Flavour and Good Taste

Starring Graham Ross

Steve King
GrahamFest, Oxford, 30/09/11

Graham

c.1980

c.2006

PROF G G ROSS
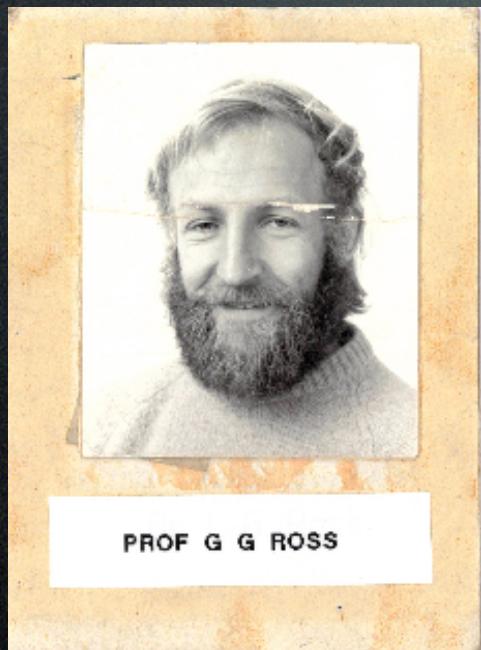
Fermion masses and mixings

(Profile of a viable string theory)

G.G.Ross, KITP, Santa Barbara, Sept 2006

The Standard Model

auge structure

$(3) \times SU(2) \times U(1)$ SU(5), SO(10)?

Multiplet content

(?)

undamental parameters

quark and lepton masses and mixings
CP violating phase

recision tests - no non-SM (ν) phenomena

Good taste 1: Large top quark mass predicted way ahead of its time from infrared fixed points (Brian Pendleton talk) and radiative EWSB in MSSM (Luis Ibanez talk)
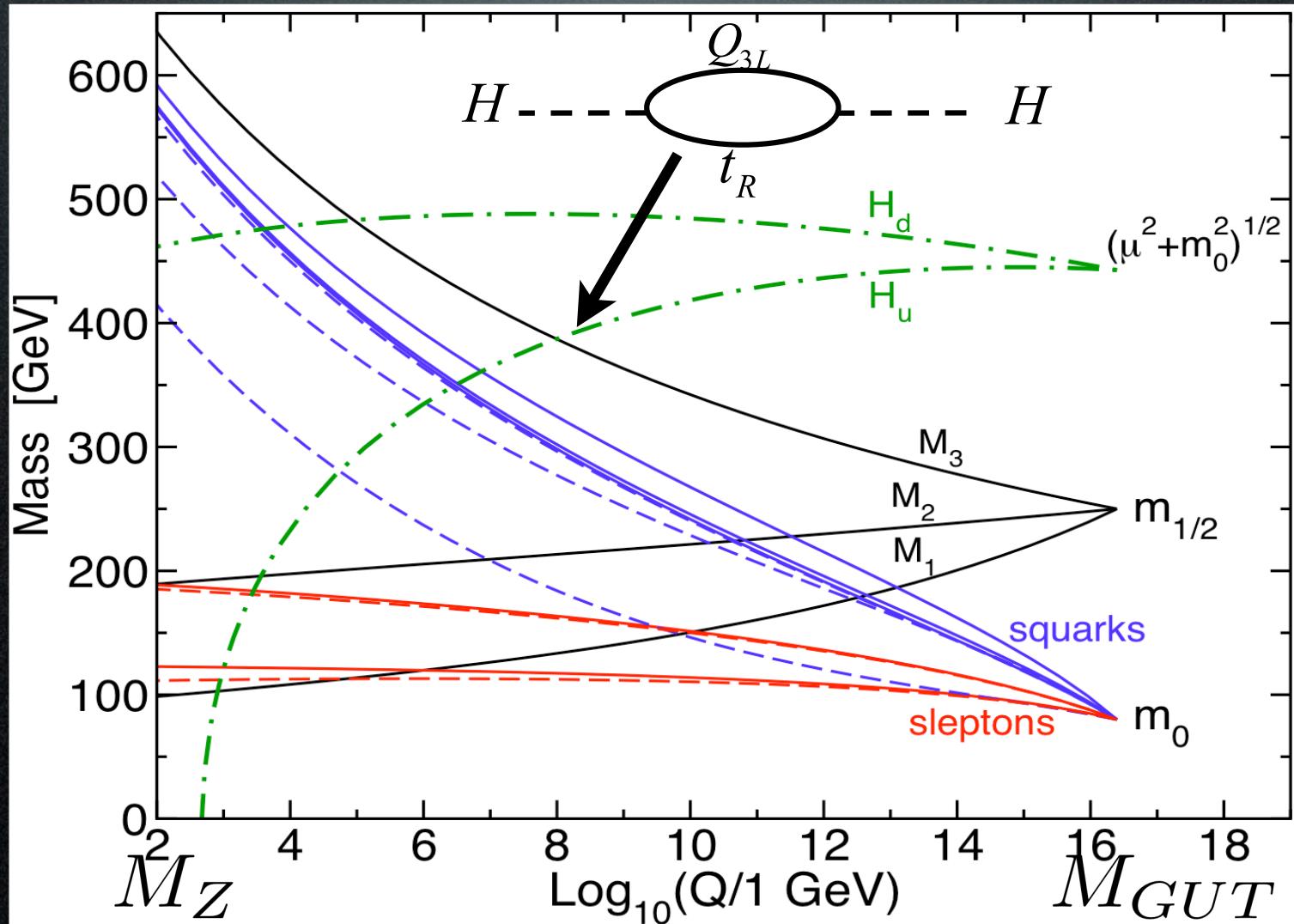
Good taste 2: GST relation from texture zero and symmetric structure

Graham: "the only quantitative prediction BSM which has chance to be correct in fermion sector"

$$(M^d)_{2\times 2} \propto \begin{pmatrix} 0 & \varepsilon^3 \\ \varepsilon^3 & \varepsilon^2 \end{pmatrix}$$

Good taste 3: use family symmetry and GUTs to explain quark and lepton masses and mixings

$$U_{\mathrm{CKM}} = U_{\mathrm{u}} U_{\mathrm{d}}^{\dagger}$$

GUT relation

e.g.: $U_{\nu} = U_{\mathrm{TB}}$

$$U_{\mathrm{MNS}} = U_{\mathrm{e}} U_{\nu}^{\dagger}$$
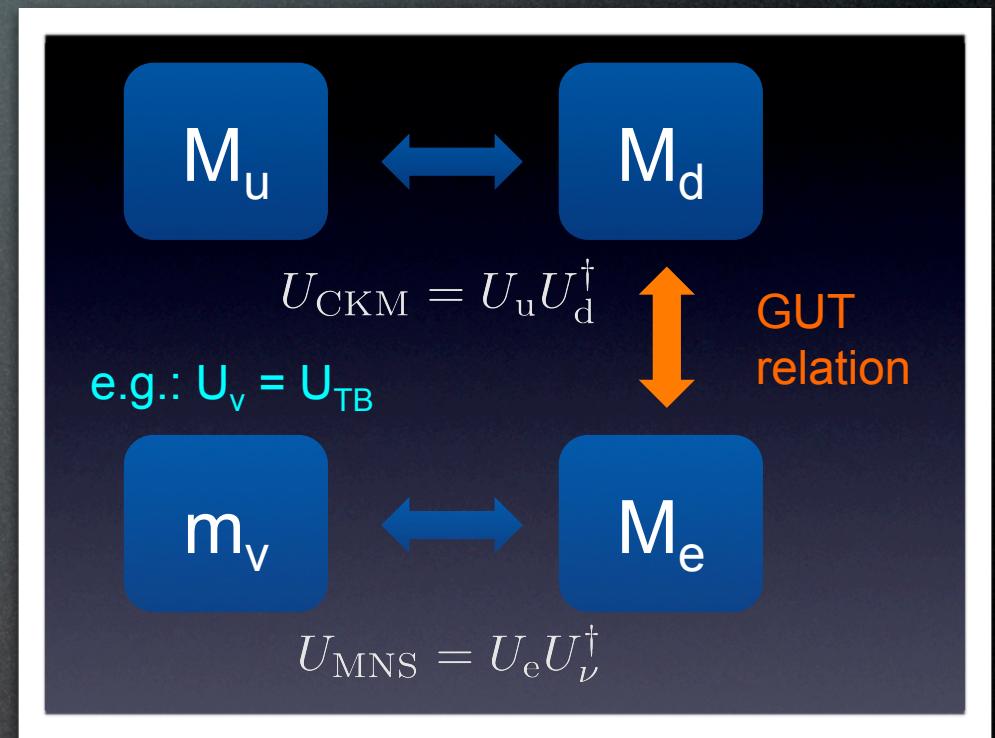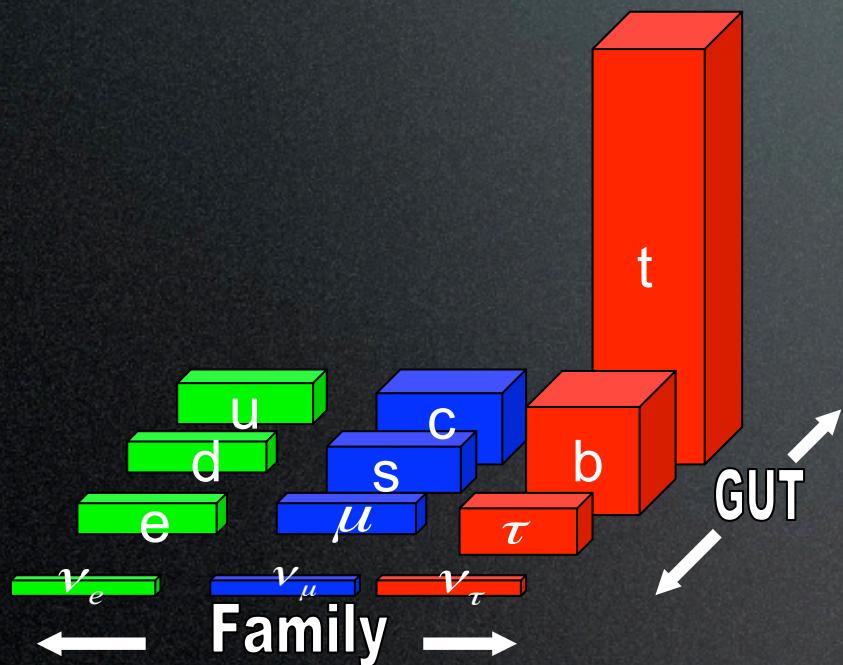
Good taste 4: Choose non-Abelian 2-3 family symmetry due to small V_{cb}

$$M^d \sim \begin{pmatrix} 0 & \epsilon^3 & \epsilon^3 \\ \epsilon^3 & \epsilon^2 & \epsilon^2 \\ \epsilon^3 & \epsilon^2 & 1 \end{pmatrix}$$
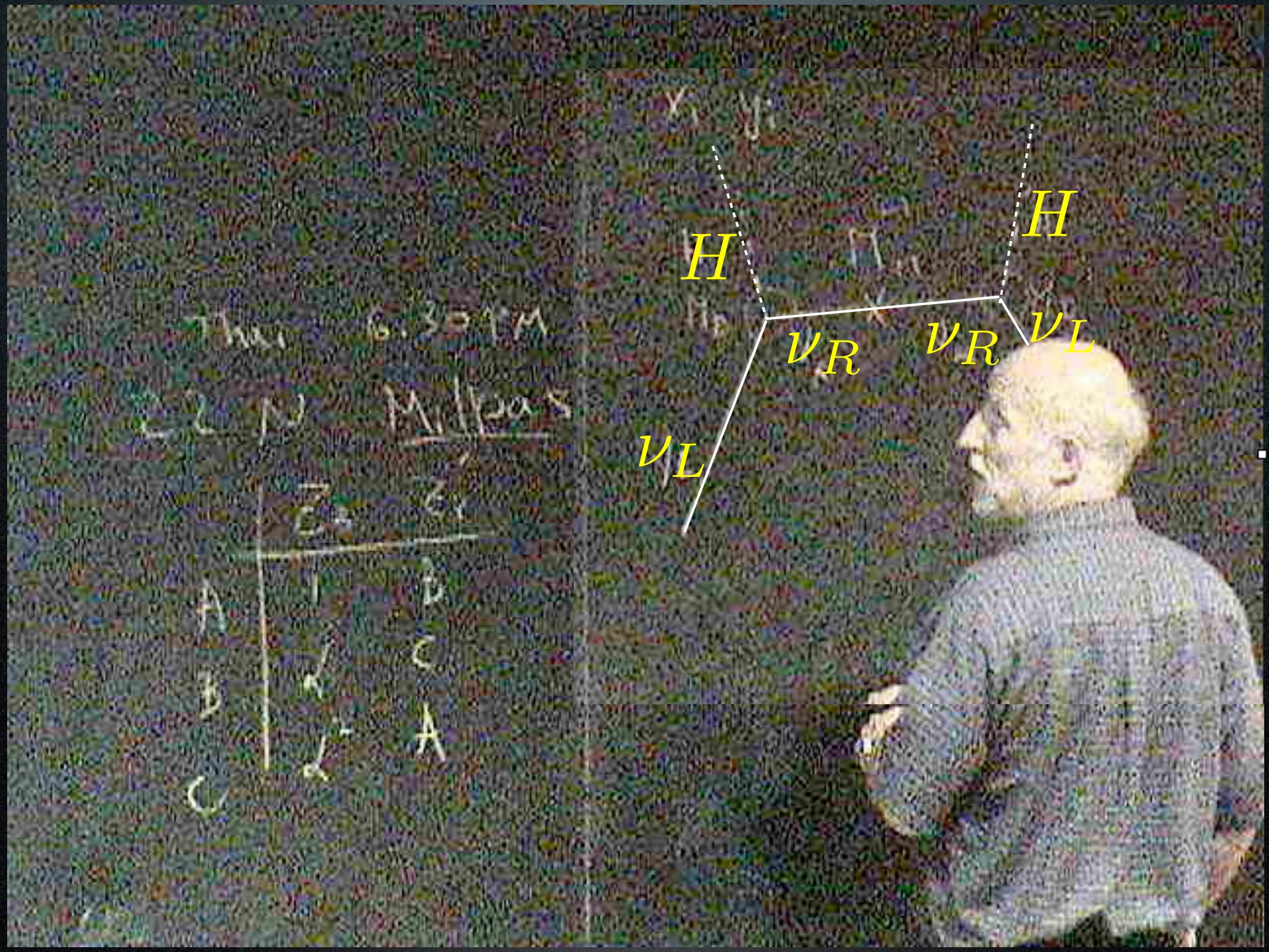
Good taste 5: Choose non-Abelian family symmetry spanning all three families due to large neutrino mixing via see-saw and SD

$$M_R = \begin{pmatrix} M_1 & 0 & 0 \\ 0 & M_2 & 0 \\ 0 & 0 & M_3 \end{pmatrix} \qquad M_D = \begin{pmatrix} 0 & \varepsilon^3 & \varepsilon^3 \\ -\varepsilon^3 & \varepsilon^3 & \varepsilon^3 \\ \varepsilon^3 & \varepsilon^3 & 1 \end{pmatrix} v$$

$$M^\nu = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & -1 \\ 0 & -1 & 1 \end{pmatrix} \frac{\varepsilon^6 v^2}{M_1} + \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix} \frac{\varepsilon^6 v^2}{M_2} + O\left(\frac{v^2}{M_3}\right)$$

Tri-bimaximal neutrino mixing

The Family Business

SU(3)

S. F. King and G. G. Ross, Phys. Lett. B 520 (2001) 243 [hep-ph/0108112];

G. G. Ross and L. Velasco-Sevilla, Nucl. Phys. B 653 (2003) 3 [hep-ph/0208218] ;

S. F. King and G. G. Ross, Phys. Lett. B 574 (2003) 239 [hep-ph/0307190];

I. de Medeiros Varzielas and G. G. Ross, Nucl. Phys. B 733 (2006) 31 [hep-ph/0507176]

R.d.A.Toorop, F.Feruglio, C.Hagedorn[arXiv:1107.3486].

C. Luhn, S. Nasri and P. Ramond, J. Math. Phys. 48 (2007) 123519 [arXiv:0709.1447]; S. F. King and C. Luhn, Nucl. Phys. B 820 (2009) 269 [arXiv:0905.1686]. S. F. King and C. Luhn, Nucl. Phys. B 832 (2010) 414 [arXiv:0912.1344 [hep-ph]].

PSL$_2$(7)

Δ_{96}

SO(3)

S. F. King, JHEP 0508 (2005) 105 [hep-ph/0506297]; S. F. King and M. Malinsky, JHEP 0611 (2006) 071 [hep-ph/0608021].

I. de Medeiros Varzielas, S. F. King and G. G. Ross, Phys. Lett. B 648 (2007) 201 [hep-ph/0607045].

Δ_{27}

Z$_2$ × Z$_7$

S$_4$

C. Luhn, S. Nasri and P. Ramond, Phys. Lett. B 652 (2007) 27 [arXiv:0706.2341].

C. Hagedorn, M. Lindner and R. N. Mohapatra, JHEP 0606 (2006) 042 [hep- ph/0602244]; F. Bazzocchi, L. Merlo and S. Morisi, arXiv:0901.2086. C.Hagedorn, S.F.King, C.Luhn, JHEP 1006 (2010) 048. [arXiv:1003.4249].

A_4

Other symmetries:

A. Aranda, C. D. Carone and R. F. Lebed, Phys. Rev. D 62 (2000) 016009 [hep- ph/0002044]; F. Feruglio, C. Hagedorn, Y. Lin and L. Merlo, Nucl. Phys. B 775 (2007) 120 [hep-ph/0702194]; M. C. Chen and K. T. Mahanthappa, Phys. Lett. B 652 (2007) 34 [arXiv:0705.0714]; P. H. Frampton and T. W. Kephart, JHEP 0709 (2007) 110 [arXiv:0706.1186]; A. Aranda, Phys. Rev. D 76 (2007) 111301 [arXiv:0707.3661]; P. H. Frampton and S. Matsuzaki, arXiv:0902.1140.

W. Grimus and L. Lavoura, JHEP 0508 (2005) 013 [hep-ph/0504153]; W. Grimus and L. Lavoura, JHEP 0601 (2006) 018 [hep-ph/0509239]; N. Haba, A. Watanabe and K. Yoshioka, Phys. Rev. Lett. 97 (2006) 041601 [hep-ph/0603116]; R. N. Mohap- atra, S. Nasri and H. B. Yu, Phys. Lett. B 639 (2006) 318 [hep-ph/0605020]; Y. Koide, Eur. Phys. J. C 50 (2007) 809 [hep-ph/0612058]; M. Mitra and S. Choubey, Phys. Rev. D 78 (2008) 115014 [arXiv:0806.3254].

M. Frigerio, S. Kaneko, E. Ma and M. Tanimoto, Phys. Rev. D 71 (2005) 011901 [hep-ph/0409187]; K. S. Babu and J. Kubo, Phys. Rev. D 71 (2005) 056006 [hep- ph/0411226]; Y. Kajiyama, E. Itou and J. Kubo, Nucl. Phys. B 743 (2006) 74 [hep- ph/0511268]. L.L.Everett, A.J.Stuart, Phys.Rev.D79 (2009)085005.[arXiv:0812.1057]

E. Ma and G. Rajasekaran, Phys. Rev. D 64 (2001) 113012 [hep-ph/0106291]; E. Ma, Phys. Rev. D 73 (2006) 057304 [hep-ph/0511133]; G. Altarelli and F. Feruglio, Nucl. Phys. B 720 (2005) 64 [hep-ph/ 0504165]; K. S. Babu and X. G. He, hep- ph/0507217; G. Altarelli and F. Feruglio, Nucl. Phys. B 741 (2006) 215 [hep- ph/0512103]; M. Hirsch, A. S. Joshipura, S. Kaneko and J. W. F. Valle, Phys. Rev. Lett. 99 (2007) 151802 [hep-ph/0703046]; Y. Lin, Nucl. Phys. B 813 (2009) 91 [arXiv:0804.2867]; G. Altarelli and D. Meloni, arXiv:0905.0620. T. J. Burrows and S. F. King, Nucl. Phys. B 835 (2010) 174 [arXiv:0909.1433 [hep-ph]]. K. S. Babu, E. Ma and J. W. F. Valle, Phys. Lett. B 552 (2003) 207 [hep- ph/0206292]; F. Bazzocchi, S. Morisi and M. Picariello, Phys. Lett. B 659 (2008) 628 [arXiv:0710.2928]; M. Honda and M. Tanimoto, Prog. Theor. Phys. 119 (2008) 583 [arXiv:0801.0181]; G. Altarelli, F. Feruglio and C. Hagedorn, JHEP 0803 (2008) 052 [arXiv: 0802.0090]; P. Ciafaloni, M. Picariello, E. Torrente-Lujan and A. Urbano, arXiv:0901.2236. S. F. King and M. Malinsky, Phys. Lett. B 645 (2007) 351 [hep-ph/0610250].

complete model

$$U(3) \otimes SU(2) \otimes U(1) \otimes G_f \otimes G \subset SO(10) \otimes G_f \otimes G$$

King, GGR, Velasco

Good taste 6: relate family symmetry and GUTs to string theory (George Leontaris talk)

Happy retirement Graham!