String Phenomenology

Summary Talk

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First a warning:

I had to (unfortunately) miss some of the talks,

so apologies to all the authors that I missquote/ don't quote.

The resposibility (also for those 'events' that I reconstructed from 'detector data') is entirely mine.

2. String Phenomenology

has up to now consisted in exploring low-energy possibilities of a theory that was developped by and large by purely logical/mathematical deduction.

Indeed (to paraphrase T.D. Lee) there were, until recently, 'no phenomena'.

Fortunately, things have started to change Λ_{cosmo}, μ's, CMB ...

and we can confidently predict that string phe. conferences will look quite different in a few years (and possibly merge with the main string's conferences).

↳ In the meantime ... string theory does predict a plethora of new phenomena:

* Susy
* Extra dims
* Extended gravitnl sector
* Extended objects
* Unification

All of these had been discussed (and 'discovered') independently, but the fact that they are **all needed** to make a consistent quantum gravity (the only one we know), forces us to take them very seriously.

↳ The discovery of <u>any</u> of <u>these</u> will enhance our confidence in the theory, but (unfortunately) the inverse is <u>NOT TRUE</u>:

there is no inevitable argument that allows us to fix any of the relevant scales

$$M_{gluino},\ M_{KK},\ M_{moduli},\ M_s,\ M_{GUT}$$

or even to seriously constrain its allowed range

$\exists$ few very general restrictions

eg $M_{KK} \lesssim M_S \lesssim M_{Planck}$

& some 'plausibility arguments', but otherwise the only limit on these scales is what is not directly ruled out by expmt:

* TeV modifcns of SM

* submm modifcns of gravity

{ & possibly IR modifcns (observable at solar-system scales?)

G. Dvali

Good news: we might be at the discovery threshold in many fronts

Bad news: none forced on us by (our present understanding of) string theory, in the same way that ~TeV is forced by shortcomings (fine tuning) of SM.

The main new threshdd is, of course, the

* LHC (higgs, susy, other ?)
about which we have heard several talks

Bethke, Kane, Hollik, Nath

There, however, other possible discoveries that were less discussed

* Cosmic strings ?

Sazhin et al have announced preliminary finding (pair of similar nearby elliptic galaxies) with $G\mu \gtrsim 4 \times 10^{-7}$

(marginally in conflict with upper limit from CMB anisotropy)

↳ CMB & pulsar timing bounds will improve sensitivity by factor 10-100 in coming decade

↳ Furthermore, grav. waves from string cusps (Damour + Vilenkin) could be seen down to $G\mu \simeq 10^{-12}$, and possibly even in LIGO I.

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* Variation of fundml constants

strongest bound from geochemical data (Oklo natural reactor)

$$\frac{\dot{\alpha}}{\alpha} = -0.2(\pm 0.8) \times 10^{-17} \text{ / years}$$

over period 10^9 years

↳ high-redshift quasar absorption lines give a limit

$$\dot{\alpha}/\alpha \lesssim 1.2 \times 10^{-16}/\text{year}$$

↳ Interestingly enough, atomic-clock expmts are now in same accuracy range

eg

$$\frac{d}{dt} \ln\left(\alpha^{0.49} \left[m_q/\Lambda_{QCD}\right]^{0.17}\right)$$

$$\simeq 0.2(\pm 7.0) \times 10^{-16}/\text{year}$$

(Bize et al)

Satellite-based expms will improve current limits by several orders of magnitude !

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* Microgravity limits

is $\sim$meV ($\sim \Lambda_{cosmo}^{1/4} \sim \delta m_\nu$) a new scale ?

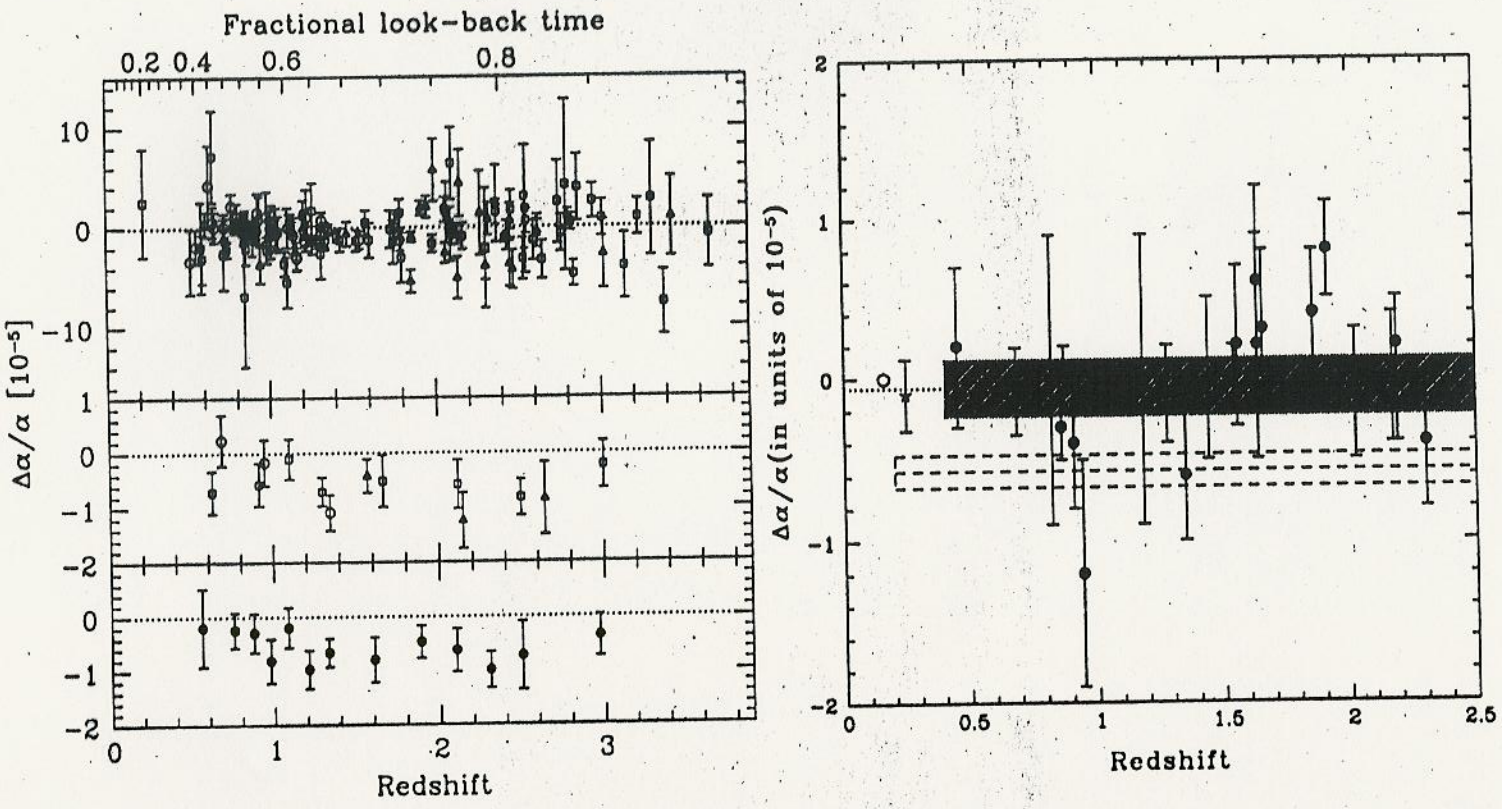

Figure 4: The analysis of quasar spectra on the variation of the fine structure constant from (left) the Keck/Hires data [67] and (right) the VLT/UVES data [72]. The left plot depicts their previous low redshift (open circles), previous high redshift (open triangles) and new (open squares) samples. The raw results with 1σ error bar are shown on the top panel while the middle panel shows the results with an arbitrary bining and the bottom panel combines the three samples. The right plot present the results from the VLT/UVES data [72]. The dash lines represent the weighted mean and 1σ range from the analysis of Ref. [67] while the dash region marks the weighted mean and its 3σ error bars.

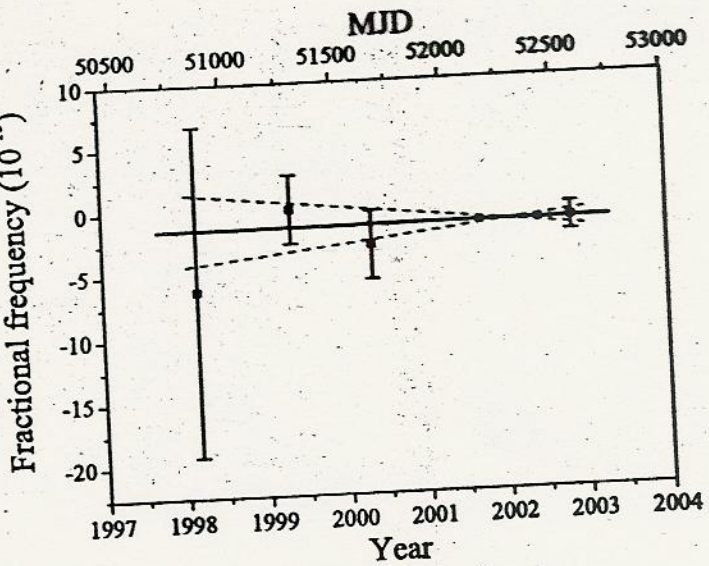

FIG. 3: Measured ^{87}Rb frequencies referenced to the ^{133}Cs fountains over 57 months. The 1999 measurement value ($\nu_{\mathrm{Rb}}(1999) = 6\,834\,682\,610.904\,333$ Hz) is conventionally used as reference. A weighted linear fit to the data gives $\frac{d}{dt}\ln\left(\frac{\nu_{\mathrm{Rb}}}{\nu_{\mathrm{Cs}}}\right) = (0.2 \pm 7.0) \times 10^{-16}\,\mathrm{yr}^{-1}$. Dotted lines correspond to the 1σ slope uncertainty.

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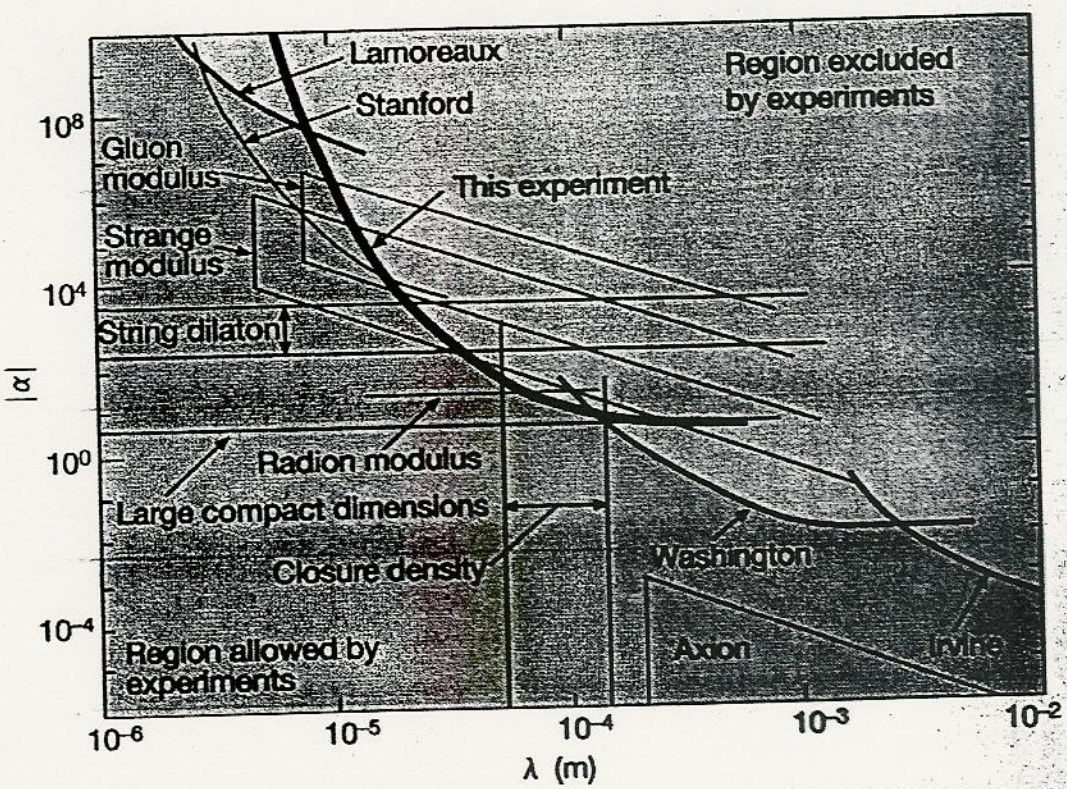

↳ This brings us to one of the main themes of this conference (judging also from the # of talks):

Fluxes + Moduli stabiliznt

In recent years, there was substantial theoretical progress in the study of this class of compactificnts, involving both NS-3 form & RR fluxes and magnetic fluxes on D-branes.

We understand many of their gross new features, among which their potential for providing **isolated vacua**.

↳ These compactificnts will/have lead to the developmnt of nice new/old technology:

* gauged sugra — Derendinger, Ferrara

* generalized complex geometry à la Hitchin — Louis

* instanton & duality techniques for $W_{non\text{-}pert}$ — Mayr, Kallosh

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↳ The issue of isolated vacua is, as we have heard, plagued by potential pitfalls:

* one must extremize wrt to all moduli (including axions)
  Partial or stepwise stabiliznts may easily fail.

* one must compute, rather than guess, non-pert. effects (to avoid risk of cancellnts, or different

behavior of multi-instanton sums).

* One must control all potential corrections : Kähler potential ? back-reaction from flux ? α' corrections.

These various loopholes are being closed ...

Zwirner, Denef, Reffert

(cf also Jockers, Dall'Agata, Conlon, Behrndt

and it now looks very plausible that $\exists$ classes of ISOLATED ANTI-DESITTER STABLE VACUA.

↳ It would be nice to have, as much as possible, a CFT control of such vacua (as offered by D-brane magnetic flux fixing) cf. non-abelian orbifolds

Antoniadis, Bianchi

↳ But the more crucial issue is that of the 'lift':

* Are there Minkowski or dS 'vacua', sufficient long-lived & without moduli ? (AdS vacua could then be a cosmologically endangered species)

* What is the typical mass of moduli in such vacua ? (cf microgravity expmts)

KKLT have given plausibility arguments, but given the importance of the claim I think we need more concrete proof.

↳ One other central theme in the conference was heterotic and/versus type I model building.

* Many of the type-I possibilities have by now been explored, but the construction of truly realistic vacua remains a challenge

Uranga, Cvetic, Shiu, Marchesano, Angelantonj

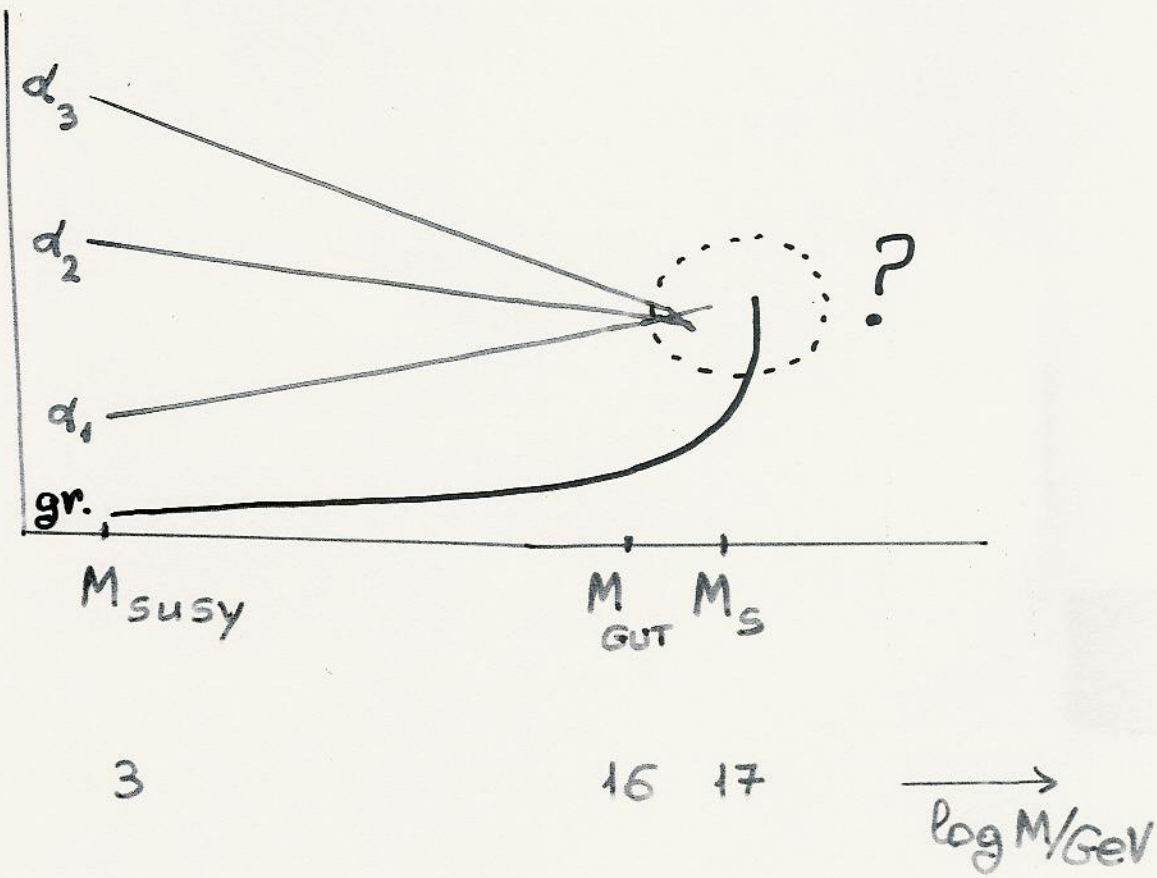
This was nicely illustrated, in the heterotic context, by Langacker's effort to find a see-saw mechanism to give neutrinos a mass.

↳ Heterotic (or inspired) model-building is being revived

Nilles, Ovrut, Honecker, Raby
Buchmüller, Groot Nibbelink, Faraggi

and I believe for very good reason:

while more restrictive in many ways, it leads naturally to the one quantitative, successful phenomenological prediction of string theory



while the match is not perfect, it is good at the $\lesssim 10\%$ level, and could potentially be fixed by 'small modificns'

Hebecker

↳ Of course GUT type I models with no large xtra dims could have similar 'success'.

↳ String Cosmology ?

still in quite primitive state, though some nice ideas for implementing acceptable inflation

Linde, Quevedo, Koers, Krause

↳ there were ~~many~~ of course many other interesting talks:

* String-loop calculus of susy breaking mediation to branes — Taylor

* 'split susy': corner of parameter space with interesting LHC signature — Dimopoulos

* Flavor structure; dynamical μ; U-folds — Kobayashi, Kim, Gray

effects of Green-Schwarz; toy landscape — Kiritsis, Dienes

phases of gravity; attractor mechanism — Rabinovici, Trivedi

+ GONG SHOW !

Pluralism & youth are 'healthy signs'

Lastly, what about Landscape Statistics and Anthropic Considerations ?

Douglas, Acharya, Gmeiner

↳ STATISTICS looks to me like an 'experimental project': try to discover correlations (new notions of naturalness) which (if they exist) we are not { smart / sophisticated } enough to deduce in a more direct way.

Worth pursuing by some people, but aware of standard caveats:

* What measure ?
* Dynamics

as for anthropic considerations

I have little new wisdom to

offer:

↳ It is a logical possibility, that some of the fundml constants are 'set by the environment', like the distance of sun to earth.

↳ It has not, up to now, proved to be a fruitless hypo

As for anthropic considerms, I have little new wisdom to offer:

* It is a logical possibility

* and one that has, until now, proved particularly fruitless (especially if applied to fundml constants that have plausible, if incomplete, alternative explanations).

* perhaps we need it for Λ (but gravity 'less understood' of all forces, including in IR - Woodard, Tsami; Duali should not give in, unless absolutely 'forced' in framework of quantum gravity...

I could not summarize the thing better than Woody Allen (as related to me by Boris Pioline):

' There is little doubt that parallel worlds exist ....

... the only questions are

how far are they
from downtown,
and how late do
they stay open?

and lastly,

Thanks to the organizers for this very nice conference, and for their wonderful hospitality !