Quadratic sensitivity of the Higgs mass due to Fayet-Iliopoulos terms in five dimensions

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collaboration with

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based on:

Nucl. Phys. B619 (2001) 373, B619 (2001) 385

hep-th/0203055

and work in progress...

Motivation:

Extra dimensions:

- why 4 dimensions?
- String and M-theory
- D-branes

Supersymmetry:

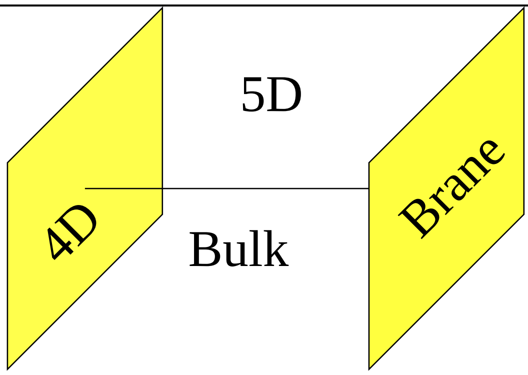
- no fine-tuning
- very restrictive
- non-perturbative

Experimental opportunities:

- Newton's law
- KK excitations
- running coupling
- small M_P

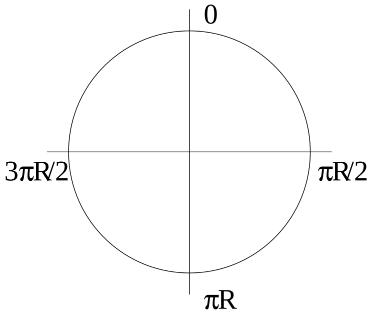
Plan of Talk:

- Barbieri-Hall-Nomura Model
- Theoretical concerns
- Fayet-Iliopoulos contributions
- Conclusion / outlook



The $S^1/\mathbb{Z}_2 \times \mathbb{Z}_2$ orbifold bulk:

- "$N = 1$ 5D supersymmetry"
- boundary conditions
- even/odd Fourier modes



Bulk fields:

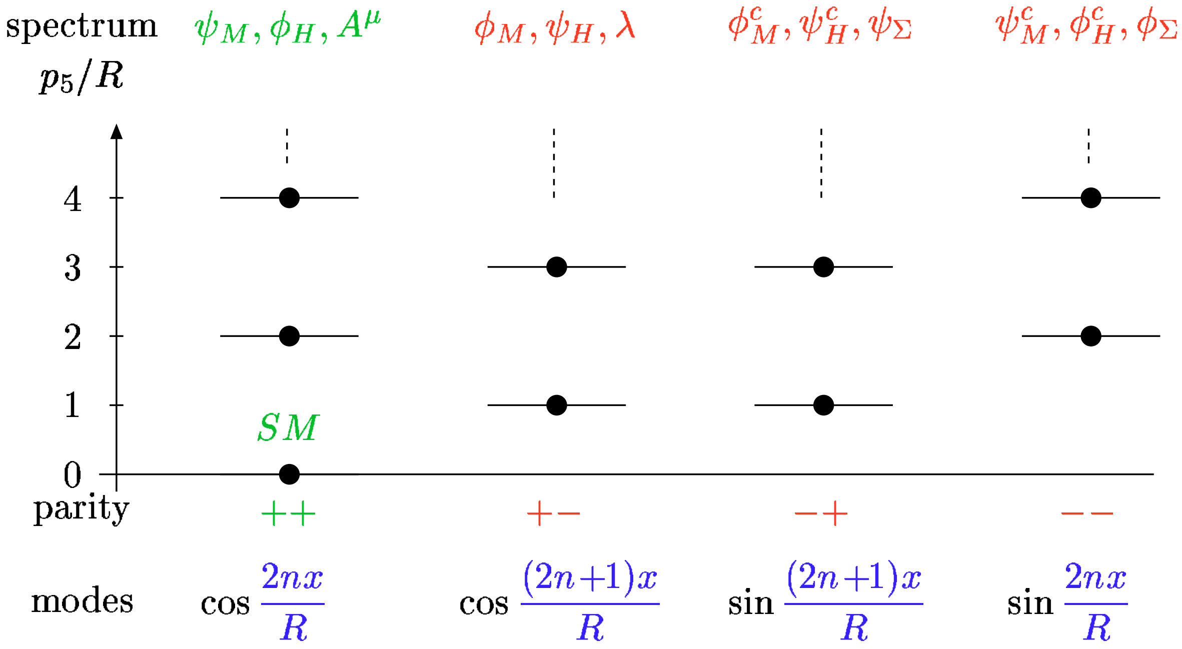
Vector Multiplet:

- gauge field A_μ, A_5
- gauginos λ^1, λ^2
- real scalar Φ

Hyper Multiplet:

- complex scalars ϕ, ϕ^c
- chiral fermions ψ, ψ^c

Compactify a 5D $N = 1$ supersymmetric field theory on $S^1/\mathbb{Z}_2 \times \mathbb{Z}'_2$ with radius R to obtain the effective 4D field theory, which has the low energy spectrum of the Standard Model Barbieri,Hall,Nomura '00.



SM in 4D :

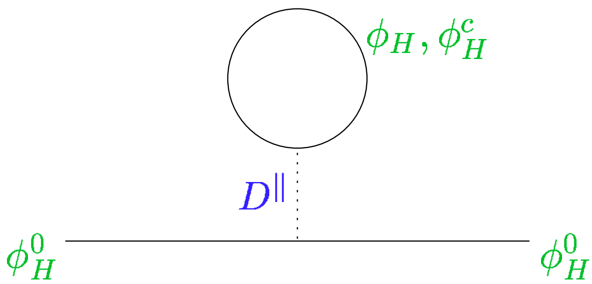
ψ_M quarks/leptons ϕ_H higgs A^μ gauge fields

It was claimed that in this model the Higgs mass is finite and equal to 127 ± 8 GeV based on a one loop calculation.

Questions concerning the physics of Kaluza-Klein theories:

- Can we make sense of infinitely many fields?
  - is KK theory "better" behaved than the low-energy its theory? Ghilencea,Nilles '01
  - What does "KK regularization" mean?
- Effective 4D theory versus 5D theory?
  - what (super)symmetries survive compactification?
  - 5D theory is not renormalizable?
  - what happens in the limit $R \to \infty$?

The tadpole of the auxiliary $D^{||}$ field has a quadratic divergence that filters into the Higgs mass parameter



$$\xi = g \int \frac{d^4 p_4}{(2\pi)^4} \left\{ \sum_{n \geq 0} \frac{1}{p_4^2 + (2n)^2 R^{-2}} - \sum_{n \geq 1} \frac{1}{p_4^2 + (2n)^2 R^{-2}} \right\}$$

Only the zero mode contribution survives Ghilencea,GN,Nilles '01 so that we get a 4 dimensional divergence:

$$\xi = g \int \frac{d^4 p_4}{(2\pi)^4} \frac{1}{p_4^2} \propto \Lambda^2$$

This result is independent of radius R. Hence, also holds in the decompactification limit $R \to \infty$!

The Higgs mass is quadratically sensitive to a high scale due to Fayet-Iliopoulos terms

- only the zero mode bosons in the loop contribute,
- this is independent of the radius R,
- and very similar SM situation.

The FI terms have an interesting structure over the 5th dimension

- they localize on the branes, Scrucca,Serone Silvestrini,Zwirner,'01
- this can lead to localization of charged bulk fields to branes, GN,Nilles,Olechowski,'02
- which may change the phenomenology of such models...