1/ NEUT. SUNY SB

EXTRA "LARGE" {>> m_{pl}^{-1}, 0,01 mm!?}

Dimensions: OLD FASHION WAY

Arkani-Hamed, Dimopoulos,

Dvali, Schmaltz Mirabelli...

NOT DIMENS. Deconstruction...

latticized 5th DIMENSIONS, N.L.σ models, ...Small HIGGS {ALTERNATIVE TO SUSY}

NOT Even R.S.

JUST THE SIMPLE ORIGINAL IDEAS {TOO SOON ABANDONED...}

WHAT HAVE WE {Robert as} Learned

WHAT HAVE WE {ROYAL, not to BLAME R} HOPED [WANTED] TO LEARN:

4/

I. Introduction:

GRAVITY IS DILUTED BY RATIO OF BRANE/BULK VOLUMES.

AT DISTANCES $r < r_0$ gravity becomes 3+n dimensional

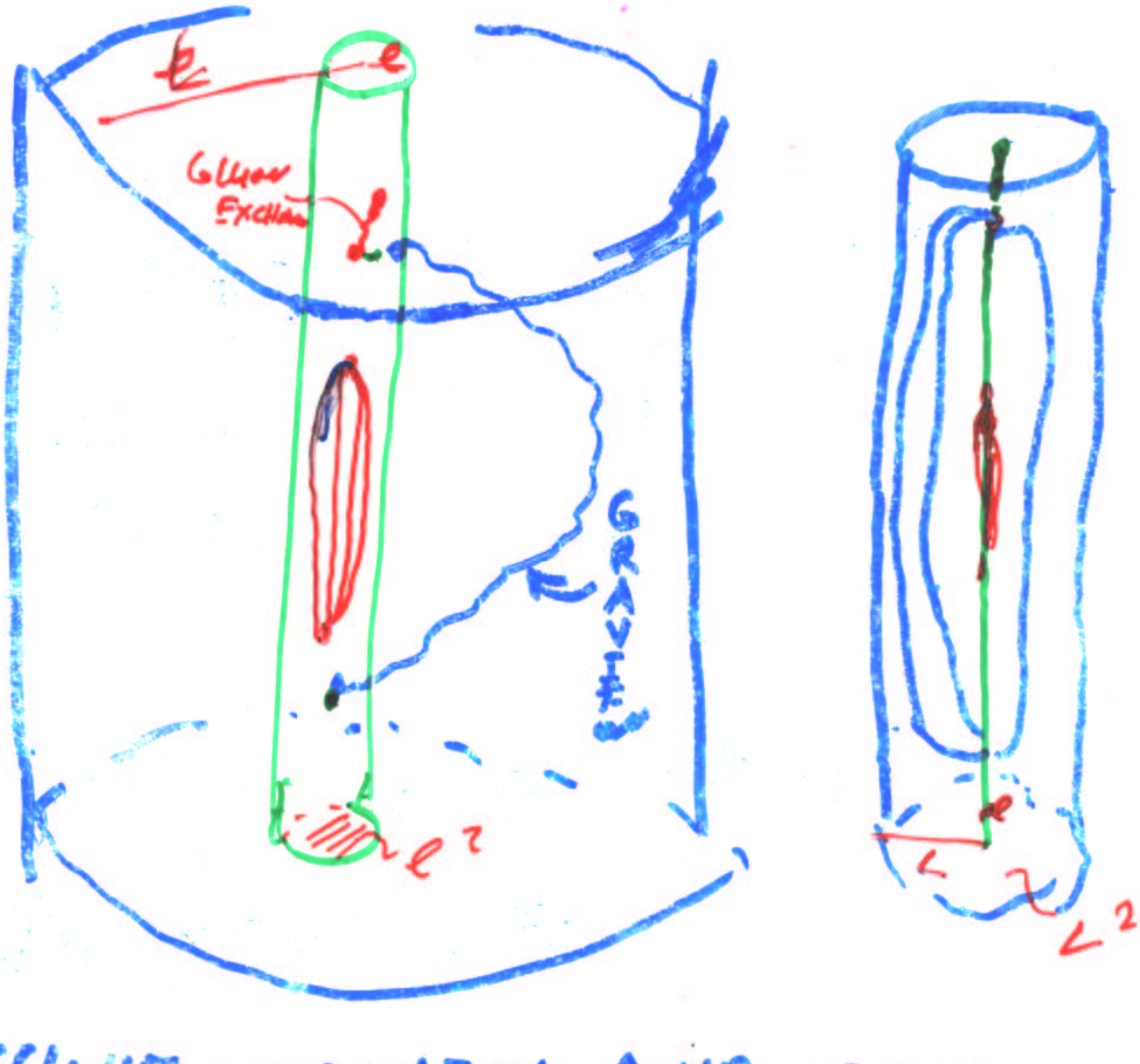
$$F_G \sim 1/r^2 \underset{r < r_0}{\longrightarrow} 1/r^4 \quad [n=2]$$ { more singular! unifies Early

CAN BE UNDERSTOOD IN 3'D TERMS AS A SUM OF

$\sum_{KK} |KK|$ $m_{KK}(n_1 n_2) \simeq \sqrt{n_1^2 + n_2^2}\ 1/r_0$

K.K.

(9) BUT GRAVITY EXTENDS BEYOND THE THIN WALL UP TO $L \approx 0{,}1$ mm.



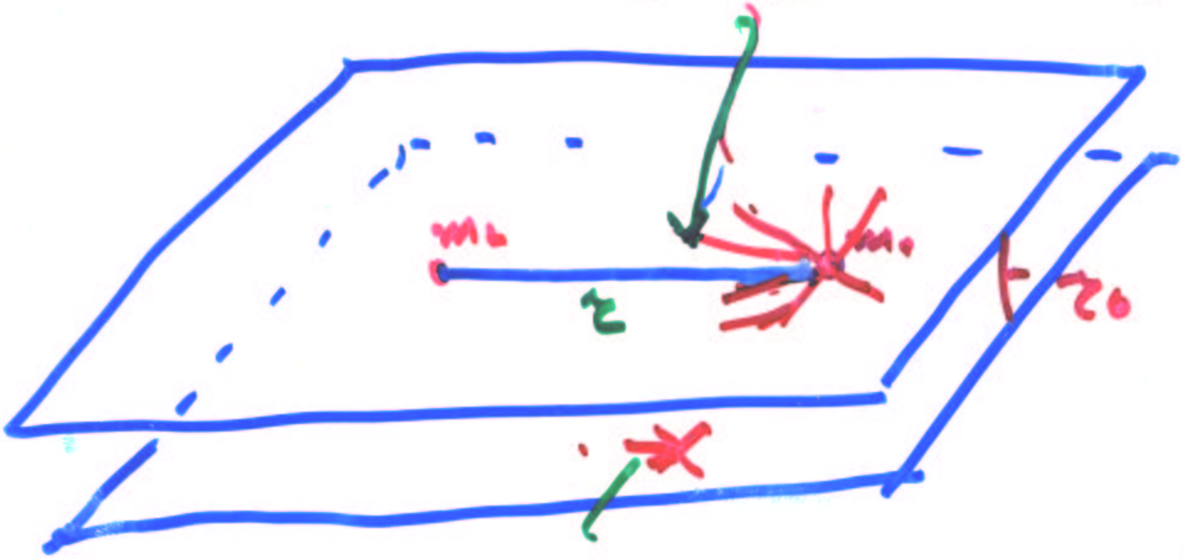
ASSUME GRAVITY AND G.INT EQUAL AT $\Delta x \approx \ell$.

THE LARGER SPREAD (OVER $A \approx L^2$) of GRA. Field Lines

As compared with spread over ℓ^2 of gauge (E.M) Field lines $G_N \approx (\ell/L)^2 \approx 10^{-34}$!

(6').

$r \gg r_0$ $\quad F_G \sim \frac{1}{r^2}$ (Gauss 3D) [5]



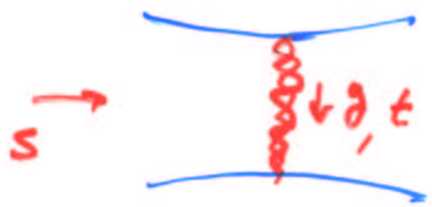
$r \ll r_0$ $\quad F_G \simeq \frac{1}{r^4}$ (Gauss 5D!)

SO GRAVITY MAY CROSS OVER FROM

$\frac{1}{r^2} \xrightarrow{r \simeq r_0} \frac{1}{r^4}$ at $r_0 = 0{,}1$ mm

a true expt' CHALLANGE

5. H.E.



$$A \approx \frac{s^2}{t} \cdot \frac{1}{M_{Pl}^2}$$

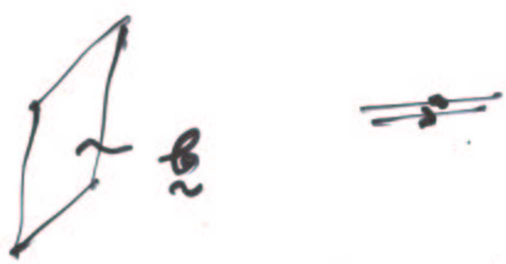
SO $\sigma_{GRV} \approx s$ but small....

But the sum of KK Exchanges Enhances IT DRAMATICALLY!

[S. N & R.S PRD...]

SHORT-CUT:

AT HIGH ENERGY – EIKONAL DESCR.



$x_0 \pm x_3$

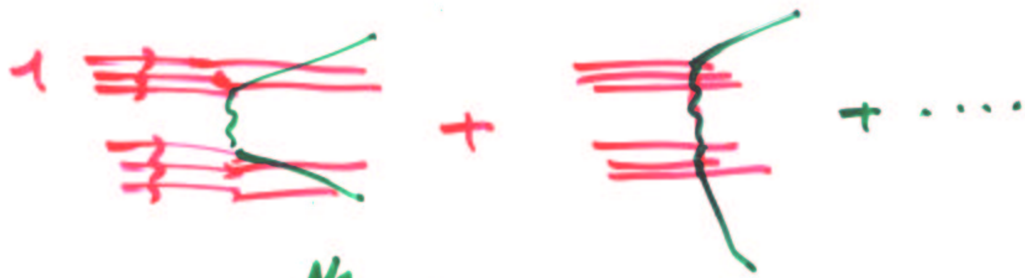
p_+, p_-

PROP IN b IS $\frac{1}{b^2}$ { b space IS 4-d for $n=2$ }

P.W. AMP $\approx \frac{1}{M_*^4} S \frac{1}{b^2}$; $b^2_{max} \approx \frac{S}{M_*^4}$ $\sigma = \frac{S}{M_*^4}$!!)

IN H.E AMP $\approx S e^{-\mu b}$ $\sigma \lesssim (\ln s)^2$ F.B.

(i) INVARIANCE UNDER "COMPOSITION" ∝ "UNIVERSALITY" ...(12)



$s \cong 2E_1E_2$

$E_1 = \sum_{i=1}^{N_1} \epsilon_i^{(1)}$ $\qquad \sigma_{12} \approx \frac{s}{m_s^4} \approx \frac{E_1 E_2}{m_s^4}$

$E_2 = \sum_{j=1}^{N_2} \epsilon_j^{(2)}$

$$= \frac{\sum \epsilon_i^{(1)} \sum \epsilon_j^{(2)}}{m_s^4}$$

$$= \sum_{i,j} \frac{\epsilon_i^{(1)} \epsilon_j^{(2)}}{m_s^4}$$

$$= \sum_{i,j} \sigma_{ij}$$

H.E SCATTERING OF ORSGINAL 1-2 PARTICLES

$= \sum$ pairwise scattering of their constituents!

(ii). BLACK HOLE FORMATION SCENARIO

$R_{sw} = \frac{\sqrt{s}}{m_s^2}$

If $b \lesssim R_{sw}$ we will FORM B.H

(next evaporate quickly)

$\sigma \approx \pi R_{sw}^2 = s/m_s^4$.

(iii): $s = m_{pl}^2$ MAX. ENERGY

$\sigma = \frac{m_{pl}^2}{m_s^4} = r_0^2$

MAX. CS ??

$\sigma(pp)$ [$E \approx 10^{12}$ GeV] $\overset{?}{\approx}$ 200 mb $\approx 10^{-25}$ cm²
$s = 10^{12}$ GeV² $= 10^6\, m_s^2 \ldots$]

NOW $\sigma_{new}(pp) \simeq \sigma_{new}(\nu p) = \cdots$
ONLY DEP. ON ENERGY

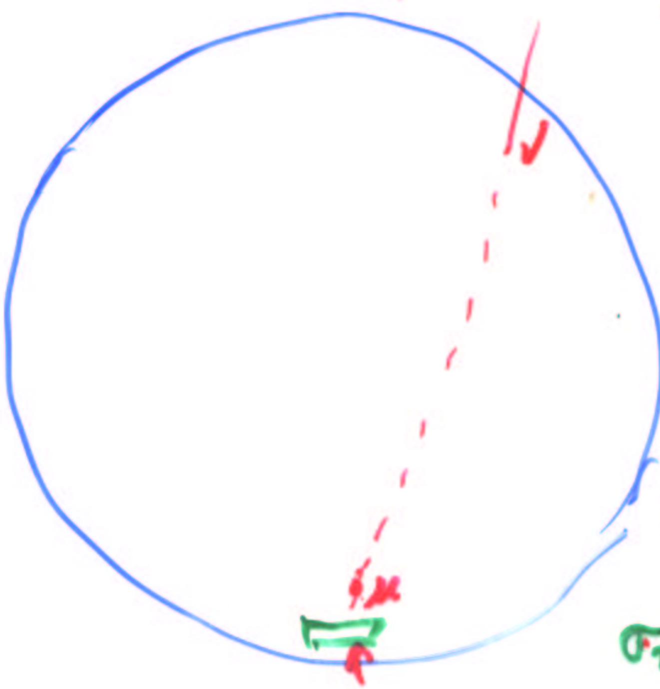
$$\sigma_{new} = \frac{10^6 (TeV)^2}{(TeV)^4 \mu_s^4} = 4 \cdot 10^6 \cdot 10^{-34}\,cm^2 \approx 10^{-29} \ldots cm^2$$

$\sigma_{new} \leq \sigma_{Hadronic}$ [NO EXPLANATION].

But could effect ν propagation: IN EARTH

ν DETector AMANDA

NP



no "UPWARD" GOING ν's WITH $E \gtrsim 10^8$ GeV

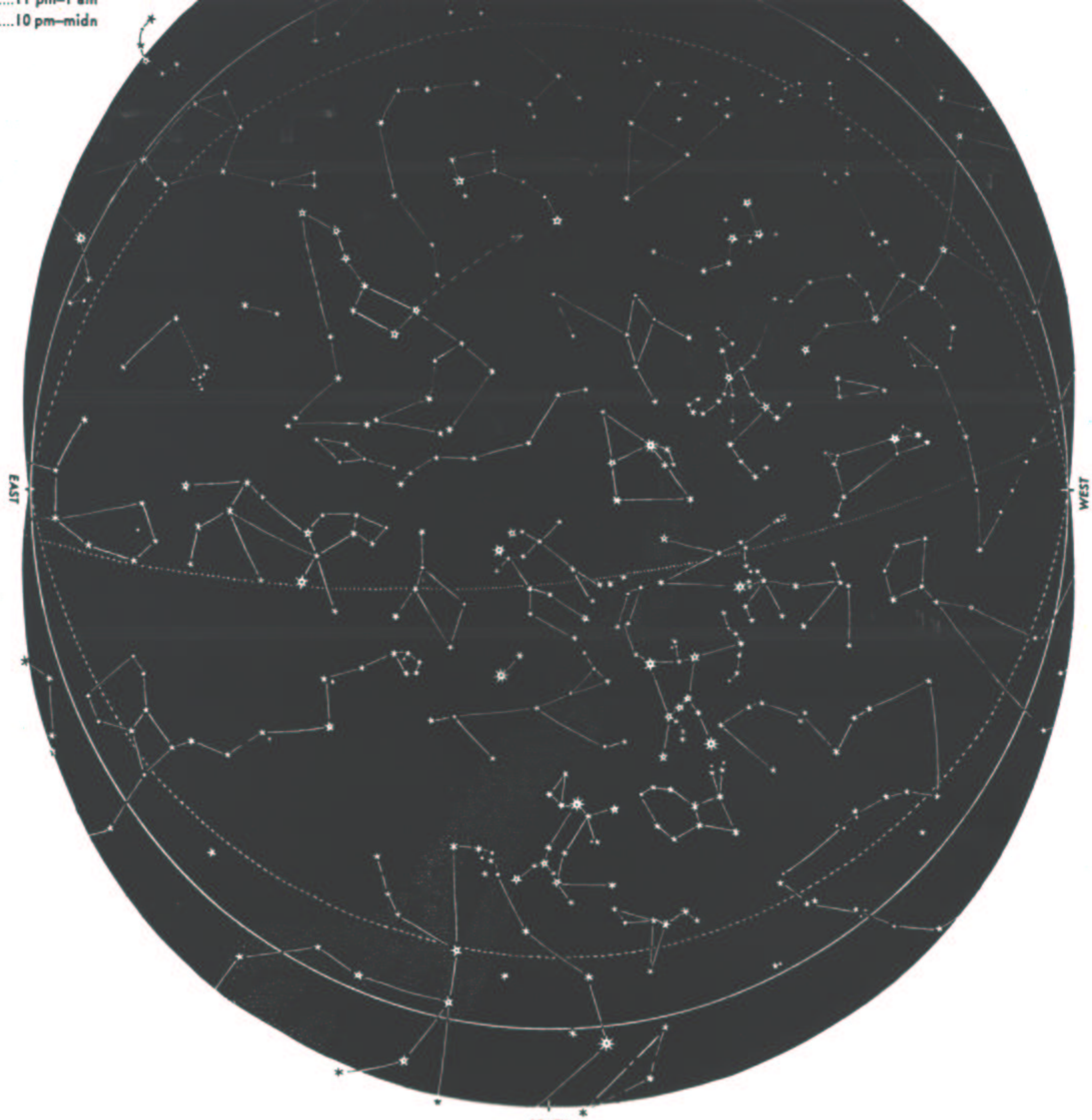
$\sigma_{WK} \approx \frac{1}{M_W^2}$ (log ...)

$\sigma_{new} \approx \frac{s}{m_s^4}$

$\sigma_{new} = \sigma_{WK}$ at
$s \approx m_s^2 \cdot 50$-500
$W \approx 10$ TeV-80 TeV

SP

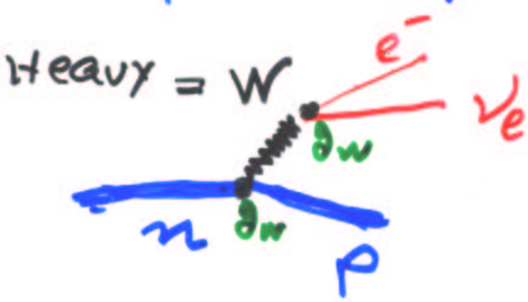
JAN 1......11 pm–1 am
JAN 16....10 pm–midn



second brightest of all stars, white, low above horizon in south. Watch horizon north of east for rising **Arcturus** in Herdsman, orange, already farther up if you are farther north than lat. 40°. Trace the **Great Hexagon,** formed by seven of the twenty brightest stars of the sky (see preceding chart) in richest region of sky; regions to east and west rather dull by contrast. Look for charming **Pleiades** high east. Twins almost overhead: sit down, facing south, to see them well. If you are far south, trace part of the great Ship, and perhaps the Dove, west of Big Dog's hind feet, and, just for sport, the faint Unicorn.

The TWO ROUTS TO WEAKNESS:

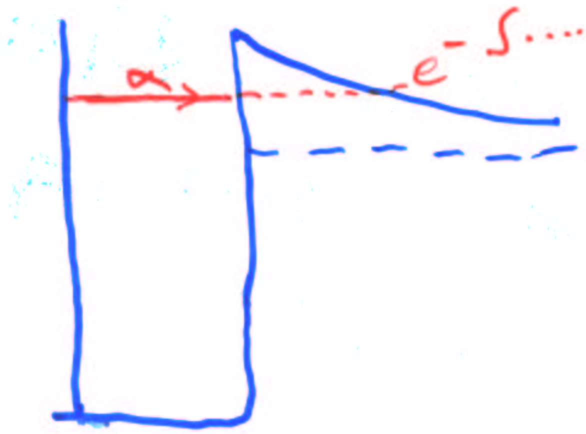
(1). β Decays "weak INTERACTIONS"



$$G_F \propto \frac{g_W^2}{M_W^2} \approx \frac{10^{-5}}{(GeV)^2}$$

Heavy MASSES "HIDE INTERACTION"

(2) α Decays: very Long lifetime DUE TO TUNNELING



USUALLY (1) IS USED.

EXAMPLE "GUTS" and PROTON LONGEVITY:

CHARGE QUANTIZATION & "Running" of COUPLINGS TO COMMON VALUE suggest

$SU(3)_c \times SU(2) \times U(1) \leftarrow SU(5), SO(10)\dots$

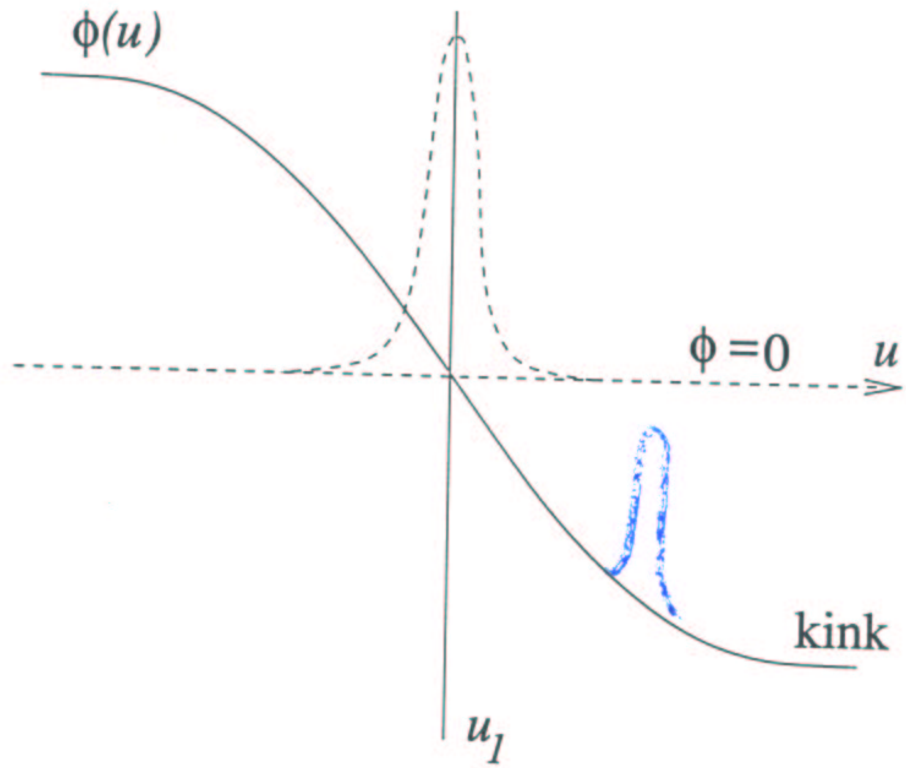


Figure 1: The kink solution as a function of the fifth compact coordinate u. A chiral massless fermion having, thanks to the Yukawa coupling, the indicated Gaussian profile, is supported at $u = u_1$ By adding other fermions with appropriate five dimensional mass terms aand the same yukawa couplings ,we could generate symilar xiral domain walls fermions attached to the same kink solution at different locations u_i

KINK GENERATES LINEAR POTENTIAL : MASSLESS FERMION HAVE GAUSSIAN W.F

$\left(\frac{\partial}{\partial u} + u\right)\psi_u^0 = 0 \quad \psi_u^0 = e^{-u^2/2}$

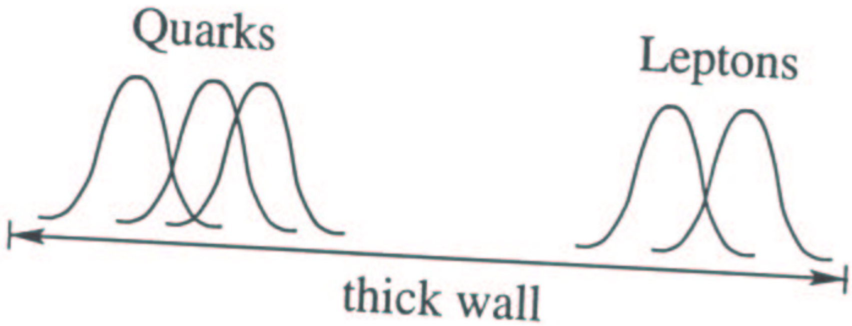


Figure 1: *Profile of Standard Model fermion wave functions (vertical axis) in the extra dimensions (horizontal axis). The fermions freely propagate in 3+1 dimensions (not shown) and are "stuck" at different locations in the extra dimensions. The gauge and Higgs fields' wave functions occupy the whole width of the thick wall. Direct couplings between the fermions are then suppressed by the exponentially small overlap of their wave functions. If – as shown here – quarks and leptons live on opposite ends of the wall profile protons become essentially stable. The hierarchy of Yukawa couplings arises from order one (in units of the fermion wave function width) distances between left and right handed components of the fermions.*

we will see that the long-distance 4-dimensional theory can naturally have exponentially small Yukawa couplings, arising from the small overlap between left- and right-handed fermion wave functions. Similarly, without imposing any symmetries to protect against proton decay, the proton decay rate can be exponentially suppressed to safety if the quarks and leptons are are localized at different ends of the wall *. We emphasize that there is nothing fine-tuned about this from the point of view of the low-energy 4-dimensional theory: all the exponentially small couplings are technically natural. However, our examples violate the usual intuition that small couplings in a low-energy theory must be explained by symmetries in the high-energy theory. Instead,

*Our approach to to the fermion mass hierarchy similar in spirit to the one in [7]. For other approaches to suppressing Yukawa couplings and proton decay, see [6].

SEP! Q–L BUT NOT
$Q\bar{Q} \Rightarrow n\bar{n}$ viable!

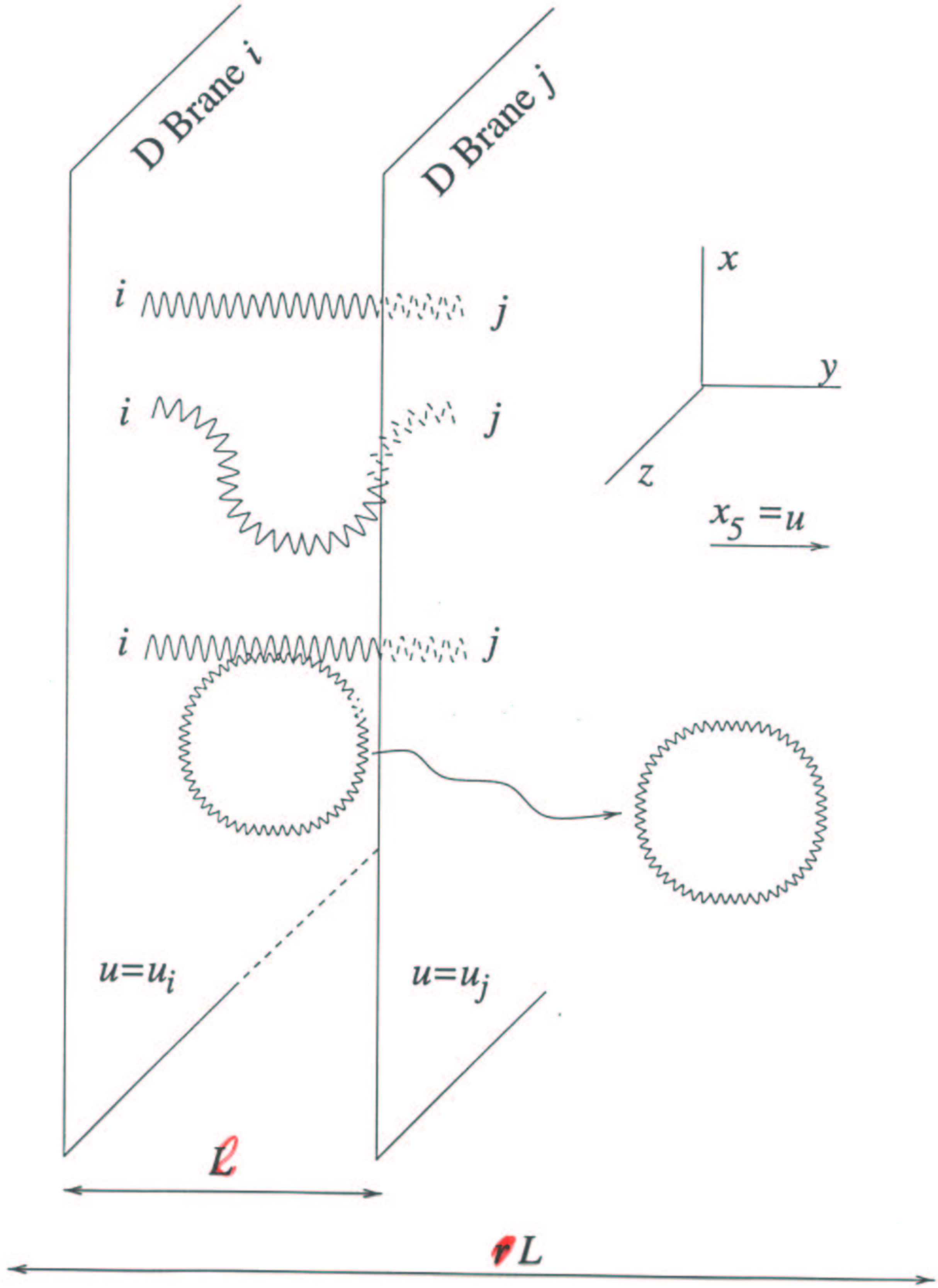


Figure 2: Open strings connecting the i th aand j th brane. the sequence of open strings starting with the uppermost streched string and proceeding with time down-wards, illustrates the gradual distortion of the open string ,which eventually lead to the excision of a closed string. The open string with the d boundry conditions and ,afortiori,its lowest spin one massless gauge bossons, are limmited to move in the 'Fat Brane" region of size L. the closed sstring and the

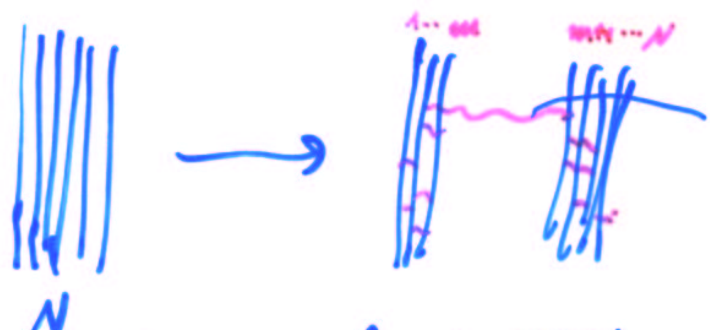
N degenerate D branes

N^2 DIRECTED 0 length STRINGS =>

U(N) GAUGE BOSONS V_μ^{ij}

THE GAUGE BOSSONS ARE RESTRICTED TO THE ABOVE REGION (u ≃ 0). BY CONSTRUCTION. !!

SYMMETRY BREAKING (HIGGS) HAS A SIMPLE INTERPRETATION



$SU(N) \to SU(m) \times SU(N-m)$

Figure 4: illustrating how the joining modes of the two DN and ND half strings naturally leads to the a D string

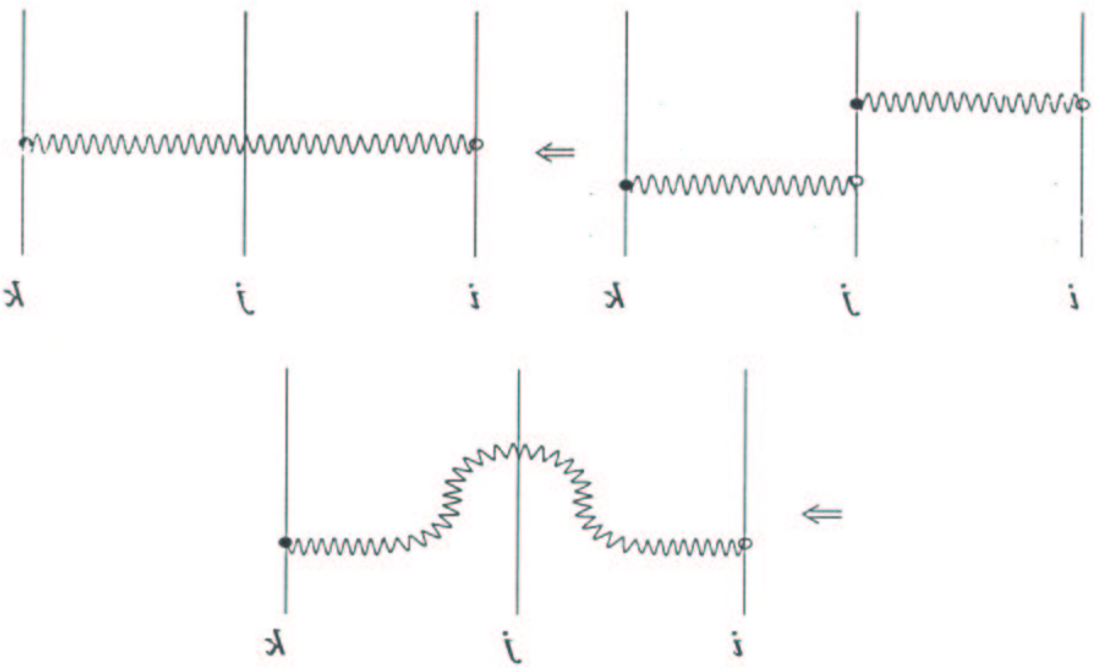
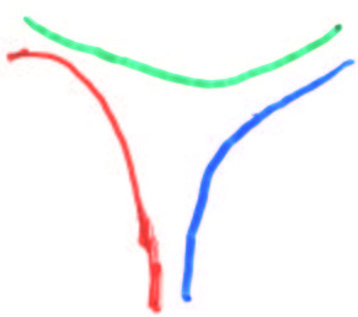


Figure 5: The trilinear gauge coupling from the brane point of view. In the Dbrane language it It corresponds to the string bit $V_{i,\bar{j}}$ joining with the string bit $V_{j,bar k}$ so as to produce the resultant string bit$V_{i,\bar{k}}$. The same operations of (dis) joining openn strings are involved here as in the fermion -fermion gauge boson coupling ilustrated in the previouse figure. The open strings are attached to the i'th j'th and k'th D branes. Hence unlike the previouse case where some streching of the half strings was requierd in order to achieve contact,here the latter is guranteed and no Gaussian supression is expected stretching of the



't Hooft double line

g coupling = string couplings

universal

no need for GUTS ?!

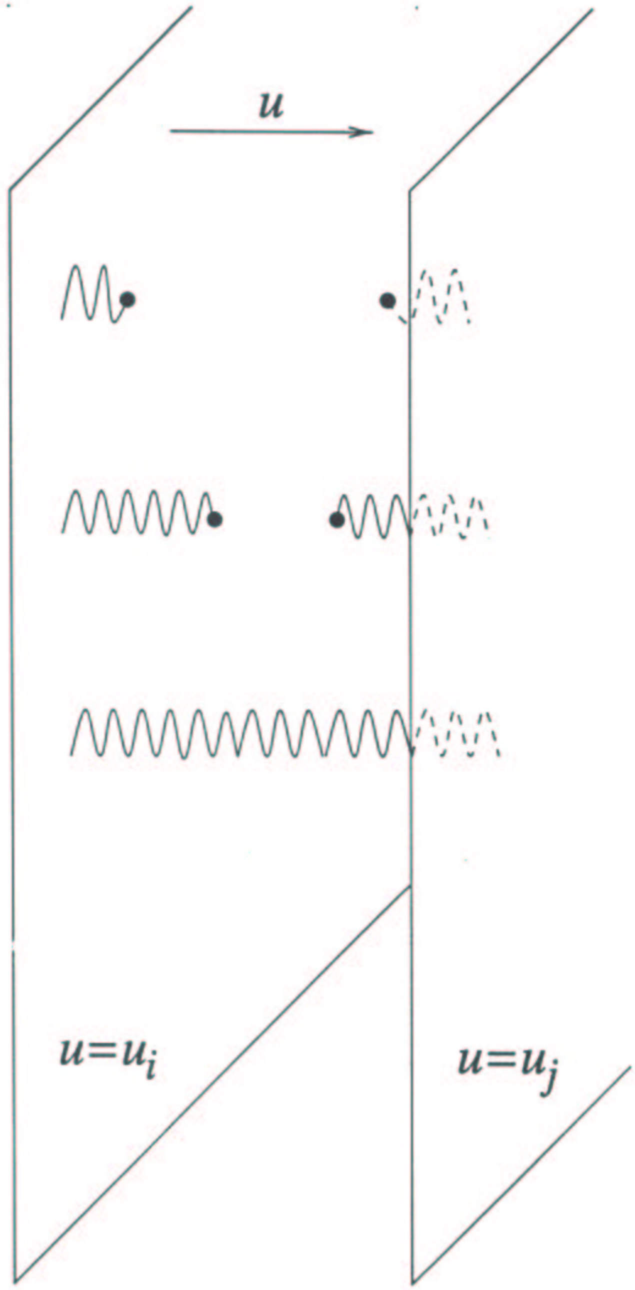


Figure 3: Illustrating the half string = massless fermion idea. Such fermions which are confined to their respective branes by the string tension into gaussiaan wave packetsjusst like in thecaseof the domaain wall of fig 1. However by gradual distortion the two half string can tunnel and form one open string connecting the ith' and jth' branes. in the limmit of exact symmetry i.e of degeneraate branes, the Gaussian supression factor is absent, and we recuperate via this universal string joining (Or string separation) the universal fermion fermion to gauge boson coupling.

SO IN THIS PICTURE WE HAVE A VERY SUGGESTIVE PATTERN

SPIN (0) ⇒ points on Brane (HIGGS) H_i

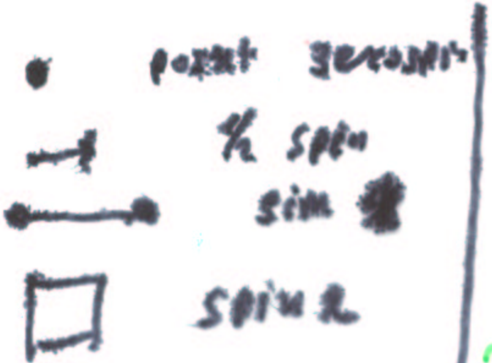
SPIN 1 ⇒ STRING BITS (Links) connecting two Branes. {Gauge Fields} $V_{\mu ij}$

{FITS WITH LATTICE PICTURE $U_{\mu\nu}$}

SPIN 2 ⇒ CLOSED STRINGS {Loops} with no index

IT IS EXTREMELY suggestive that the MISSING PART NAMELY SPIN ½ Fermions will Also Fit Here as Half STRINGS connected on one side only

ψ_i (!) Fermions in Fundamental Rep.



{Chirality, Group structure ......}

DISTANCE OF END POINT "The Fermion" = DISTRIBUTED IN A GAUSSIAN WAY NATURALLY.

ALL couplings universal.

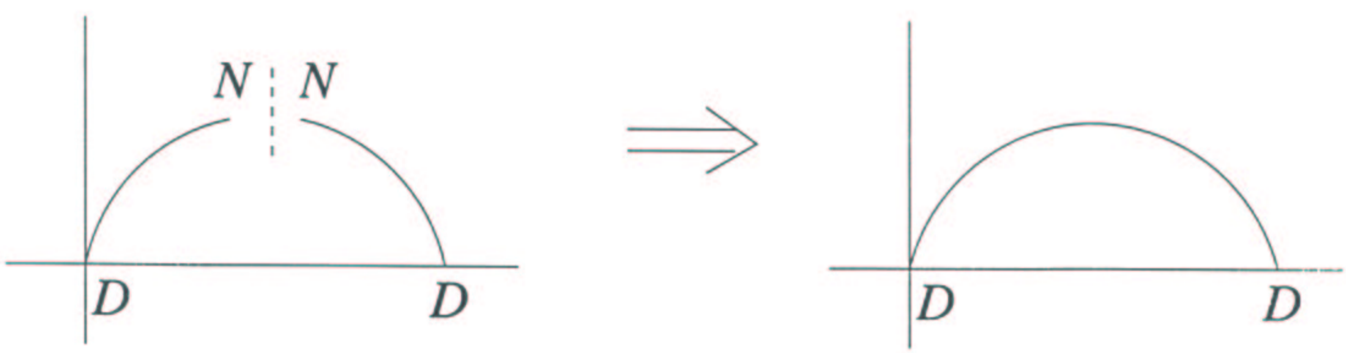
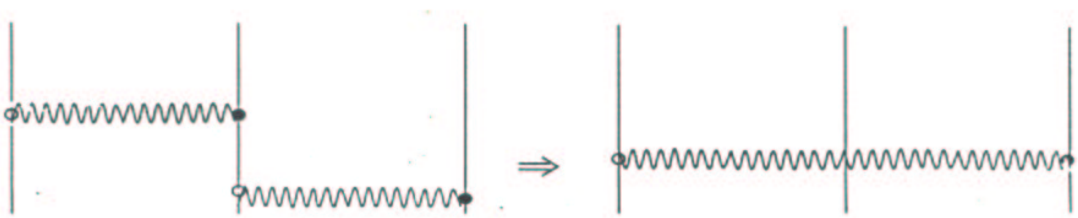


Figure 4: illustrating how the joining of the free "N" ends of the twwo lowest (Quarter wave) modes of the two DN and ND haalf strings naturally leads to the lowest (Half wave) mode of a D string



(Carnegie-Mellon University), K. Kleinknecht and B. Renk (Johannes-Gutenberg Universität Mainz).

In the Standard Model with SU(2) × U(1) as the gauge group of electroweak interactions, both the quarks and leptons are assigned to be left-handed doublets and right-handed singlets. The quark mass eigenstates are not the same as the weak eigenstates, and the matrix relating these bases was defined for six quarks and given an explicit parametrization by Kobayashi and Maskawa [1] in 1973. It generalizes the four-quark case, where the matrix is parametrized by a single angle, the Cabibbo angle [2].

By convention, the mixing is often expressed in terms of a 3 × 3 unitary matrix V operating on the charge $-e/3$ quarks (d, s, and b):

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix} . \quad (11.1)$$

The values of individual matrix elements can in principle all be determined from weak decays of the relevant quarks, or, in some cases, from deep inelastic neutrino scattering. Using the constraints discussed below together with unitarity, and assuming only three generations, the 90% confidence limits on the magnitude of the elements of the complete matrix are:

$$\begin{pmatrix} 0.9745 \text{ to } 0.9760 & 0.217 \text{ to } 0.224 & 0.0018 \text{ to } 0.0045 \\ 0.217 \text{ to } 0.224 & 0.9737 \text{ to } 0.9753 & 0.036 \text{ to } 0.042 \\ 0.004 \text{ to } 0.013 & 0.035 \text{ to } 0.042 & 0.9991 \text{ to } 0.9994 \end{pmatrix} . \quad (11.2)$$

The ranges shown are for the individual matrix elements. The constraints of ...

$m_e \simeq 0{,}5$ MeV $\quad \Delta m^2_{\nu_\mu - \nu_e} \simeq 0{,}003\,(\text{eV})^2$

$m_\mu = 100$ MeV

$m_\tau = 1750$ MeV

$m_u^{(0)} \simeq 1.5$ MeV $\quad m_s^{(0)} = 120 \pm$ MeV $\quad m_t^0 = 180$ GeV

$m_d^{(0)} \simeq 7.9$ MeV $\quad m_c^{(0)} = 1{,}4$ GeV $\quad m_b^0 = 4{,}5$ GeV

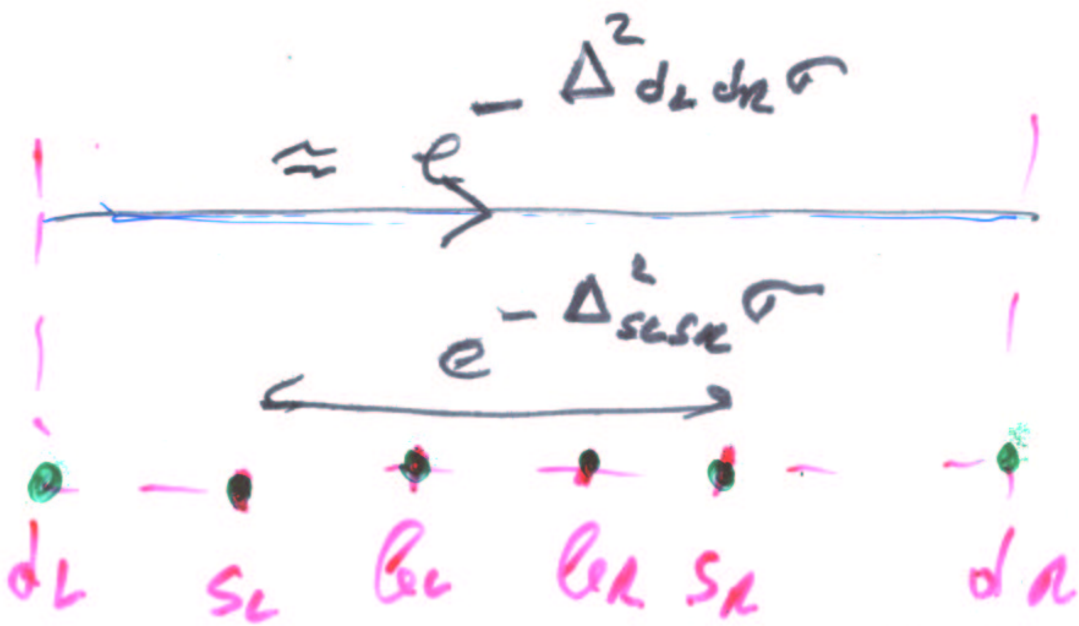
$V_{us} \simeq V_{cd} \simeq \sqrt{m_d/m_s} - \sqrt{m_u/m_c}$ {Fritzsch}

$\begin{pmatrix} \nu_e \\ e \\ u \\ d \end{pmatrix} \begin{pmatrix} \nu_\mu \\ \mu \\ c \\ s \end{pmatrix} \begin{pmatrix} \nu_\tau \\ \tau \\ t \\ b \end{pmatrix}$

BUT V'MAX. ??!

$Q_i > L_i$

THE HIGHER THE CHAR[GE]
THE HEAVIER THE FERM[ION]



$\approx V_{ds}$

$V_{sd} = V^*_{ds}$

$m_d = V_{ds}^2 \, m_s$

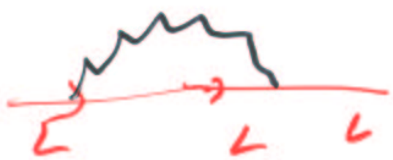
V_{us} (CKM)

$\approx \sqrt{\frac{m_u}{m_s}}$ (FRITSCH

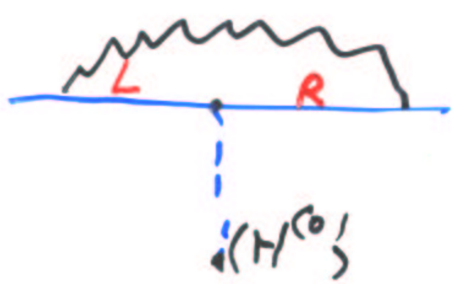
GAUGE INT AND MASS HIEARCHY

Well Known:

non confining.
G.I. <u>cannot</u> generate masses



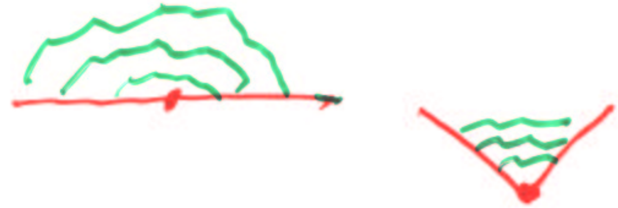
BUT ONCE MASSES ARE THERE GAUGE INTERACTIONS WILL MODIFY THEM

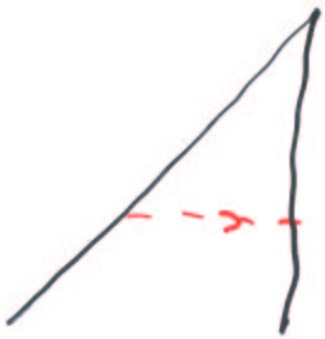


SINCE IN PRESENT CASE MASSES ARE GENERATED VIA TUNNELING

Could the Effect of G.I. BE MORE DRAMATIC?

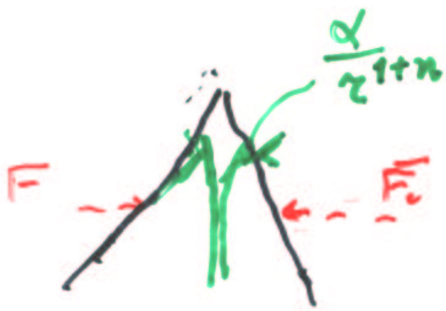
$X_5 = (y)$





tunnel through lin. potential

OR SYMMETRICALLY FROM BOTH SIDES



BUT NOW GAUGE INTERACTIONS IN x_5 DIREC.

MAY MODULATE BARRIER.

EFFECT MOST DRAMATIC FOR TOP-COLOR

INT ~TEAR IT OF THE WALL ...

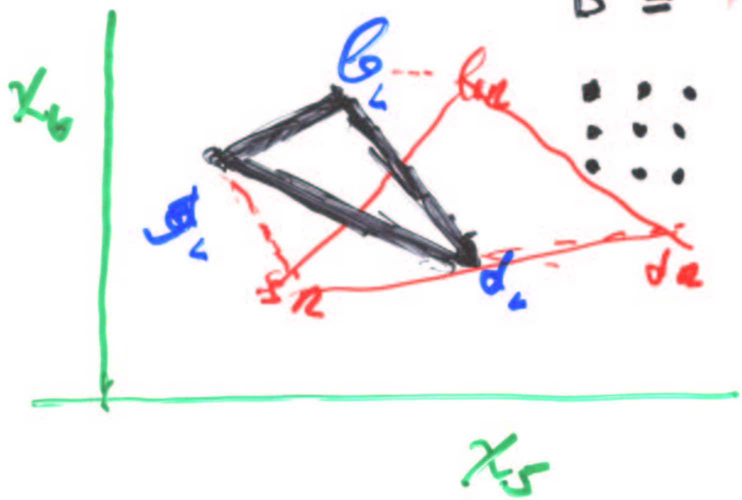
USING THE NON-RENORMALIZEABILITY

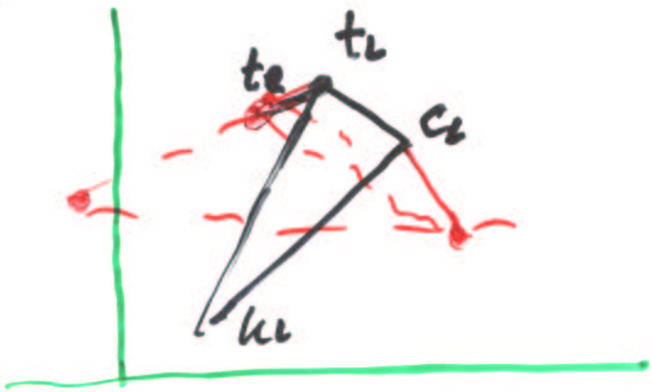
OF GAUGE ~~FT~~ F.T IN $\geq$ 4 Dim.!

SOME SPECULATIONS ON [2] EXTRA DIMENSIONS AND ~~CP~~ (CPV-CPU)

"B" $= F_{(5,6)} \approx \dfrac{1}{m_x^2}$

[1 unit of flux per (10 TeV)$^{-2}$]





← SYMILAR FOR

COULD δ_{KM} BE A

BA = "AB" PHASE?

$\propto$ ~~JARKSLO~~ JARLSKOG FACTOR

!!

DARK MATTER
(Shadow?)

EXTREMELY NATURAL!

GRAV ONLY....

"OUR S.M." BRANE

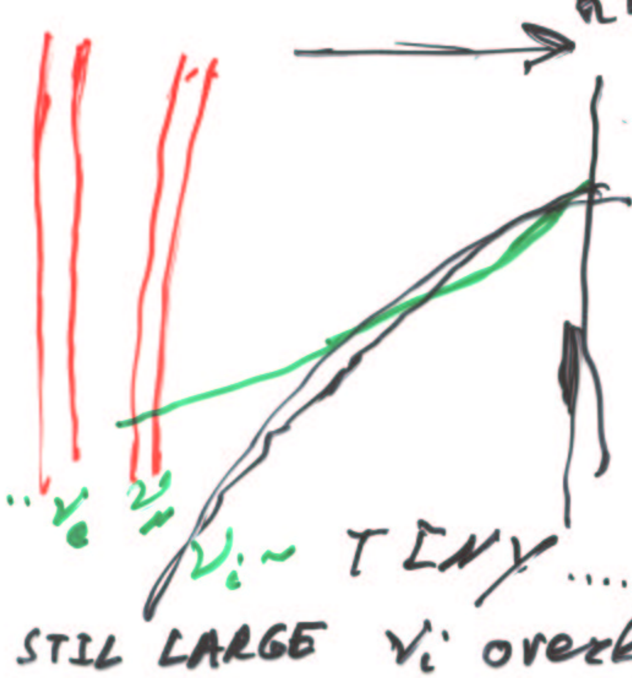
$SU(3) \times SU(2) \times U(1)$

$SU(3') \times SU(2)' \times U(1)'$ OR OTHER.

could there be LIFE IN THE DARK

CHARGES EQUAL REGARDLESS of GUTS?!

RH ν_R {NEUTRAL CAN BE SEPARATED still light!!



STIL LARGE ν_i overlaps ~ Bi-MAXIMAL MIXING.

WHY 6 PLANETS?

WHY THEIR R_i?

"TITUS BODE LAW" ⇐

DOES NOT EMERGE FROM NEWTONIAN MECH.

{ INITIAL CONDITIONS
HYDrodynamics..
OTHER S.S.
THE ENTHROPIC PRINCIPLES }

Pornografhy (and Physics) IS A QUESTION OF GEOGRAPHY!

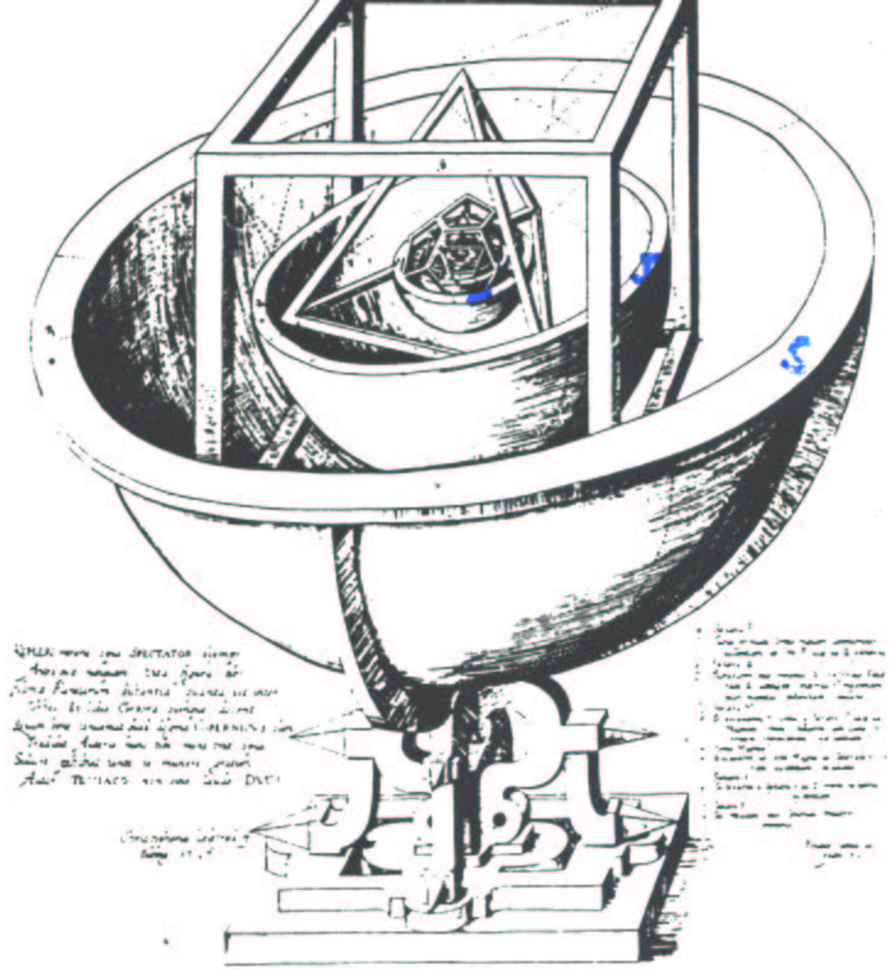


PLATE I. Model of the universe: the outermost sphere is Saturn's. From *Mysterium Cosmographicum* (1597, edition of 1621).