The LHC Diphoton Excess & F-Theory LRS Models

JOHAR M. ASHFAQUE

University of Liverpool

Work In Progress
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Motivated By The Diphoton Signal...

$$\begin{array}{rcll} E_8 & \rightarrow & E_6 \times SU(3)_\perp & \\ E_6 & \rightarrow & SO(10) \times U(1) & \text{Flipped } SO(10) \\ SO(10) & \rightarrow & SU(5) \times U(1) & \text{Flipped } SU(5) \\ SU(5) & \rightarrow & SU(3) \times SU(2) \times U(1) & \end{array}$$

see e.g.

G. K. Leontaris, Q. Shafi (2016)

A. Karozas, S. F. King, G. K. Leontaris, A. K. Meadowcroft (2016)

Aim Is Twofold

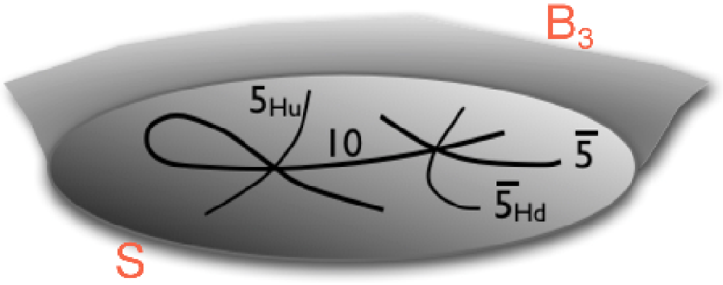
- Search for LRS Models from F-Theoretic E_6
- Exploring the connection between F-Theory Phenomenology and the LHC Diphoton Excess

Model Building Elements in F-Theory

Each lower-dimensional subspace provides an important model building element

Dimension	Ingredient	Complex Codimension	Enhancements
$8D$	Gauge Theory	1	-
$6D$	Matter	2	Rank 1
$4D$	Yukawa Couplings	3	Rank 2

The $SU(5)$ GUT: Pictorially



The six extra dimensions are compactified on B_3 whereas the $SU(5)$ degrees of freedom are localized on the submanifold S_{GUT}. The gauge bosons live on the bulk of S_{GUT} but the chiral multiplets are localized on complex matter curves. At the intersection of two matter curves with a Higgs curve a Yukawa coupling develops.

Non-Trivial Gauge Flux

The preferred GUT breaking method is turning on a non-trivial gauge flux which will break the gauge group.

The hypercharge flux is an important ingredient which provides an elegant mechanism for breaking the GUT group.

The E_6 Subgroups

$$
\begin{aligned}
E_6 &\rightarrow SO(10) \times U(1) \rightarrow SU(5) \times U(1)^2 \\
E_6 &\rightarrow SO(10) \times U(1) \rightarrow SU(4) \times SU(2) \times SU(2) \times U(1) \\
E_6 &\rightarrow SU(6) \times SU(2) \rightarrow SU(5) \times SU(2) \times U(1) \\
E_6 &\rightarrow SU(6) \times SU(2) \rightarrow SU(4) \times SU(2) \times SU(2) \times U(1) \\
E_6 &\rightarrow SU(6) \times SU(2) \rightarrow SU(3) \times SU(3) \times SU(2) \times U(1) \\
E_6 &\rightarrow SU(3) \times SU(3) \times SU(3)
\end{aligned}
$$

The Two Extended Rank 6 MSSM Models

In all the known instances

$$
\begin{aligned}
E_6 &\rightarrow SU(3) \times SU(2) \times [U(1)^3] \\
E_6 &\rightarrow SU(3) \times SU(2) \times [SU(2) \times U(1)^2]
\end{aligned}
$$

which are equivalent up to linear transformations.

C. M. Chen, Y. C. Chung (2011)

What Seems To Be The Problem?

$$SU(3)_C \times SU(3)_L \times SU(3)_R$$

U_{B-L} must not be identical to U_Y
U_{B-L} must be orthogonal to $SU(3)_C \times SU(2)_L$

$$U_{B-L} \not\perp SU(3)_R$$

see
J. Harada (2003)

A Body of Clay, A Mind Full of Play
A Second of Life - Thats Me

"We must think beyond the box if we are to broaden our horizons."
J. M. A.

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$$SU(3)_C \times SU(2)_L \times U(1)_Y \times \underbrace{U(1) \times U(1)}_{U(1)}$$

$$\lambda_D^{ijk} S_i D_j \bar{D}_k + \lambda_H^{ijk} S_i H_j \bar{H}_k + \lambda_h^{ij} S_i H_j \bar{h} + \eta_{\mathcal{D}}^i \zeta_i \mathcal{D}\bar{\mathcal{D}} + \eta_h^i \zeta_i h\bar{h}$$

see

J. M. A., L. Delle Rose, A. E. Faraggi, C. Marzo (2016)

The SM Embedding: $E_6 \to SO(10) \times U(1)_\zeta$

$$\mathbf{27} = \begin{cases} \mathbf{16}_{\frac{1}{2}} & \mathcal{F}_L + \mathcal{F}_R = (Q, u^c, d^c, L, e^c, N) \\ & \to \begin{pmatrix} Q & u^c \\ & e^c \end{pmatrix} + \begin{pmatrix} d^c \\ L \end{pmatrix} + N \\ \mathbf{10}_{-1} & \mathcal{D} + h = (D, \overline{D}, H, \overline{H}) \\ & \to \begin{pmatrix} D \\ H \end{pmatrix} + \begin{pmatrix} \overline{D} \\ H \end{pmatrix} \\ \mathbf{1}_2 & \mathcal{S} \to S \end{cases}$$

$$\mathbb{Z}_2 \text{ Monodromy} \Leftrightarrow \begin{bmatrix} \begin{bmatrix} t_1 & \\ & t_2 \end{bmatrix} & \\ & \begin{bmatrix} t_3 \end{bmatrix} \end{bmatrix}$$

$$\begin{aligned} \theta_{12} &= \theta_{21} \equiv \theta_0 \\ \theta_{23} &= \theta_{13} \\ \theta_{32} &= \theta_{31} \leftrightarrow S \end{aligned}$$

Making The Connection

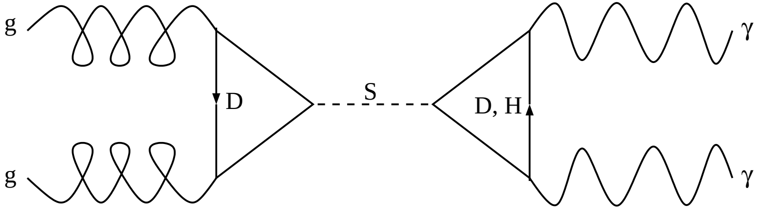

Figure: Vector-like representations $(D + \overline{D}) \in \mathbf{10}$ of $SO(10)$ contribute to the diphoton signal.

$\epsilon\upsilon\chi\alpha\rho\iota\sigma\tau\omega$!!!