

Flavour violation in "minimal" SUSY SU(5) models

Toshifumi Yamashita
(SISSA)

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@CERN

In preparation.

with F. Borzumati (SISSA & ICTP)
S. Mishima (Princeton)

“minimal” SUSY SU(5)

- “minimal” SUSY SU(5)

$5_H, \bar{5}_H, 24_H,$ $10_i, \bar{5}_i, 1_{i'}$ mass

$$W_H = M_5 \bar{5}_H 5_H + \lambda_5 \bar{5}_H 24_H 5_H + M_{24} 24_H^2 + \lambda_{24} 24_H^3$$

$$W_M = Y_{10} 10_i 10_j 5_H + Y_5 \bar{5}_i 10_j \bar{5}_H + \dots$$

+ possible non-renormalizable terms

~~SU(5)~~ & ~~SM~~ breaking part is unchanged.

Plan



- Introduction
- Problems of GUTs & Solutions
 - Double-Triplet Splitting
 - Fermion Spectra
 - Proton Decay
- Analysis
- Summary

Introduction

- LFV vs. QFV in SUSY-GUTs

LFV



ν Yukawa

Type I

$$LNH_u$$

F. Borzumati &
A. Masiero (1986)

Type II

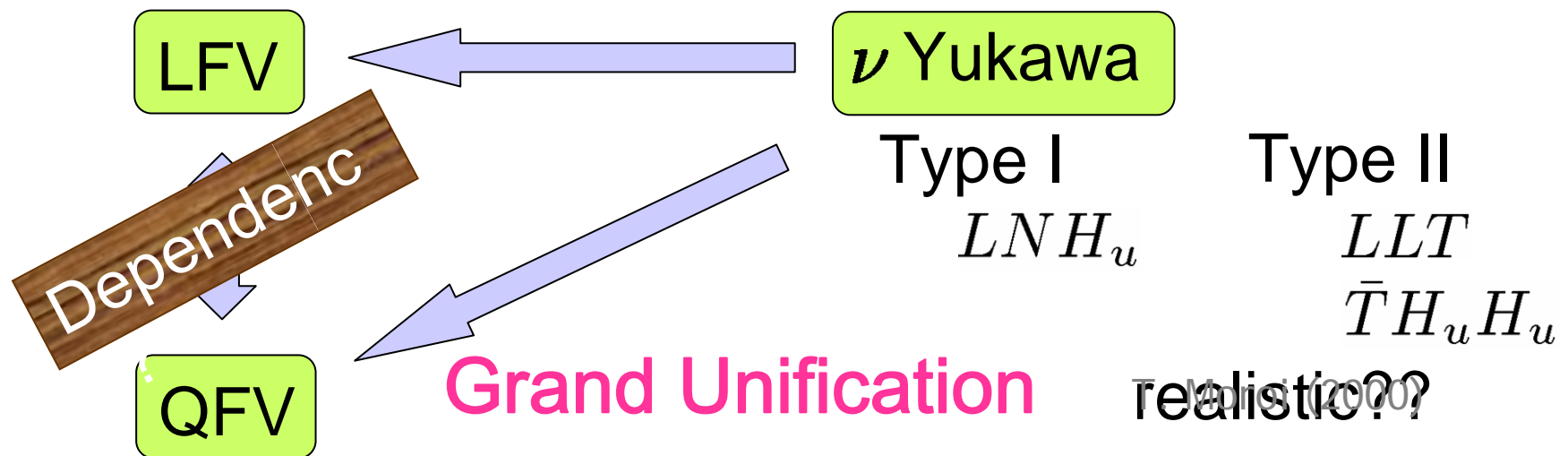
$$LLT$$

$$\bar{T}H_uH_u$$

A. Rossi (2002)

Introduction

● LFV vs. QFV in SUSY-GUTs



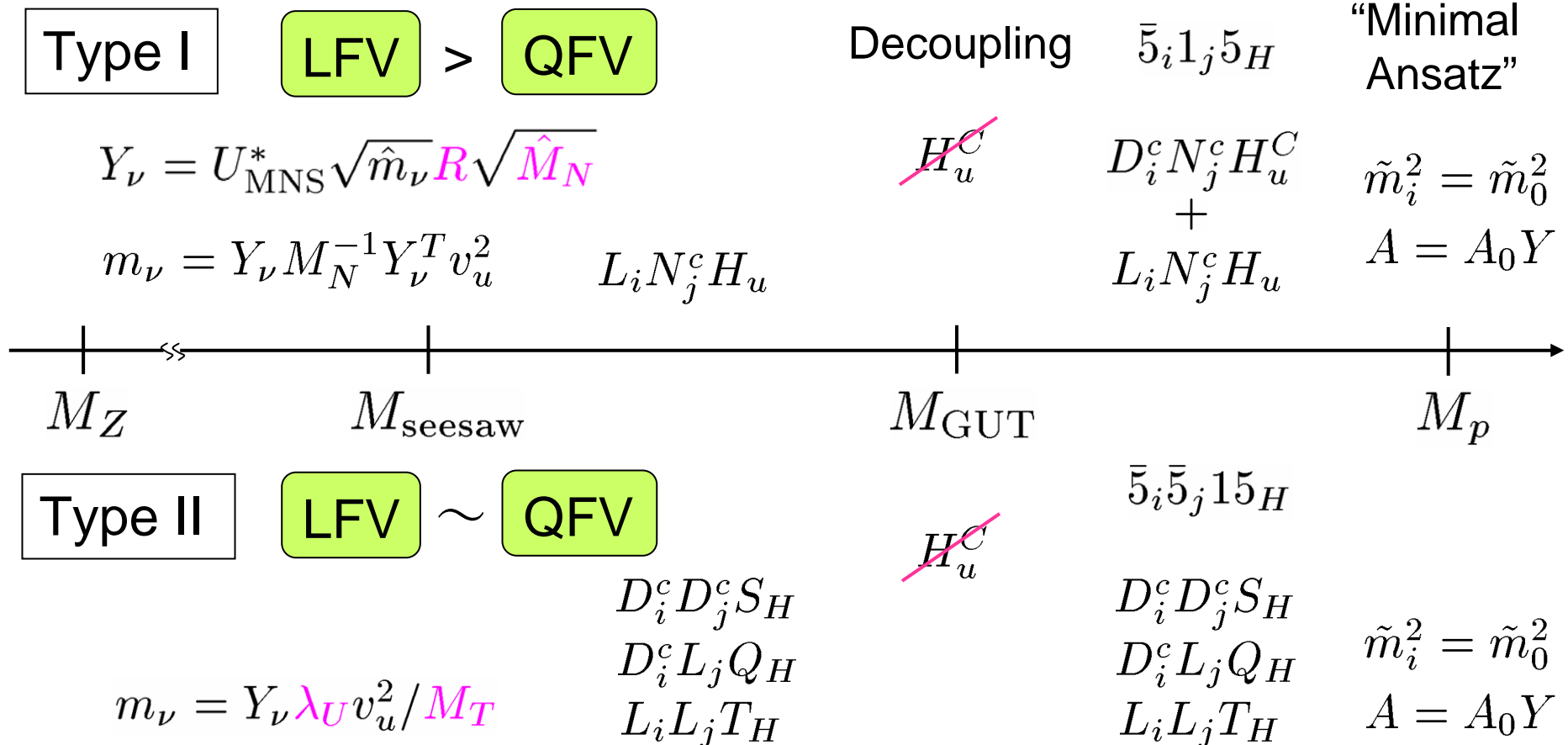
Grand Unification

- Double-Triplet Splitting
- Fermion Spectra
- Proton Decay

➡ **New Physics** above GUT

Introduction

Type I vs. Type II Seesaw



Problems of GUTs & Solutions

- SUSY-GUT

Higgs?

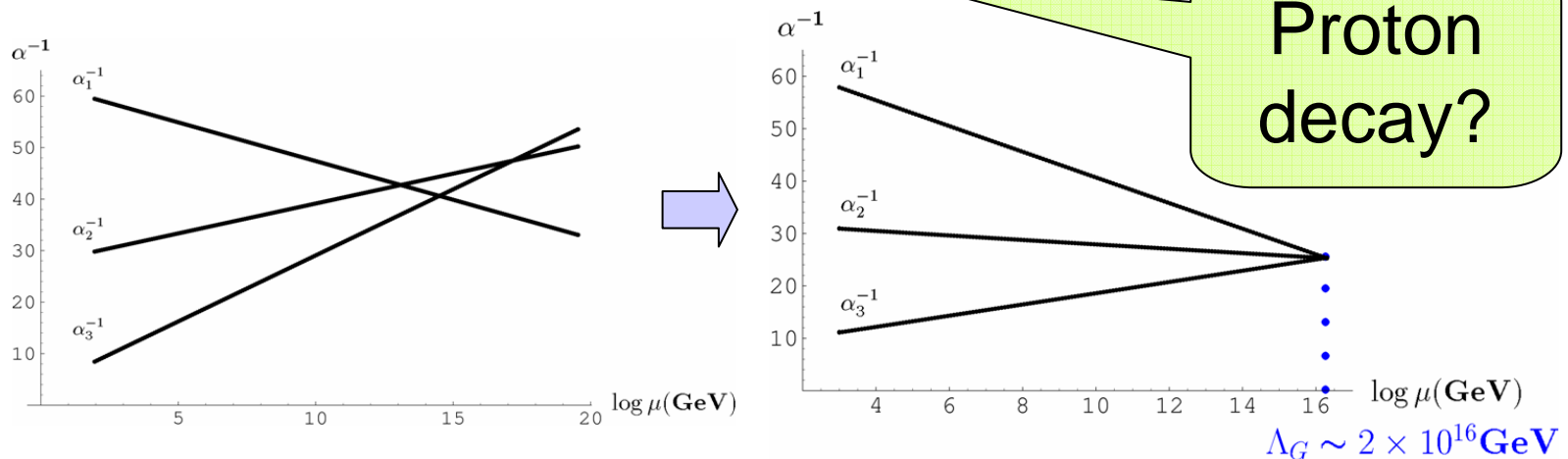
Wrong relation?

- fascinating extension of SM

- unifications of forces and of matter
- stabilization of the weak scale

~~SUSY?~~

- gauge coupling unification (GCU)



Problems of GUTs & Solutions

- SUSY-GUT

- The Hierarchy problem is solved.
- Gauge Coupling Unification

But . . .

- DT Splitting problem
- Proton decay (vs. GCU)
- Fermion Yukawa
- SUSY flavor problem

← Minimal Ansatz

⇒ LFV ↔ QFV

Problems of GUTs & Solutions

- DT Splitting problem

$$\bar{5}_H = (H_d^C, H_d), \quad 5_H = (H_u^C, H_u)$$

$$\langle 24_H \rangle = \begin{pmatrix} 2v & 0 \\ 0 & -3v \end{pmatrix}, \quad v \sim 10^{16} \text{ GeV}$$

$$W_{\text{DT}} = \bar{5}_H (M_5 - \lambda_5 24_H) 5_H$$

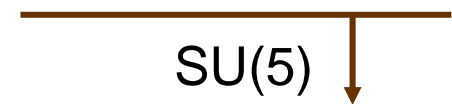
$$m_3 = m + 2v > 10^{16} \text{ GeV}$$

$$m_2 = m - 3v \sim 10^2 \text{ GeV}$$

← Fine-tuning of $10^{14}!!$

Problems of GUTs & Solutions

- Solutions for DTS problem
 - In Xtra Dim.
 - Sliding Singlet mechanism
 - Dimopoulos-Wilczek mechanism
 - GIFT mechanism
 - Missing Partner mechanism



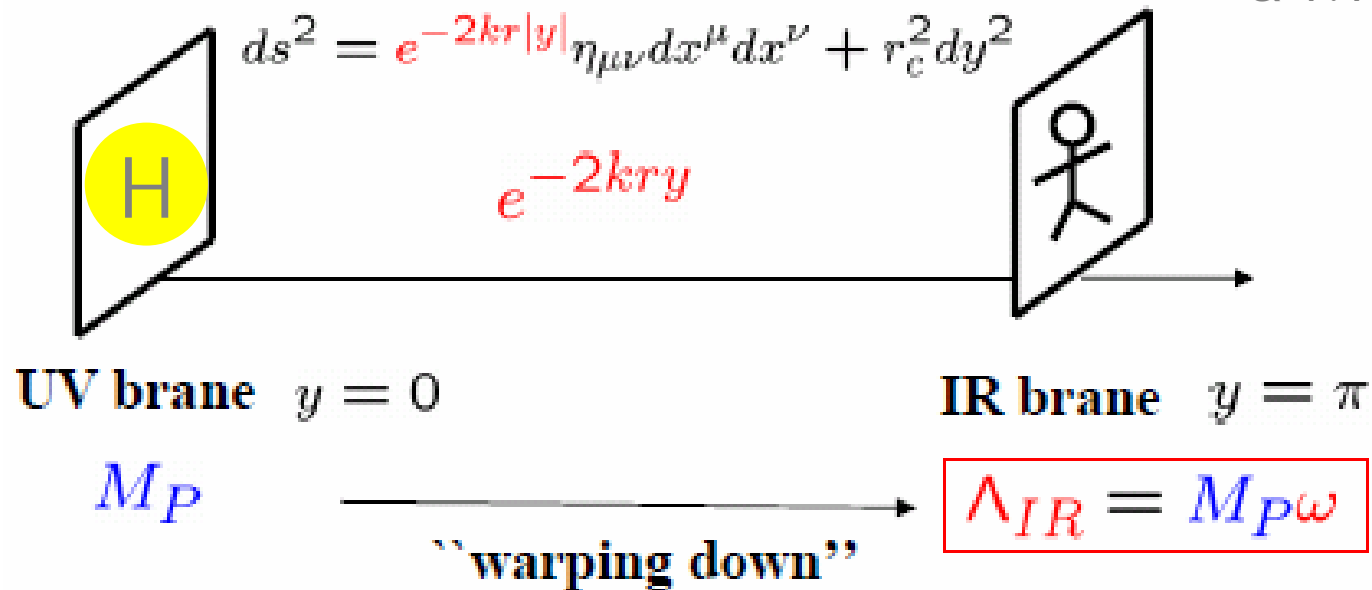
$$\begin{array}{ccccc}
 \bar{5}_H & \langle 75_H \rangle & 50_H & \bar{5}_0_H & \langle 75_H \rangle & 5_H \\
 \left(\begin{array}{c} \bar{3} \\ \bar{2} \end{array} \right) & \longleftrightarrow & \left(\begin{array}{c} 3 \\ \text{others} \end{array} \right) & \longleftrightarrow & \left(\begin{array}{c} \bar{3} \\ \text{others} \end{array} \right) & \longleftrightarrow & \left(\begin{array}{c} 3 \\ 2 \end{array} \right)
 \end{array}$$

➡ Non-Perturbative below M_p .

Problems of GUTs & Solutions

- Low Scale Gravity Mediation

H. Itoh, N. Okada
& T.Y. (2006)



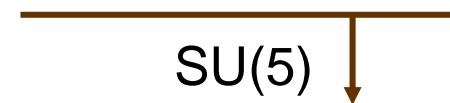
If Gravity mediation with the Minimal Ansatz.

➡ Lower cutoff scale Λ_{IR} !!

Gravitino LSP (SuperWIMP).

Problems of GUTs & Solutions

- Solutions for DTS problem
 - In Xtra Dim.
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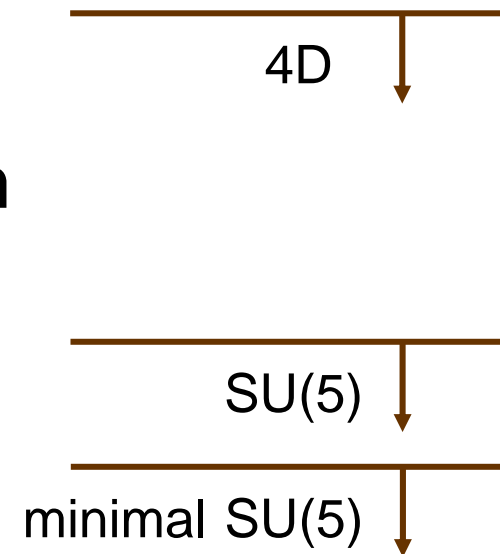


$$\begin{array}{ccccc}
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Problems of GUTs & Solutions

- Solutions for DTS problem
 - In Xtra Dim.
 - Sliding Singlet mechanism
 - Dimopoulos-Wilczek mechanism
 - GIFT mechanism
 - Missing Partner mechanism
 - Fine-tuning



Not natural, but **technically natural**.

It is true for both μ & B .

Y.Kawamura, H.Murayama
& M.Yamaguchi (1995)

Problems of GUTs & Solutions

- Fermion Spectrum

Wrong GUT relation: $M_d = M_e^T$

- Non-Renormalizable Operators

$$\kappa \bar{5}_i 24_H 10_j \bar{5}_H \xrightarrow{\langle 24_H \rangle} \text{GUT breaking}$$

$\mathcal{O}(M_{\text{GUT}}/M_{\text{cutoff}})$

⇒ Little effects on RGE
~~New mixing~~ in Flavor

- Proton Decay

NRO can suppress
only Yukawa of H^C .



$M_C \sim M_{\text{GUT}}$ is allowed.

D.E. Costa & S. Wiesenfelds (2003)

Analysis

● Parameters & Benchmark values

- We change M_{cutoff} .
- GUT parameters : $M_{\text{GUT}} = M_{\text{c}} = 2 \times 10^{16} \text{ GeV}$
 $\lambda_{24} = 1, \quad \lambda_{15} = 0$
- Seesaw parameters :
Type I : $\hat{M}_N = M_R \mathbf{1}, \quad \mathbf{R} = \mathbf{1}, \quad M_R = 10^{15} \text{ GeV}$
Type II: $M_T = 10^{15} \text{ GeV}, \quad \lambda_U = \lambda_D \sim 1$
- Low energy parameters :
 $m_\nu : \text{NH}, \quad \sin \theta_{13} = 0, \quad \theta_{\text{Maj}} = 0$
- ~~SUSY~~ parameters : $\tilde{m}_0^2 = A_0 = M_{1/2} = 1 \text{ TeV}$

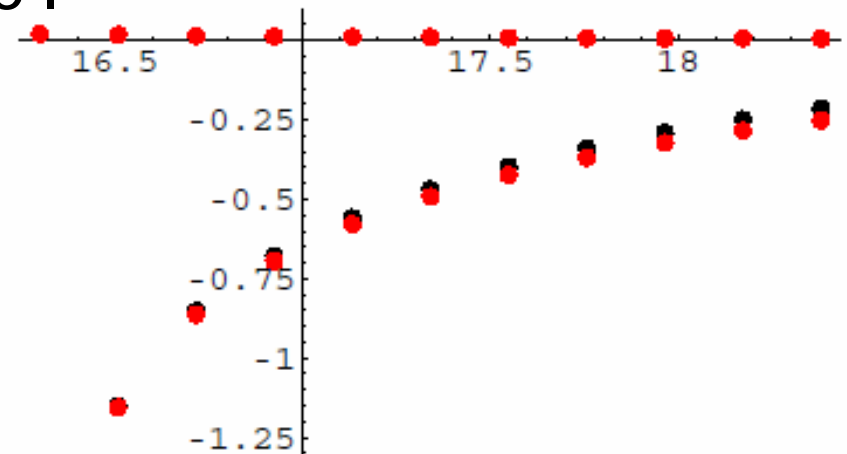
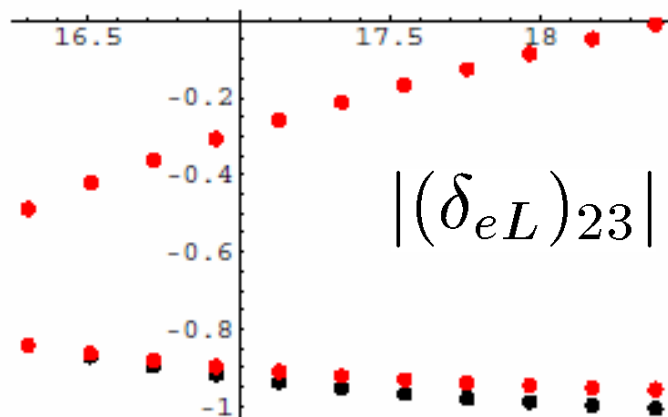
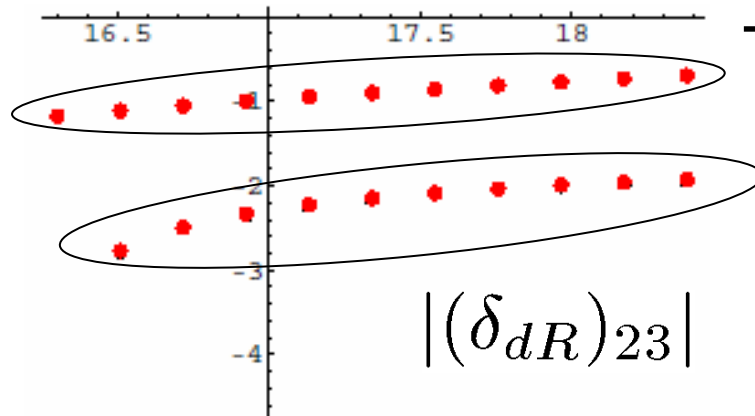
Analysis

Preliminary.

● Results : $M_{\text{seesaw}} = 10^{15} \text{ GeV}$

● : $\lambda_{24} = 1$

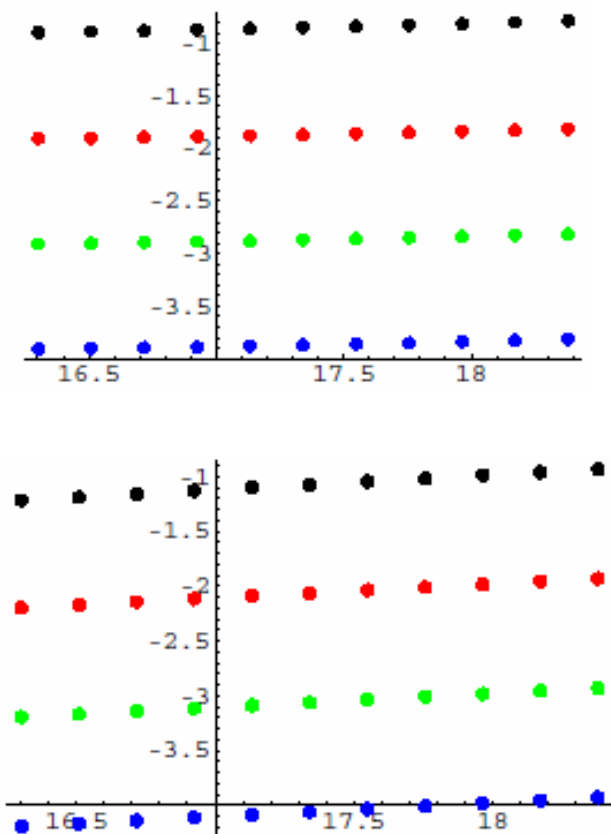
● : $\lambda_{24} = 0.01$



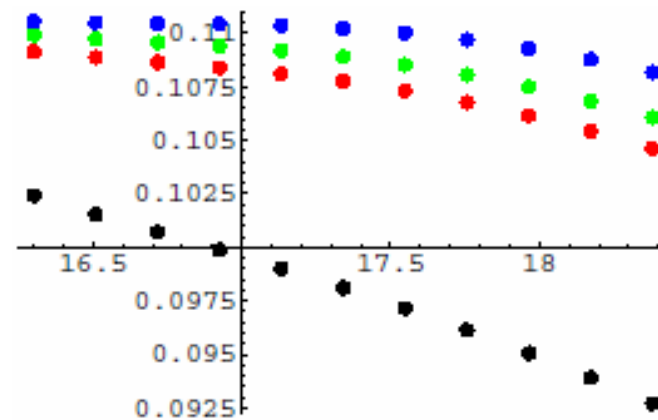
Analysis

Preliminary.

- Results : $M_{\text{seesaw}} = 10^{12}$ GeV (Type II)



- : $Y_\nu^2 \sim 10^{-1}$
- : $Y_\nu^2 \sim 10^{-2}$
- : $Y_\nu^2 \sim 10^{-3}$
- : $Y_\nu^2 \sim 10^{-4}$



$$\log_{10} |R_{23}| \sim 0.1$$

Summary



- We investigate LFV & QFV in “minimal” SU(5) models with Type I / Type II seesaw.
 - Cutoff dependence:
 - Type I : sensitive
 - Type II: QFV/LFV is insensitive
 - λ_{24} dependence : quite small
- Future works
 - More exhaustive scan.
 - Phenomenological constraints
 - More natural model : MP, SO(10)...