

# Dynamical determination of compactification parameters

**GrahamFest  
2011**

G.G. Ross, Z. Lalak,  
C. Muñoz, J.A.C.  
1990

**Thanks !!**

**for such a wonderful idea**

# GrahamFest

Oxford

29 & 30 September 2011

## Programme

### Friday 30 September

The day begins at 9am

**09:00-09:10** Welcome by Chairman of Physics

**09:10-09:20** Reading out of messages

**09:20-09:40** John Ellis (King's College London): *Sniffing out the gluon*

**09:40-10:00** Mike Pennington (Jefferson Lab): *Roads to freedom*

**10:00-10:20** Keith Ellis (Fermilab): *Perturbation theory and the parton Model in QCD*

**10:20-10:40** Alan Barr (Oxford): *Invisible particles at the LHC*

**10:40-11:15** Break

**11:15-11:35** Bob Jaffe (MIT): *Encounters with Voodoo QCD*

# Generosity

•  
• 80' s  
•

F. del Aguila

L. Ibáñez

J.A.C.

C. Muñoz

•  
•  
•

90' s

B. de Carlos

A. Ibarra

•  
•  
•



Dear Graham,  
from the Dark Side of the Universe, in China,

**7<sup>th</sup> International Workshop on  
the Dark Side  
of the Universe**

Sept. 26-30, 2011, KITPC/ITP-CAS, Beijing

In association with the KITPC program  
"dark matter and new physics", Sept. 21-Nov. 6, 2011  
"String phenomenology and cosmology", Sept. 6-Nov. 11, 2011

**DSU 2011**

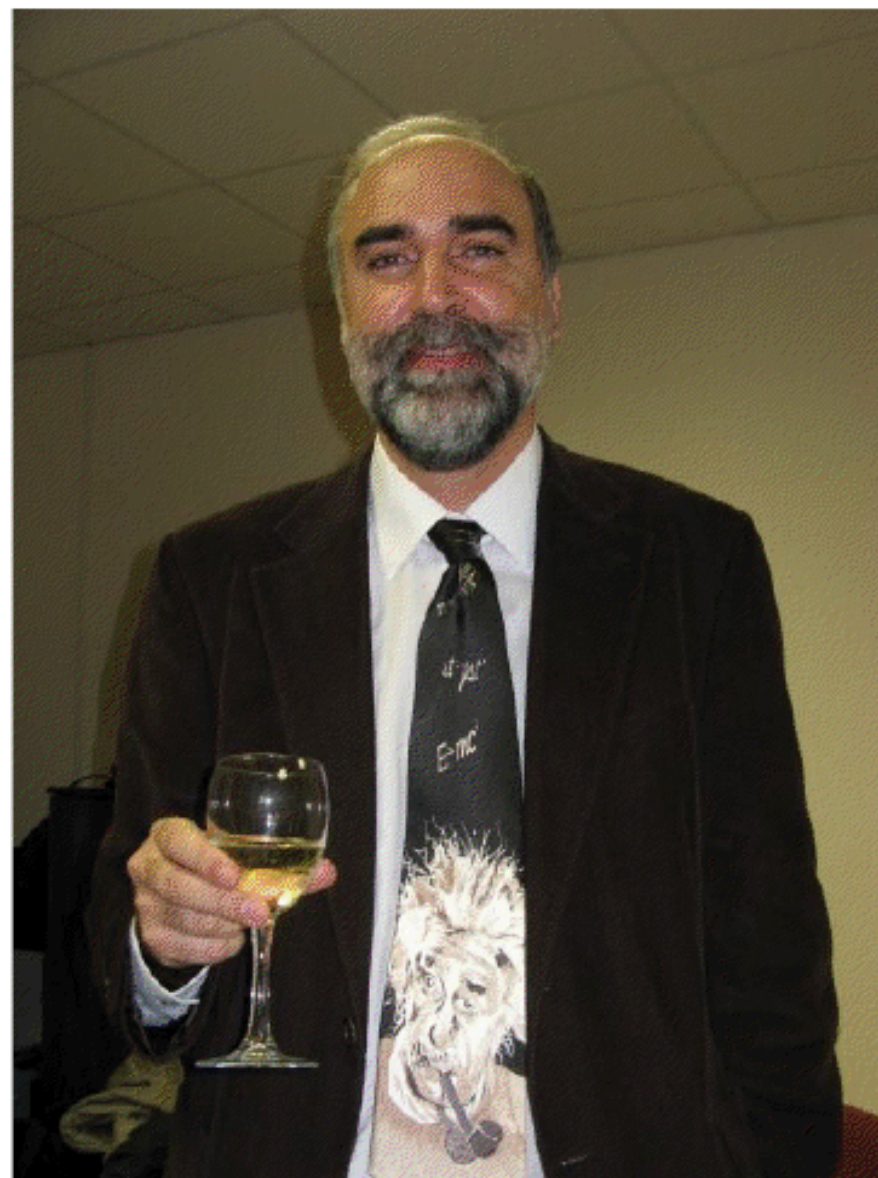
International committee	Local committee
Costa Belaz, <i>Miami University, Australia</i>	Xiao-Jun Bi, <i>IBPC-CAS</i>
David Daloz, <i>University of Wisconsin, USA</i>	Rong-Gen Cai, <i>KITPC/ITP-CAS</i>
Shahar Khalil, <i>British University, Egypt</i>	Xue-Li Chen, <i>NJAC</i>
Arash A. Rypke, <i>New Mexico State University, USA</i>	Hong-Jian He, <i>Tsinghua U.</i>
Pyungwon Kim, <i>KIAS, Seoul, Korea</i>	Qing-Guo Huang, <i>KITPC/ITP-CAS</i>
Carlos Munoz, <i>Autonomous University of Madrid and IFT, Spain</i>	Miao Li, <i>KITPC/ITP-CAS</i>
Keith A. Olive, <i>Johns Hopkins University, USA</i>	Ming-Xing Luo, <i>Zhejiang U.</i>
Qianxi Sheth, <i>Duke University, USA</i>	Gong-Feng Qiao, <i>GUCIF</i>
Joseph Silk, <i>University of Oxford, UK</i>	Bo Qiu, <i>NJAC</i>
Yue-Liang Wu, <i>KITPC/ITP-CAS, China</i>	Bin Wang, <i>Shanghai Jiao Tong U.</i>
	Xin-Ming Zhang, <i>IBPC</i>
	Yu-Fang Zhou, <i>KITPC/ITP-CAS</i>
	Shao-Hua Zhu, <i>Peking U.</i>

**Topics**

- Dark matter candidates and theory
- Galaxy clusters
- Signals of dark energy
- Standard and non-standard cosmological physics
- Direct, indirect and accelerator dark matter searches
- New physics beyond the Standard Model
- Experimental aspects of dark energy
- The dark energy cosmology

Contact: dsu2011@itp.ac.cn    Website: <http://itpc.itp.ac.cn/dsu2011>

As you can check, I am also celebrating  
appropriately the "GrahamFest".  
Many regards, and happy new life!!



# Graham's style of doing research

imaginative

witty and sharp

friendly

non-pretentious

enthusiast

insightful

direct

informal

# Graham's style of doing research

A yellow oval with a black outline, containing the word "rigorous".

rigorous

A pink oval with a black outline, containing the word "honest".

honest

Those were the days...





**Thanks a lot Graham!**

# Dynamical determination of compactification parameters

Collaboration with Graham,  
Z. Lalak and C. Muñoz

1990

# “Historical” context

(circa 1990)

★ Paradigm  $\equiv$  Heterotic String

★ Problems:

- No mechanism of SUSY breaking at the correct ( $\sim$  E.W.) scale

- No mechanism to fix the dilaton,  $S$  ( $\sim g^{-1}$  at  $M_p$ ), neither the **moduli**

★ General believe: the physical vacuum should be “selected” dynamically

## Existing mechanisms of SUSY breaking:

- VEV for the antisymmetric tensor field:  $\langle H \rangle$
- Gaugino Condensation:

$$\langle S \lambda\lambda \rangle \sim M^3 e^{-(3S/2b_0)} \equiv f(S) \in W$$

**Both  
problematic**

# Our Work

First we showed that for **any** superpotential of the form

$$W = f(S) + W_T$$

trilinear in the matter fields

any SUSY breaking minimum must fulfill some conditions, like:

$$\text{Re}(S) < (1 + \sqrt{3}) \left| \frac{f(S)}{f'(S)} \right|$$



This is completely general, i.e. it does not depend on the explicit form of  $f(S)$ . These conditions are very powerful.

Second, we showed that, when applied to one gaugino condensate, there is no realistic minimum, independently of the explicit form of  $W_T$ .

$$\text{Re}(S) < \frac{7}{18} b_0$$

(far too large  
gauge coupling)

Interesting, but frustrating....

why just **one** condensate?



Third, we showed that, when applied to several (e.g. 2) gaugino condensates, there can arise a realistic minimum ( $g_{GUT} \sim 2$ ), depending on the gauge groups involved and the matter content associated.



Moreover:

- At the same time,  $m_{3/2}$  can get a realistic value  $\sim \text{TeV}$
- The moduli, which appear in the Yukawa couplings, get also stabilized.
- The presence of (hidden) matter is crucial.
- We illustrated all these points with examples in the  $Z_3$  orbifold.



After sending the paper we discovered that the idea of multiple gaugino condensation had just been proposed by Dixon, Kaplunovsky and Peskin in a conference.

Then, all of us discovered that the idea of several condensates had been proposed before by Krasnikov.

However, he did not considered matter. As a result he found it impossible to stabilize the dilaton at a realistic value and to get the correct amount of SUSY breaking, corroborating our results.

Later, our formulation was refined by making it T-dual invariant. However our basic results were correct and have remained.



The mechanism was later called “racetrack mechanism” and has been used in many papers

Remarks on the racetrack scheme

Racetrack models in theories from extra dimensions.

Building a better racetrack.

Racetrack inflation.

Moduli-mixing racetrack model.

Inflation in a refined racetrack.

D-term Uplifted Racetrack Inflation.

Patterns of supersymmetry breaking in (...) racetrack models.

..... etc.



**Congratulations, Graham!**