Unrelated mixing and flavour non-conservation

3 families from one in 5+1 dim

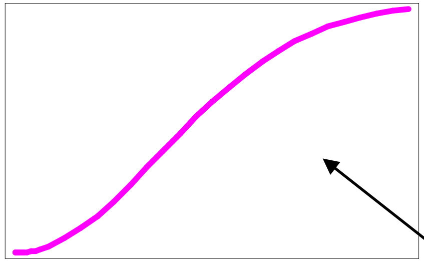
$$\Phi = e^{i n\phi}$$

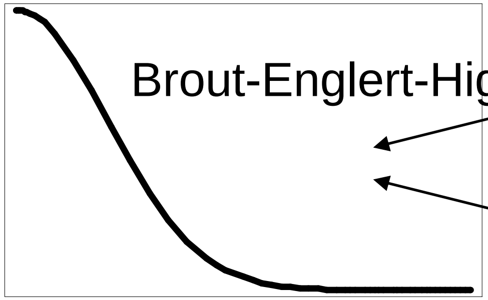
Just a reminder: we assume a background scalar field Φ providing a vortex in the 2 extra dimensions;
It vanishes at the origin– where we live!
For winding number n, we get n 4-dim chiral fermions for each 6-dim fermionic field.

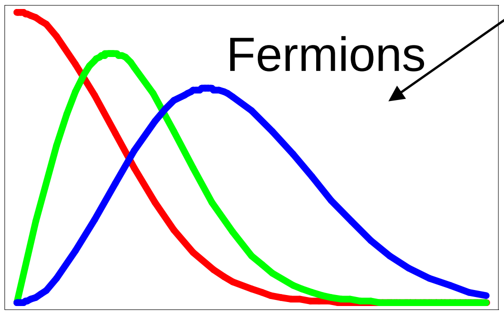
For some reason, n=3 !!!

A summary of (older) work in collaboration with
Maxim Libanov, Serguey Troitsky, Emil Nugaev

vortex





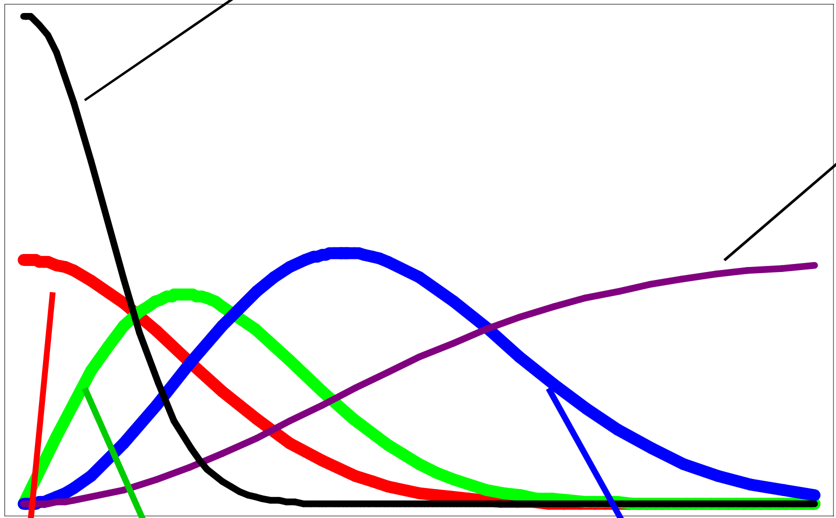


Field Content

fields		profiles	charges		representations	
			$U(1)_g$	$U(1)_Y$	$SU(2)_W$	$SU(3)_C$
scalar	Φ	$F(r)e^{i\theta}$ $F(0)=0,\ F(\infty)=v_\Phi$	$+1$	0	$\mathbf{1}$	$\mathbf{1}$
scalar	X	$X(r)$ $X(0)=v_X,\ X(\infty)=0$	$+1$	0	$\mathbf{1}$	$\mathbf{1}$
scalar	H	$H(r)$ $H(0)=v_H,\ H(\infty)=0$	-1	$+1/2$	$\mathbf{2}$	$\mathbf{1}$
fermion	Q	3 L zero modes	axial $+3/2$	$+1/6$	$\mathbf{2}$	$\mathbf{3}$
fermion	U	3 R zero modes	axial $-3/2$	$+2/3$	$\mathbf{1}$	$\mathbf{3}$
fermion	D	3 R zero modes	axial $-3/2$	$-1/3$	$\mathbf{1}$	$\mathbf{3}$
fermion	L	3 L zero modes	axial $+3/2$	$-1/2$	$\mathbf{2}$	$\mathbf{1}$
fermion	E	3 R zero modes	axial $-3/2$	-1	$\mathbf{1}$	$\mathbf{1}$

Table 1: Scalars and fermions wi … ience, we describe here also the profile … wave functions in extra dimensions.

The 3 fermion modes have different shapes, and different winding properties in the extra dimension variable ϕ



The 3 fermion modes have different shapes, and different winding properties in the extra dimension variable ϕ

We get a mass matrix like :

$$\begin{array}{cc} \begin{pmatrix} small & \varepsilon & \\ & medium & \varepsilon \\ & & large \end{pmatrix} & \begin{array}{c} n = \\ 2 \\ 1 \\ 0 \end{array} \end{array}$$

An auxiliary scalar X , with winding $e^{i\phi}$ can give the small Cabibbo mixings ε

The scheme is very constrained, as the profiles are dictated by the equations, instead of being imposed by hand, like in multilocalisation; Yet, several schemes possible …

Some developments :

- compactification of the 2 extra dim actually takes place on a sphere instead of a plane
  - -avoid localisation problem of gauge bosons
  - -little difference for charged modes,
  - -avoid multiple light neutrino excitations

Neutrinos :

-Could be treated the same (DIRAC) way (specially on the sphere)
$\rightarrow$ hierarchical modes,

-Large angles posssible by favouring diagonal/off diagonal couplings for charged leptons/neutrinos

-Alternative involves one extra “bulk” field for R neutrinos $\rightarrow$ hierarchical scheme could have one massless neutrino.

« family number » (n) is approximatively conserved ! - $e^{in\phi}$ plays somewhat like a U(1) horizontal symmetry, No FCNC for the lowest KK gauge boson exchange.

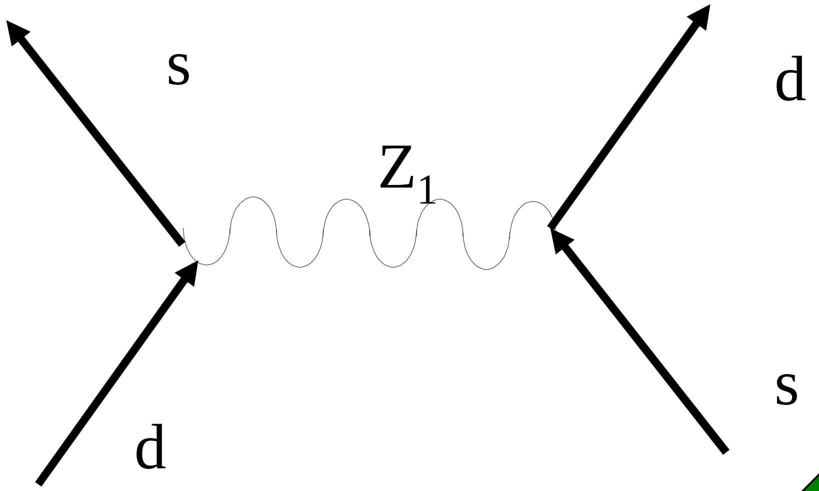
All gauge bosons, in particular, Z and Gluons possess 2 types of Kaluza-Klein excitations

- radial (approx. flavor conserving, up to ε)
- angular : $Z_{\pm 1}$ behaves like $e^{i\phi}$

$Z_{\pm 1}$ thus carries « family number »

Flavour violation in the charged sector is fairly independent of the mixing matrix !
Lepton flavour violation not directly linked to neutrino sector

« family number » (n) is approximatively
conserved ! - somewhat like U(1) horizontal symmetry $e^{i\phi}$



u e

c μ

$Z_{\pm 1}$ thus carries
« family number »

Flavour conserving

Flavour violating,

LIMITS

Family number conserving

→ LIMITS

Typical limit

$K_L \rightarrow \mu^- e^+$ or $\mu^+ e^-$ B.R. $< 10^{-12}$

Expect thus typical mass scale $M_{Z1} > (10^{12})^{1/4} M_Z = 100$ TeV

In fact, the small overlap of wave functions implies

some suppression of the coupling; κ

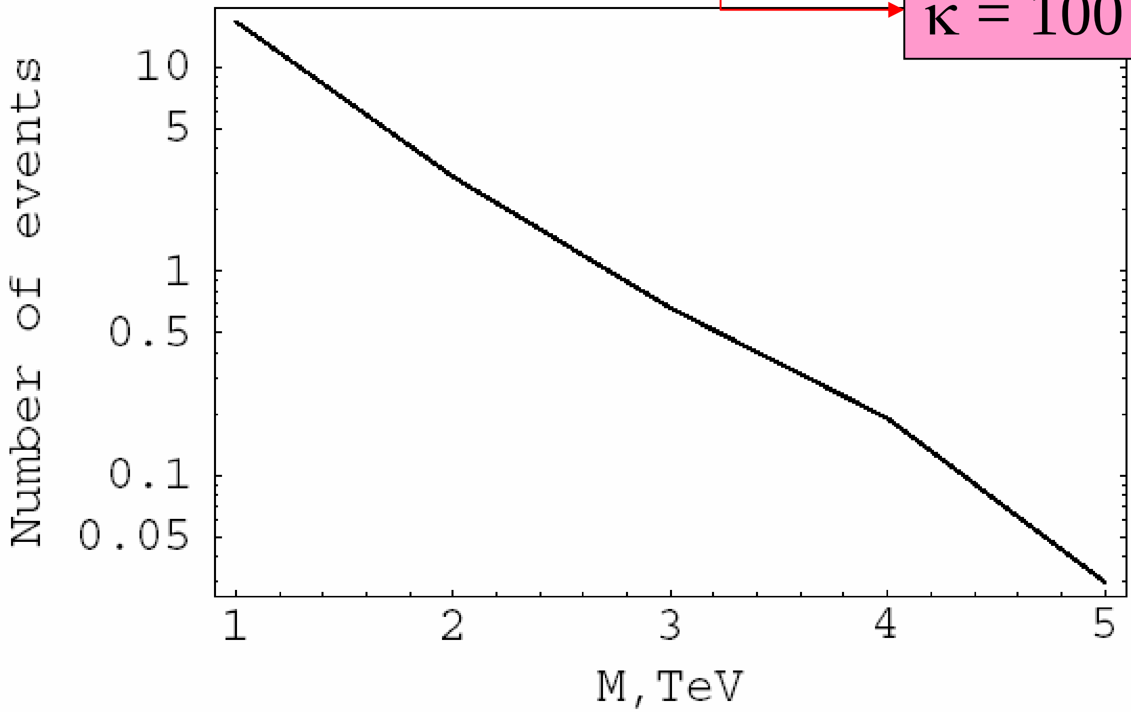
→ bound becomes $M(Z_1) > \kappa\ 100$ TeV

$\mu \rightarrow e\,\gamma$ NOT a favoured process at this order !!

$\mu \rightarrow e\,\nu\,\nu'$, $\tau^- \rightarrow \mu^-\,\mu^-\,e^+$- (or $\mu\,\nu\,\nu'$) possible

We saturate the bound on κ

$\kappa = 100\ \mathrm{TeV}/M_{Z1}$



$\mu^+ e^-$ pairs produced,

numbers for $\mu^- e^+$ are one order below at LHC,
due to quark content of protons

LHC (1 year high lumin, 100 fb^{-1})

$\bar{t} + c$ or $\bar{b} + s$ are similarly produced by the **gluon excitations**,

Expect a **few 1000's events ---** but must consider background!