

# Costas Kounnas memories

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Kounnas and Cremmer Memorial Day

ENS, Paris, 3 July 2023



## NATURALLY VANISHING COSMOLOGICAL CONSTANT IN $N = 1$ SUPERGRAVITY

E. CREMMER

*Ecole Normale Supérieure, Paris, France*

and

S. FERRARA, C. KOUNNAS and D.V. NANOPOULOS

*CERN, Geneva, Switzerland*

Received 5 September 1983

For  $N = 1$  supergravity theories we show that the choice of a particular class of Einstein spaces for the Kähler manifold of the hidden sector leads to a vanishing cosmological constant without unnatural fine tuning. The total scalar potential from the hidden and physical sector is positive definite. The resulting low energy softly broken global supersymmetry for the matter fields is thus the same as in the case of factorized superpotential models with a flat Kähler metric.

# Costas Kounnas 1952-2021



# Costas Kounnas 1952-2021



# Costas Kounnas 1952-2021



Costas 60th anniversary, Cyprus 2012

# Costas Kounnas 1952-2021



Costas 60th anniversary, Cyprus 2012

# some history

I knew Costas since 1977

- he was 3 years older
- he graduated from the university of Athens in 1974
- immediately after he was drafted in the army  
fight against the Turkish invasion of Cyprus
- he was thrown out from his home city and lost everything  
Varosha became a ghost town until now
- he finished his PhD in ENS with John Iliopoulos when I started mine  
(doctorat 3e cycle 1978)
- since then we started an intense scientific collaboration [12]  
and became very close friends

# Varosha before 2014





# Varosha before 2014



# Varosha now



# Varosha now [7]

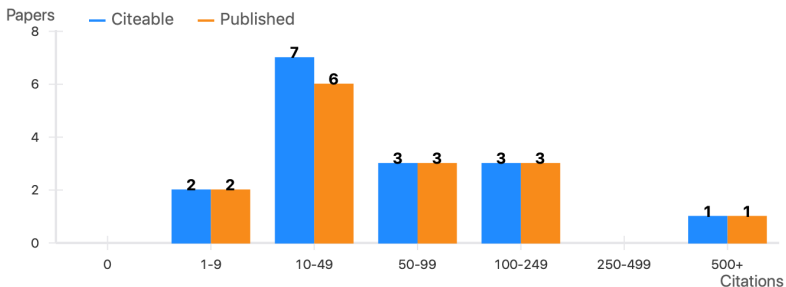


# summary of joint publications

## Citation Summary

Exclude self-citations ?

	Citeable ?	Published ?
Papers	16	15
Citations	1,801	1,786
h-index ?	14	13
Citations/paper (avg)	112.6	119.1



## A Proof of the Factorization of Mass Singularities in the Bjorken Limit

#1

Ignatios Antoniadis (Ecole Normale Superieure), L. Baulieu (Ecole Normale Superieure), C. Kounnas (Ecole Polytechnique) (Sep, 1979)

Published in: *Nucl.Phys.B* 168 (1980) 394-408

 pdf    DOI    cite


 10 citations

## Factorization Properties and Their Probabilistic Interpretation in Polarized Electroproduction and Annihilation Processes

#2

Ignatios Antoniadis (Ecole Normale Superieure), C. Kounnas (Ecole Polytechnique) (May, 1980)

Published in: *Phys.Rev.D* 24 (1981) 505

 DOI    cite

 26 citations

# QCD: deep inelastic and electroproduction

Factorisation between long and short distance dynamics

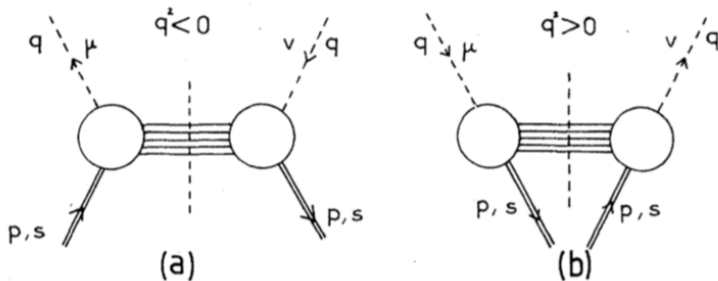
based on light-cone OPE

long-distance: universal parton distribution functions

short-distance: calculable in perturbation due to asymptotic freedom

⇒ scaling violations due to anomalous dimensions

Generalisation from space-like to time-like processes



# BSM: Unification, Supersymmetry and Supergravity

## Symmetry Breaking Effects in Grand Unified Theories

#4

[Ignatios Antoniadis](#) (Ecole Polytechnique), [C. Kounnas](#) (Ecole Normale Supérieure), [C. Roiesnel](#) (Ecole Polytechnique) (Oct, 1981)

Published in: *Nucl.Phys.B* 198 (1982) 317-364

[DOI](#) [cite](#)

[↻](#) 34 citations

## Light Gluinos in Deep Inelastic Scattering

#5

[Ignatios Antoniadis](#) (Ecole Polytechnique), [C. Kounnas](#) (CERN), [R. Lacaze](#) (Saclay) (Jun, 1982)

Published in: *Nucl.Phys.B* 211 (1983) 216-238

[DOI](#) [cite](#)

[↻](#) 71 citations

## Simple Treatment of Threshold Effects

#6

[Ignatios Antoniadis](#) (Ecole Polytechnique), [C. Kounnas](#) (CERN), [K. Tamvakis](#) (CERN) (Aug, 1982)

Published in: *Phys.Lett.B* 119 (1982) 377-380

[DOI](#) [cite](#)

[↻](#) 105 citations

## Noncompact Symmetries and Vanishing of the Cosmological Constant

#7

[Ignatios Antoniadis](#) (SLAC), [C. Kounnas](#) (UC, Berkeley), [Dimitri V. Nanopoulos](#) (CERN and UC, Santa Cruz) (May, 1985)

Published in: *Phys.Lett.B* 162 (1985) 309-316

[pdf](#) [links](#) [DOI](#) [cite](#)

[↻](#) 22 citations




# Construction of 4d strings


## Supersymmetry Among Free Fermions and Superstrings

#1

[Ignatios Antoniadis \(SLAC\)](#), [Constantin Bachas \(SLAC\)](#), [C. Kounnas \(UC, Berkeley and LBL, Berkeley\)](#), [Paul Windey \(UC, Berkeley and LBL, Berkeley\)](#) (Sep, 1985)

Published in: *Phys.Lett.B* 171 (1986) 51-56

 pdf  links  DOI  cite

 238 citations

## Four-Dimensional Superstrings

#2

[Ignatios Antoniadis \(CERN\)](#), [C.P. Bachas \(Ecole Polytechnique\)](#), [C. Kounnas \(LBL, Berkeley\)](#) (Dec, 1986)

Published in: *Nucl.Phys.B* 289 (1987) 87

 DOI  cite

 881 citations

## Higgs Phenomenon in String Theories

#12

[Ignatios Antoniadis \(CERN\)](#), [C. Bachas \(Ecole Polytechnique\)](#), [C. Kounnas \(UC, Berkeley and LBL, Berkeley\)](#) (Oct, 1987)

Published in: *Phys.Lett.B* 200 (1988) 297-304

 DOI  cite

 48 citations



## SUPERSYMMETRY AMONG FREE FERMIONS AND SUPERSTRINGS

I. ANTONIADIS<sup>1,2</sup>, C. BACHAS<sup>1</sup>

*Stanford Linear Accelerator Center, Stanford University, Stanford, CA 94305, USA*

C. KOUNNAS<sup>3,4</sup> and P. WINDEY<sup>3</sup>

*Physics Department and Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720, USA*

Received 17 October 1985

Physics Letters B 171 (1986) 51-56

A complete classification is given of all supersymmetric theories of free massless two-dimensional fermions. This, in particular, implies a classification of all free-fermion representations of super Kac–Moody algebras. It is shown that these cannot be used to construct new string theories with unbroken supersymmetry in Minkowski space–time, other than the torus-compactifications of the known ten-dimensional superstrings. Assuming anti-de-Sitter space–time could restore conformal invariance, it is shown how one could construct a string theory whose low-lying excitations form a multiplet of gauged  $N = 8$  supergravity.

# Non-linear SUSY among 2d free fermions

*Supersymmetry among free fermions.* Let us begin by considering  $N$  free Weyl–Majorana fermions in two dimensions, whose euclidean action is

$$S = \frac{1}{2} \int dz d\bar{z} \psi^A \partial_{\bar{z}} \psi^A, \quad (1)$$

where  $z = x + it$ ,  $A = 1, \dots, N$ , and summation over repeated indices is implied. This action is invariant under

$$\delta \psi^A = \eta^{ABC} \psi^B \psi^C \epsilon \quad (2)$$

(with  $\epsilon$  an infinitesimal Grassmann parameter) if and only if  $\eta^{ABC}$  is totally antisymmetric in its indices.

We now prove the following theorem:

*Theorem.* Transformation (2) is a supersymmetry if and only if the  $\eta^{ABC}$  are appropriately normalized structure constants of a semi-simple Lie group  $G$ .

# Construction of 4d strings

## FOUR-DIMENSIONAL SUPERSTRINGS

I. ANTONIADIS\*

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C.P. BACHAS

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C. KOUNNAS\*\*

*Lawrence Berkeley Laboratory, Berkeley, California 94720, USA*

Received 30 December 1986

Nuclear Physics B 289 (1987) 87-108

We solve completely the constraints of factorization and multiloop modular invariance for closed string theories in which all internal quantum numbers of the string are carried by free periodic and antiperiodic world-sheet fermions. We derive a simple set of necessary and sufficient rules, and illustrate how they can be used to find the spectrum, one-loop amplitudes and low-energy lagrangian of many realistic four-dimensional chiral models. We prove that modular invariance and factorization ensure the presence of a massless graviton and the correct connection between spin and statistics. We also prove that the existence of a massless spin- $\frac{3}{2}$  state ensures the absence of tachyons and the vanishing of the one-loop cosmological constant.

# Construction of 4d strings

Basic idea:

describe the compactification space by a (S)CFT of free 2d fermions

Heterotic string  $c = (6 + 3, 22) \Rightarrow 18$  L-moving and 44 R-moving  
with non-linear supersymmetry  $SU(2)^6$

Parameters:

boundary conditions around the 2 cycles of the world-sheet torus

$\Rightarrow$  Hamiltonian and fermion number projection

Constraints: one-loop modular invariance and 2-loop factorisation

$\Rightarrow$  sum over several sectors of boundary conditions

Set of rules for constructing chiral models with interesting phenomenology

$N = 1$  SUSY, 3 generations, exact  $\alpha'$ -calculability of effective SUGRA,

$SO(10)$  underlying structure: flipped  $SU(5)$ , Pati-Salam, Standard Model

# Curved backgrounds and non critical strings


## Exact supersymmetric string solutions in curved gravitational backgrounds

#15

[Ignatios Antoniadis](#) (Ecole Polytechnique), [S. Ferrara](#) (CERN), [C. Kounnas](#) (CERN) (Feb, 1994)

Published in: *Nucl.Phys.B* 421 (1994) 343-372 • e-Print: [hep-th/9402073](#) [hep-th]

 pdf    DOI    cite

 68 citations

## $\mathcal{N} = 2$ Superliouville and Noncritical Strings

#13

[Ignatios Antoniadis](#) (Ecole Polytechnique), [C. Bachas](#) (CERN), [C. Kounnas](#) (Ecole Normale Superieure) (Mar, 1990)

Published in: *Phys.Lett.B* 242 (1990) 185-190

 DOI    cite

 20 citations

## The Dilaton Classical Solution and the Supersymmetry Breaking Evolution in an Expanding Universe

#1

[Ignatios Antoniadis](#) (SLAC), [C. Kounnas](#) (UC, Berkeley and LBL, Berkeley) (Feb, 1986)

Published in: *Nucl.Phys.B* 284 (1987) 729 • Contribution to: *ICHEP 86*

 pdf    links    DOI    cite

 25 citations

## On the Possibility of Avoiding Singularities by Dilaton Emission

#2

[Ignatios Antoniadis](#) (CERN), [G.F.R. Ellis](#) (CERN), [John R. Ellis](#) (CERN), [C. Kounnas](#) (LBL, Berkeley), [Dimitri V. Nanopoulos](#) (Wisconsin U., Madison) (Feb, 1987)

Published in: *Phys.Lett.B* 191 (1987) 393-398

 DOI    cite

 9 citations

# Superstrings at finite temperature

## Superstring phase transition at high temperature #1

[Ignatios Antoniadis](#) (Ecole Polytechnique), [C. Kounnas](#) (Ecole Normale Superieure) (Feb, 1991)

Published in: *Phys.Lett.B* 261 (1991) 369-378

 DOI  cite

 159 citations

## Nonperturbative supersymmetry breaking and finite temperature instabilities in N=4 superstrings #2

[Ignatios Antoniadis](#) (Ecole Polytechnique), [J.P. Derendinger](#) (Neuchatel U.), [C. Kounnas](#) (Ecole Normale Superieure and CERN) (1998)

Published in: *PoS corfu98* (1998) 074 • Contribution to: [CORFU 1998](#), [CORFU 1998](#), 074 • e-Print: [hep-th/9908137](#) [hep-th]

 pdf  links  DOI  cite

 15 citations

## Nonperturbative temperature instabilities in N=4 strings #3

[Ignatios Antoniadis](#) (Ecole Polytechnique), [J.Pierre Derendinger](#) (Neuchatel U.), [Costas Kounnas](#) (CERN) (Feb, 1999)

Published in: *Nucl.Phys.B* 551 (1999) 41-77 • e-Print: [hep-th/9902032](#) [hep-th]

 pdf  DOI  cite

 72 citations

## Superstring phase transition at high temperature

I. Antoniadis

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Received 26 February 1991

Physics Letters B 261 (1991) 369-378

We analyse the phase transition of superstring at high temperature. We derive the exact effective potential of the “ $T$ -winding” mode which becomes tachyonic above the Hagedorn temperature. We show that in the heterotic case a phase transition occurs which, from the world-sheet point of view, is a generalization of the Kosterlitz–Thouless transition. We derive the conformal field theory describing the new phase and we find that the central charge of the system  $\hat{c}$  is lowered by two units. The resulting high-temperature phase then corresponds to a non-critical superstring in  $(7+1)$  dimensions. Moreover, the new vacuum exhibits a miraculous “space-like” supersymmetry which leads to the vanishing of the free energy, at least up to the one-loop level. We finally argue that our result could describe a transition from a “cold” to a “hot” phase in the history of the early universe.

## Non-perturbative temperature instabilities in $N = 4$ strings <sup>★</sup>

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<sup>a</sup> *Centre de Physique Théorique, Ecole Polytechnique, F-91128 Palaiseau, France* <sup>2</sup>

<sup>b</sup> *Institut de Physique, Université de Neuchâtel, Breguet 1, CH-2000 Neuchâtel, Switzerland*

<sup>c</sup> *Theory Division, CERN, 1211 Geneva 23, Switzerland*

Received 11 February 1999; accepted 8 March 1999

Nuclear Physics B 551 (1999) 41-77

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### Abstract

We derive a universal thermal effective potential, which describes all possible high-temperature instabilities of the known  $N = 4$  superstrings, using the properties of gauged  $N = 4$  supergravity. These instabilities are due to three non-perturbative thermal dyonic modes, which become tachyonic in a region of the thermal moduli space. The latter is described by three moduli,  $s, t, u$ , which are common to all non-perturbative dual-equivalent strings with  $N = 4$  supersymmetry in five dimensions: the heterotic on  $T^4 \times S^1$ , the type IIA on  $K_3 \times S^1$ , the type IIB on  $K_3 \times S^1$  and the type I on  $T^4 \times S^1$ . The non-perturbative instabilities are analyzed. These strings undergo a high-temperature transition to a new phase in which five-branes condense. This phase is described in detail, using both the effective supergravity and non-critical string theory in six dimensions. In the new phase, supersymmetry is perturbatively restored but broken at the non-perturbative level. In the infinite-temperature limit the theory is topological with an  $N = 2$  supersymmetry based on a topologically non-trivial hyper-Kähler manifold. © 1999 Elsevier Science B.V. All rights reserved.



# Superstrings at finite temperature

exponential degeneracy of states  $\Rightarrow$  limiting temperature  $T_H$  (Hagedorn)

string gas partition function diverges at  $T_H$

universal value depending only on the critical dimension

microscopic description: tachyonic  $T$ -winding mode for  $T > T_H$

Euclidean time on a circle of radius  $1/(2\pi T)$  suggesting phase transition

Euclidean theory in one dimension lower has spontaneously broken SUSY

due to boundary conditions: bosons periodic vs fermions antiperiodic

Basic idea: compute the effective supergravity in 4d compactifications

$\Rightarrow$  effective potential of the  $T$ -winding mode and radion

minimum: non-critical string with central charge deficit  $\delta\hat{c} = 4 \Rightarrow$

High- $T$  phase: 6d non-critical string with half supersymmetry restored

# My memories of Costas

- He was a close friend and a precious colleague
- He had a unique way of doing physics in lively and intense discussions
- My memory is full of stories
  - working on the blackboard after midnight inside a smoking cloud
  - with after dinner drinks listening his numerous funny stories
- Our community lost a great physicist with unique personality
- His legacy will stay in our memories for ever

