EXTRA "LARGE" $\gg m^2$, $0.01 m^2$?

Dimensions: OLD FASHION WAY

Arkani-Hamed, Dimopoulos, Dvali, schmaltz mirabeli.

Not dimensions. Deconstruction...

latticizes 5th dimensions, m.l.o. models, Small Higgs \{ alternative to SUSY\}

Not even R.S.

Just the simple original ideas \{ too soon abandoned \}

What have we \{ Robert \} learned

What have we \{ Royal, not to blame \}

Hoped I wanted to learn.
I. Introduction:

GRAVITY is diluted by ratio of Brave / Bulk volumes.

At distances ∝ 10^(-2) it becomes 3+n dimensional

F_0 \sim \frac{1}{r^2} \rightarrow \frac{1}{r^n} [n=2] \text{ (more singular)}

Can be understood in x_k, x_y

3'D terms as a sum of
(9) But gravity extends beyond the thin wall up to \( L \approx 0.1 \text{ mm} \).

Assume gravity and g.int equal at \( \alpha x = \ell \).

The larger spread (over \( A = L^2 \)) of gra. field line as compared with spread over \( \ell^2 \) of gauge (E.M) field lines \( G_n \approx (4\pi L)^2 \approx 10^{-34} \).
(6')

\[ F_G = \frac{1}{2} \varepsilon_{20} \text{ (Gauss)} \]

\[ r_{20} \]

\[ F_G = \frac{1}{2} \frac{(Gauss)}{50!} \]

**SO GRAVITY MAY CROSS OVER FROM**

\[ \frac{1}{2} \varepsilon_{20} \rightarrow \frac{1}{2} \varepsilon_{20} \quad \alpha + \gamma_0 = 0.1 \text{ m/s}^2 \]

**A TRUE EXPERIMENTAL CHALLENGE**
\[ A \approx \frac{s^2}{t} \cdot \frac{1}{m^2} \]

So \( \sigma_{\text{inel}} \approx S \) but small...

But the sum of KK exchange enhances it dramatically!

[small print]

\[
\text{SHORT-CUT:}
\]

\text{AT HIGH ENERGY \textit{EIKONAL} DESCR.}

\[
\begin{align*}
\mathbf{p}_1 + \mathbf{p}_2 &= \mathbf{s} \\
\mathbf{x}_1 + \mathbf{x}_3 &= \mathbf{x} \\
\mathbf{P}_1 + \mathbf{P}_2 &= \mathbf{P}
\end{align*}
\]

Prop in \( \mathbb{B} \) is \( \frac{1}{B^2} \) in \( \mathbb{G} \) space \( \mathbb{E} \) for \( \nu = 2 \frac{1}{2} \).

P.W. Amp \( \approx \frac{1}{m^2} \cdot \frac{S}{B^2} \); \( \text{e.m.} \approx \frac{S}{m^2} \); \( \sigma = \frac{s}{m^2} \).

In H.F. Amp \( \approx S e^{-\frac{m^2}{B^2}} \).
(i) Invariance under "composition" 

\( \sum E_i \) 

\[
E_1 = \sum_{i=1}^{N_1} e_i^{(1)} \\
E_2 = \sum_{j=1}^{N_2} e_j^{(2)} \\
\]

\[
\sigma = \frac{E_1 E_2}{m_s^4} = \frac{\sum e_i^{(1)} \cdot \sum e_j^{(2)}}{m_s^4} \\
= \sum_{i,j} e_i^{(1)} e_j^{(2)} \frac{1}{m_s^4} \\
= \sum_{i,j} \sigma_{ij} \\
\]

**Particle Scattering of Original 1-2** 

Pairwise scattering of their constituents! 

(ii) Black Hole Formation Scenario 

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

If \( \sigma \approx R_{sw} \) we will form B.H. 

(next evaporate quickly) 

\[
\pi R_{sw}^2 = \frac{S}{m_s^4}. 
\]
\( \sigma(\text{pp}) [E \approx 10^{12}\text{GeV}] \approx 200\,\text{mb} \)
\[ S = 10^{-2}\text{GeV}^2 = 10^6\,\text{m}_c^2 \ldots \approx 10^{-23}\,\text{cm}^2 \]

Now \( \sigma_{\text{new}}(\text{pp}) \approx \sigma_{\text{new}}(\nu\bar{\nu}) = \ldots \) only depends on energy

\( \sigma_{\text{new}} = \frac{10^6(\text{tev})^2}{(\text{tev})^4 \mu_c^2} = 4 \times 10^{-6} \cdot 10^{-34}\,\text{cm}^2 \approx 10^{-23}\,\text{cm}^2 \)

\( \sigma_{\text{new}} \leq \sigma_{\text{threshold}} \) [no explanation].

But could affect \( \nu \) propagation in Earth

T DETECTOR AMANDA

NP

\( \text{no "upward" going } \nu\)'s with \( E \geq 10^{10}\text{GeV} \)

\( \sigma_{\text{new}} \approx \frac{1}{152} (\log \ldots) \)

\( \frac{\sigma_{\text{new}}}{\sigma_{\text{old}}} \approx \frac{S}{m_c^2} \)

\( \sigma_{\text{new}} = \sigma_{\text{old}} \) at

\( S \approx m_c^2, 50-500 \)

\( \text{was } 10\,\text{TeV} \ldots \text{to } 50\,\text{TeV} \)
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 routes to weakness:

1. $\beta$ decays "weak interactions"

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

Heavy masses "hide interactions"

2. $\alpha$ decays: very long lifetime due to tunneling

Usually (1) is used.

Example "cuts" and proton longevity:

Charge quantization $\alpha$ "running" of couplings to common value suggest $SU(3)_c \times SU(2) \times U(1) \leftarrow SU(5), SO(10)\ldots$
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 and the same Yukawa couplings, we could generate similar xiral domain walls fermions attached to the same kink solution at different locations $u_i$.

**Kink Generates Linear Potential**: Massless Fermions Have Gaussian W.F

$$(\frac{\partial}{\partial u} + u)\psi^0_u = 0 \quad \psi^0_u = e^{-u^2/2}$$
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 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 the fermion mass hierarchy similar in spirit to the one in [7]. For other approaches to suppressing Yukawa couplings and proton decay, see [6].
Figure 2: Open strings connecting the $i$th and $j$th brane. The sequence of open strings starting with the uppermost stretched string and proceeding with time downwards, illustrates the gradual distortion of the open string, which eventually lead to the excision of a closed string. The open string with the d boundary conditions, a fortiori, its lowest spin one massless gauge bosons, are limited to move in the "Fat Brane" region of size $L$. The closed string and the
$N$ degenerate D branes

$N^2$ directed length strings $\Rightarrow U(N)$ gauge bosons $V^i_i$

The gauge bosons are restricted to the above region ($u = 0$).

By construction.

Symmetry breaking (Higgs) has a simple interpretation.

\[
\begin{array}{c}
\begin{array}{c}
\begin{array}{c}
N \\
N
\end{array}
\end{array}
\end{array}
\rightarrow
\begin{array}{c}
\begin{array}{c}
\begin{array}{c}
\text{Distance} \leq \langle \phi \rangle \\
= M V_i \phi_i
\end{array}
\end{array}
\end{array}
\end{array}
\]

\[
SU(N) \rightarrow SU(n) \times SU(N-n)
\]
Figure 5: The triangulation scheme coupling from the plane point of view. In the Dirac language it corresponds to the string picture joining with the string picture. The same operations of (a) joining open strings are involved here. The open strings are attached to the left, and the open strings below the branes. Hence, unlike the previous case where some stretching of the bulk strings was required in order to save the consistent perturbative picture, in this case no Gaussian suppression is expected stretching of the triangle.

The Hooft double line coupling = string coupling.

Is there any need for cuts? 
Figure 3: Illustrating the half string = massless fermion idea. Such fermions which are confined to their respective branes by the string tension into gaussian wave packets just like in the case of the domain 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 limit of exact symmetry i.e of degenerate branes, the gaussian suppression 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)
Spin 1 → string bets (links) connecting two branes (gauge fields)
Spin 2 → closed strings + loops with no index

It is extremely suggestive that the missing part namely Spin 1/2 fermions will also fit here as half strings connected on one side only.

ψ_i (i) Fermions in Fundamental Rep.

<table>
<thead>
<tr>
<th>point fermion</th>
<th>½ chirality, group structure ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>% spin</td>
<td></td>
</tr>
<tr>
<td>sim</td>
<td></td>
</tr>
<tr>
<td>spin</td>
<td>distance of end point</td>
</tr>
</tbody>
</table>

"The fermions are distributed in a Gaussian way naturally, all couplings universal."
Figure 4: Illustrating how the joining of the free "N" ends of the two lowest (Quarter wave) modes of the two DN and ND half strings naturally leads to the lowest (Half wave) mode of a D string.
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 $b$):

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

(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:

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

(11.2)

The ranges shown are for the individual matrix elements.

\[ m_e = 0.5 \text{ MeV} \]
\[ m_{\mu} = 100 \text{ MeV} \]
\[ m_{\tau} = 1750 \text{ MeV} \]

\[ \Delta m^2_{\nu_e - \nu_\mu} = 1 \times 10^{-3} \text{ eV}^2 \]

\[ m^0_{\mu} > 45 \text{ MeV} \]
\[ m^0_{\tau} = 120 \pm 1 \text{ MeV} \]
\[ m^0_\tau = 180 \text{ GeV} \]
\[ m^0_{\mu} = 1.4 \text{ GeV} \]
\[ m^0_\tau = 4.5 \text{ GeV} \]

\[ V_{us} \approx V_{cd} \approx \sqrt{\frac{m_{\mu}}{m_{\tau}} - \sqrt{\frac{m_{\mu}}{m_{\mu}}}} \quad \{ \text{Fritzsch} \} \]

\[ Q > Li \]

\[ \text{THE HIGHER THE CHANCE} \]
\[ \text{THE HEAVIER THE FERMA} \]
Gauge int and mass hierarchy are well known: G. I. cannot generate masses.

But once masses are there, gauge interactions will modify them.

Since in present case masses are generated via tunneling could the effects of G. I. be more dramatic?
But now gauge interactions in $X$ do not necessarily modulate the barrier. Effect most dramatic for top-color int. It tears it off the wall... Using the non-renormalizability of gauge field in 3+1 dim.
Some speculations on extra dimensions and $c_p$ (CPU-CPU)

$B = F(x, y) \propto \frac{1}{Mx} \left[ 1 \text{ unit of flux per (10 rev)$^2} \right]$

Similar for

Could $\delta m$ be a $BA = "RB"$ phase?

FARLSS90 FARLSS90 FACTOR
DARK MATTER
(Shadow?)

EXTREMELY
NATURAL!

GRAV ONLY....

COULD THERE BE LIFE IN THE DARK

"OUR S.M."
BRANE
SU(3) x SU(2) x U(1)

CHARGES EQUAL REGARDLESS
OF GUTS ?!

RH \downarrow \text{NEUTRAL CAN BE SEPARATED}
STILL EIGHT!!

STILL LARGE \nu \text{; OVERPOP. MAXIMAL MIXING}
WHY 6 PLANETS?
WHY THEIR A.I?

"TITUS = ROSE LAW"

DOES NOT EMERGE FROM NEWTONIAN MECH.

INITIAL CONDITION

HYDRODYNAMICS

OTHER S.S.

THE ENTHROPE PRINCIPLES

COSMOGRAPHY (AND PHYSICS)

IS A QUESTION OF GEOGRAPHY!