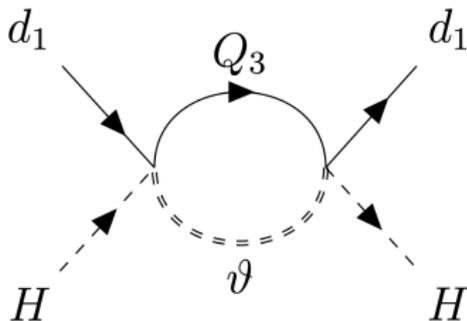


Froggatt-Nielsen models meet the SMEFT

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Background

The flavour puzzle: what explains the dramatic hierarchies in fermion masses and mixings?

For instance:

$$\frac{m_u}{m_t} \sim 10^{-5}.$$

Potential solutions: introduce new symmetries, fields, extra dimensions, etc.

Froggatt-Nielsen Models

Setup:

SM + new $U(1)$ symmetry + flavon field θ .

Yukawa sector:

$$\mathcal{L} \supset y_{ij} \bar{\psi}_i H \psi_j \longrightarrow \mathcal{L} \supset c_{ij} \bar{\psi}_i H \psi_j \left(\frac{\theta}{\Lambda_{UV}} \right)^{x_{ij}}$$

$$\theta = \frac{v_\theta + \vartheta}{\sqrt{2}}$$

Define $\lambda \equiv v_\theta / (\sqrt{2} \Lambda_{UV}) \sim 0.1$.

Get light Yukawas: $\mathcal{L} \supset c_{ij} \bar{\psi}_i H \psi_j \lambda^{x_{ij}}$

Problem

Froggatt-Nielsen models predict the correct fermion masses by design.

How can we falsify these models?

→ We need to understand *what else* they predict!

→ Match to the SMEFT and study ensuing operator structures.

Strategy

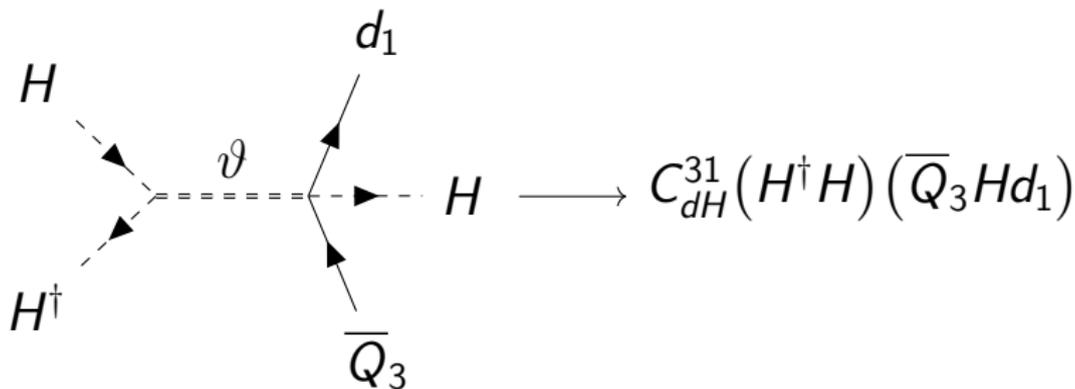
1) Write down a Froggatt-Nielsen EFT up to a given mass dimension. E.g.

$$\mathcal{L}_{\text{FN}} \supset y_{33}^d \bar{Q}_3 H d_3 + y_{32}^d \bar{Q}_3 H d_2 \\ - \kappa(\theta^* \theta)(H^\dagger H) + c_{31} \bar{Q}_3 H d_1 \left(\frac{\theta}{\Lambda_{\text{UV}}} \right)$$

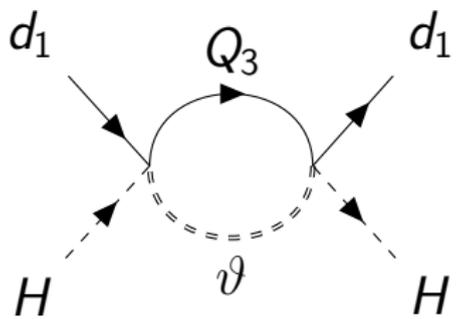
2) Match to the SMEFT up to a given mass dimension by integrating out θ .

Can be done at tree- and 1-loop-level.

Tree-level matching



1-loop matching



A Feynman diagram representing a 1-loop matching process. It features a central loop with two vertices. The top vertex is connected to an incoming d_1 line (solid arrow) and an outgoing d_1 line (solid arrow). The bottom vertex is connected to an incoming H line (dashed arrow) and an outgoing H line (dashed arrow). The top part of the loop is a solid line with an arrow pointing clockwise, labeled Q_3 . The bottom part of the loop is a dashed line with an arrow pointing clockwise, labeled ϑ .

$$\longrightarrow C_{Hd}^{11}(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{d}_1 \gamma^\mu d_1)$$

Conclusions

Goal: Understand the IR imprint of Froggatt-Nielsen models.

Method: Systematically match a Froggatt-Nielsen EFT to the SMEFT.

Findings: Rich flavour structure especially in $(\bar{\psi}_i \gamma^\mu \psi_j)(\bar{\psi}_k \gamma^\mu \psi_l)$ and $(H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{\psi}_i \gamma^\mu \psi_j)$ operators.

The End

Thank you for listening!