a(even),\ \ A_\mu^{\hat a}(odd)$$
$$A_5^A = A_5^a(odd),\ \ A_5^{\hat a}(even)$$

- Only even fields have zero modes $\phi_{even}^{(n)}, n = 0, 1, 2, \ldots$ while odd field have only non zero modes $\phi_{odd}^{(n)}, n = 1, 2, \ldots$
- The Higgs mechanism acts for all modes as

Higgs mechanism

$$(A_\mu^{\hat a}\ massless + A_5^{\hat a})^{(n\neq 0)} = A_\mu^{\hat a\,(n\neq 0)} massive$$
$$(A_\mu^{a}\ massless + A_5^{a})^{(n\neq 0)} = A_\mu^{a\,(n\neq 0)} massive$$

- The massless states are the zero modes

Massless states

$$A_\mu^{a\,(n=0)},\ \ A_5^{\hat a\,(n=0)}$$

- To get a doublet out of an adjoint one has to make a careful orbifold breaking
- One has to enlarge the gauge group since the

SM Higgs is NOT in the adjoint representation of $SU(2) \times U(1)$

- For instance

$SU(3) \to SU(2) \times U(1)$

Achieved by the orbifold action
$A_\mu(-y) = UA_\mu(y)U^\dagger,\ A_5(-y) = -UA_5(y)U^\dagger$ with

$$diag(-1, -1, +1)$$

which breaks $SU(3)$ into $SU(2) \times U(1)$

- The Higgs mass is protected from quadratic divergences in the bulk of the extra dimension by the five-dimensional gauge symmetry

- The orbifold has two fixed points at $y = 0, \pi R$ which are singular and four-dimensional
- The Higgs mass is protected from quadratic divergences at the fixed points by the shift symmetry (inherited from the five-dimensional gauge invariance) $\delta A_5 = \partial_y A_5$

How to get the gauge bosons

$$\begin{pmatrix} A_\mu^3 + A_\mu^8/\sqrt{3} & A_\mu^2 - iA_\mu^2 & A_\mu^4 - iA_\mu^5 \\ A_\mu^1 + iA_\mu^2 & -A_\mu^3 + A_\mu^8/\sqrt{3} & A_\mu^6 - iA_\mu^6 \\ A_\mu^4 + iA_\mu^5 & A_\mu^6 + iA_\mu^7 & -2A_\mu^8/\sqrt{3} \end{pmatrix}$$

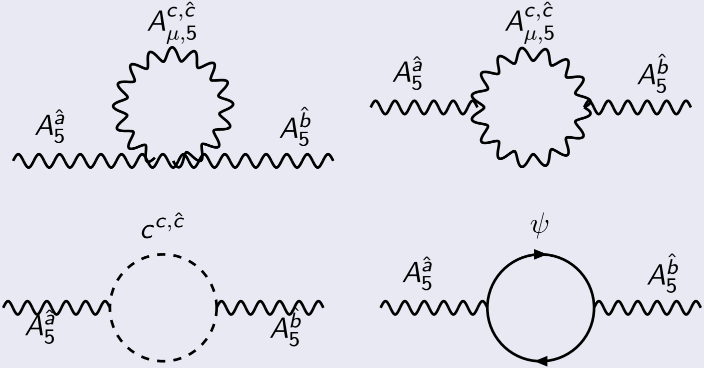
How to get the Higgs bosons

$$\begin{pmatrix} A_5^3 + A_5^8/\sqrt{3} & A_5^2 - iA_5^2 & A_5^4 - iA_5^5 \\ A_5^1 + iA_5^2 & -A_5^3 + A_5^8/\sqrt{3} & A_5^6 - iA_5^6 \\ A_5^4 + iA_5^5 & A_5^6 + iA_5^7 & -2A_5^8/\sqrt{3} \end{pmatrix}$$

- Since the space is compactified there can be finite contributions to the $A_5^{\hat{a}}$ mass proportional to $1/R$

Hosotani breaking

The diagrams contributing to the mass of $A_5^{\hat{a}}$ are



$$m_{\hat{a}}^2 = \frac{3g^2}{32\pi^4 R^2}\zeta(3)\left[3C_2(\mathcal{G}) - 4T(R)N_f\right]$$

There is a number of difficulties with this (otherwise very nice) scenario

Drawbacks

- In more than five dimensions a (quadratically divergent) tadpole localized at the fixed points F_{ij} is generated by radiative corrections while the quartic Higgs coupling is sizeable and generated by the term F_{ij}^2 in the bulk
- In five dimensions there is no localized tadpole but there is neither a tree-level quartic coupling which means difficulties with *too small a Higgs mass*
- It is difficult to have a theory with the correct prediction for the weak angle [extra $U(1)'s$ are usually required]
- Fermion masses are difficult to accomodate since they come from gauge couplings: in particular the top quark use to be too light
- The compactification scale is usually too small in conflict with EWPT
- The theory has a very low cutoff after which it becomes non-perturbative

Some of these difficulties can be alleviated by embedding GHU in a warped (Randall-Sundrum) five-dimensional space time

Wayouts

- Warped models are valid up to scales of order M_{GUT} or M_{Planck} and they can unify
- The Higgs is holographic, i.e. it is localized towards the IR brane [at higher scales it is composite]
- Fermion masses can be implemented by means of their localization, i.e. five-dimensional masses
- The top quark (to get a big mass) is localized as the Higgs. So it is also holographic
- EWPT as well as corrections to the $Zb\bar{b}$ vertex lead to KK-masses in the $2.5 - 4$ TeV, which imply $\sim 1\%$ fine-tuning for the Higgs mass (similar to the MSSM)
- These models are the modern version of technicolor theories: they make use of the AdS/CFT correspondence for calculability

Conformal Higgs

Unparticles

- Recently Georgi [a] has introduced a new way of studying conformal sectors, with a fixed point at the scale Λ, that couple to the Standard Model.
- Fields in a conformal theory can acquire large anomalous dimensions γ and modify the scaling dimension d of the field
- If the conformal symmetry is broken at a scale m_g, which provides a continuum of states above the mass gap the propagator for a scalar particle can be described as

$$\Delta(p) \propto \frac{1}{(-p^2 + m_g^2 - i\epsilon)^{1-\gamma}}$$

- The particle propagator is reached for the case $\gamma = 0$

[a] H. Georgi, hep-ph/0703260

Un-Higgs

- Making a step forward along the previous direction one can speculate with the idea that the Higgs is an object of a conformal theory (unparticle) with a fixed point at a scale Λ and a scaling dimension $d = 1 + \gamma$, where γ is the anomalous dimensions: an un-Higgs [a]
- The un-Higgs is coupled to the SM fields by Yukawa interactions

$$\mathcal{L} = h_t \frac{1}{\Lambda^\gamma} H^\dagger \bar{q}_L t_R + h.c.$$

- For $\gamma > 0$ the operator is irrelevant and does not take the conformal theory out of the fixed point
- The conformal symmetry should be broken at a scale m_g which is related to the VEV of the un-Higgs, v^d: it can be triggered by SM top-loop effects

[a] D. Stancato and J. Terning, 0807.3961 [hep-ph]

The fine-tuning/hierarchy problem

- The Higgs mass term is given by

$$m_H^{2(1-\gamma)}|H|^2$$

- The radiative corrections induced by the top Yukawa coupling are

$$\delta m_H^{2(1-\gamma)} = \frac{3h_t^2}{8\pi^2}\Lambda^{2(1-\gamma)}$$

- The sensitivity of the Higgs mass to radiative corrections is

$$1 + \frac{3h_t^2}{8\pi^2}\left(\frac{\Lambda^2}{m_H^2}\right)^{1-\gamma}$$

- For $\gamma = 0$ it is the usual sensitivity appearing from quadratic divergences
- For $\gamma \to 1$ the sensitivity is tiny for any value of Λ
- For instance for $\gamma = 0.7$ one can push $\Lambda = 10$ TeV without much tuning

Conclusions

- The last word will be from LHC
- One possibility is that the theory below M_{Planck} is just the Standard Model: in that case we should try to find other solutions to the hierarchy problem, as e.g. an anthropic solution/landscape
- If the Higgs is light (< 135 GeV) then an excellent candidate is the MSSM although supersymmetric particles should show up at LHC
- If the Higgs is heavy then other particles should appear to restore agreement with present electroweak precision tests
- If there is no Higgs at all other resonances should appear to restore unitarity in WW scattering
- Even if the Higgs is found we will (probably) need a linear collider for Higgs precision physics