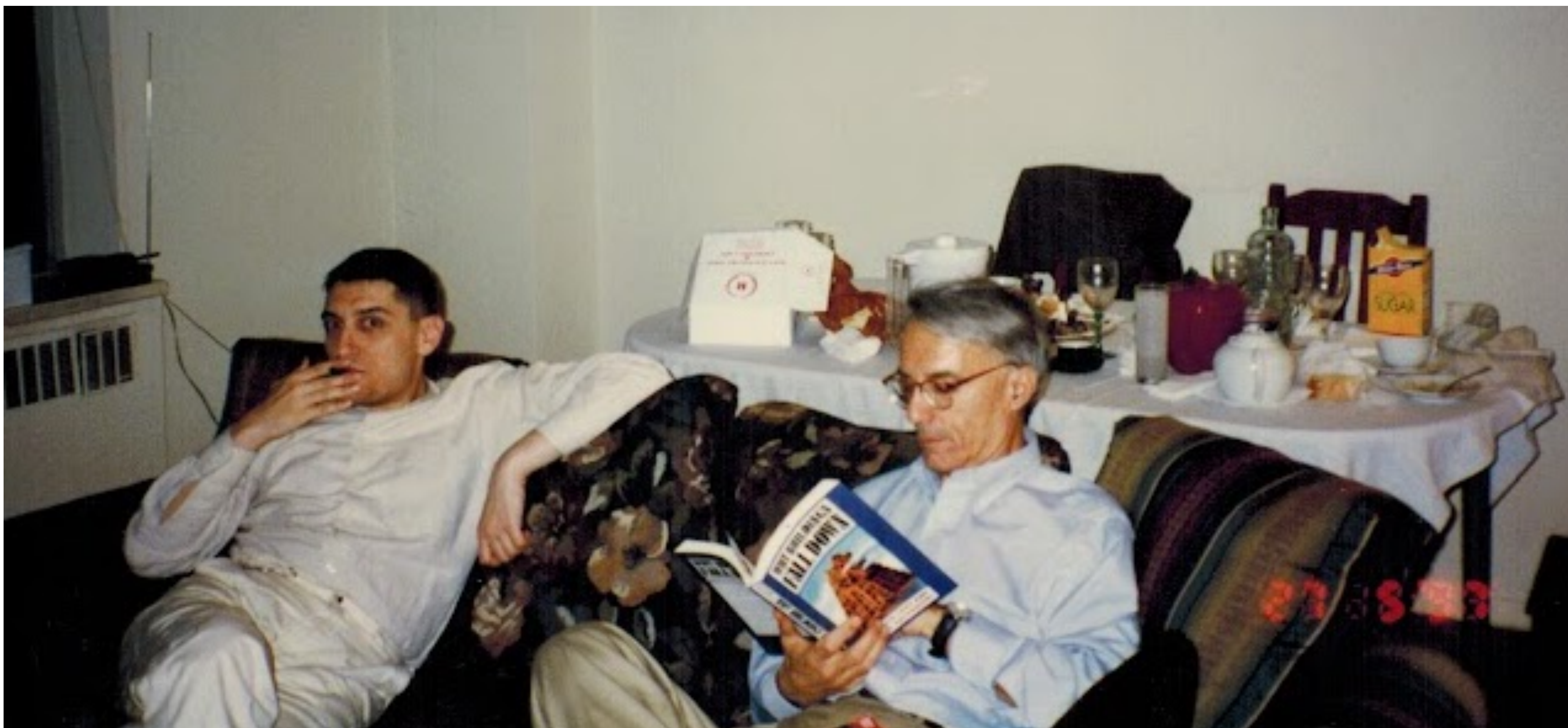
STOGIES AND SUPERGRAVITY

(a few scenes from 35+ years of work and friendship with Luciano)



RANDOM FACTS

- FIRST PAPER: MAY 1984
- LAST PAPER: AUGUST 2009
- 28 PAPER, 2000+ INSPIRES CITATIONS
- A teatime mishap; "I don't regret cigarettes but I do miss a Toscanello"; a Death Valley trip in a dismal pea-green Oldsmobile Delta 88; diverging opinions over Poussin: "a color-blind painter that can't draw" [me] vs "a most profound philosopher-painter" [Luciano]; Meeting at NYU on September 12 2001; burning down the NYU (guest)house…

N. Poussin pinxit — Gravé par Audran A Paris rue S.t Jacques aux 2 Piliers d'or — Avec Privilege

Armide cherchant a se vanger de Regnault qui luy avoit enlevé ses prisonniers, le trouve endormu dans une Isle deserte, elle veut luy donner d'un poignard dans le sein, mais la beauté de ce jeune guerrier l'arreste, et change tout a coup sa haine qui paroißoit implacable, en cet amour qui est si bien decrit par le Tasse et qui fait un des plus beaux ornemens de son Poeme.

THE FIRST PAPERS: PARTIAL BREAKING OF SUPERSYMMETRY (WITH A CODA)

TWO INTO ONE WON'T GO, S. Cecotti, L. Girardello, M.P.
Phys. Lett. B145 (1984) 61

No breaking of N=2 SUSY to N=1 exists in N=2 supergravity in Minkowski spacetime

AN EXCEPTIONAL N=2 SUPERGRAVITY WITH FLAT POTENTIAL AND PARTIAL AN EXCEPTIONAL N=2 SUPERGRAVITY WITH
Phys. Lett. B168 (1986) 83, S. Cecotti, L. Girardello, M.P.
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Breaking of N=2 SUSY to N= in N=2 supergravity in Minkowski spacetime?!

Understood in: MINIMAL HIGGS BRANCH FOR THE BREAKING OF HALF OF THE SUPERSYMMETRIES IN N=2 SUPERGRAVITY
S. Ferrara, L. Girardello, M.P.
Phys. Lett. B366 (1996) 155

N=2 TO N=1 SUPERHIGGS 1) DOF COUNTING

Graviton N=2 massless supermultiplet [helicity (multiplicity)]

$[\pm 2\,(1), \pm\, 3/2\,(2), \pm\, 1\,(1)]$

Graviton N=1 massless supermultiplet

$[\pm 2\,(1), \pm\, 3/2\,(1)]$

Spin 3/2 N=1 massive supermultiplet

$[\pm 3/2\,(1), \pm\, 1\,(2), \pm\, 1/2\,(3), 0\,(4)]$

ADDITIONAL DEGREES OF FREEDOM ARE NEEDED:

N=2 vector multiplet $[\pm 1\,(1), \pm\, 1/2\,(2), 0\,(2)]$

N=2 hypermultiplet $[\pm 1/2\,(2), 0\,(4)]$

THEY PROVIDE THE NECESSARY HELICITIES FOR THE N=2 TO N=1 SUPERHIGGS AND FOR A CHIRAL MULTIPLET

N=2 TO N=1 SUPERHIGGS 2) DYNAMICS [the 1984-1985 story]

The Kaehler potential is $K = \log(F_I X^I + \bar{F}_I \bar{X}^I)$ with (F_I, X^I) a holomorphic section of a symplectic bundle over the manifold of the n vector multiplet scalars

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The X^I and F_I transform into each other under electric-magnetic duality and this duality can be used to find a duality frame in which X^I, $I = 0,\ldots m$ are projective coordinates of the manifold and $F_I = \partial F(X) \partial X^I$

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For any prepotential $F(X)$ and any local N=2 Lagrangian EITHER 2 OR NONE OF THE SUPERSYMMETRIES CAN BE BROKEN IN A MINKOWSKI SPACE BACKGROUND

SO, HOW DOES THE EXCEPTIONAL N=2 EVADE THIS?

THE ANSWER WAS UNDERSTOOD COUNTLESS TOSCANELLI LATER

The X^I and F_I transform into each other under an electric-magnetic duality and this duality can be used to find a duality frame in which a prepotential always exist.

But this duality is broken by the hypermultiplets. To couple them to the vector multiplet one must choose a particular duality frame in which all their charges are electric.
In this frame $F(X)$ MAY NOT EXIST

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In fact the exceptional N=2 model we found in 1986 has

$$X^I = constant$$

so they are not even coordinates

THE BESTSELLERS: GPPZ [with M. Petrini and A. Zaffaroni]

NOVEL LOCAL CFTs AND EXACT RESULTS ON PERTURBATIONS OF N=4 SUPER YANG-MILLS FROM ADS DYNAMICS, JHEP 12 (1998) 022, hep-th/9810126

Nonperturbative RG flows between conformal fixed points from holographic duality and a holographic c-theorem from the null energy conditions

CONFINEMENT AND CONDENSATES WITHOUT FINE TUNING IN SUPERGRAVITY DUALS OF GAUGE THEORIES, JHEP 05 (1999) 026, hep-th/9903026

Nonperturbative holographic RG flows to gapped IR fixed points

THE SUPERGRAVITY DUAL OF N=1 SUPER YANG-MILLS THEORY, Nucl. Phys B569 (2000) 45, hep-th/9909047

N=1 perturbation of N=4 flowing in the IR to a holographic, strongly-coupled theory in the same universality class as N=1 pure super Yang-Mills

KEY POINTS

Type IIB string theory on $AdS_5 \times S_5$ is dual to the $SU(N)$ N=4 Super Yang-Mills theory defined on the conformal boundary of AdS_5

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$S^{IJ} = \phi^{[IJ]} + \lambda^{[I}\theta^{J]} + F_{mn}\theta^I\sigma^{mn}\theta^J + \ldots.$ containing no $\bar{\theta}^{\bar{I}}$

here $I, J = 1,..4, \quad [IJ] \sim A, \quad A = 1,..6$

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Chiral gauge invariant operators

$\mathrm{Tr}\, S^{(A_1} \ldots . S^{A_n)_T}$

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$\mathrm{Tr}\, S^{(A}S^{B)_T}$ contains 42 scalar gauge invariant operators of dimension $\Delta = R \leq 4$

THESE ARE THE SCALARS PRESENT IN THE DIMENSIONAL REDUCTION OF 10D TYPE IIB SUPERGRAVITY TO AdS_5

40 of the 42 scalars have dimension $\Delta < 4$ so they generate a flow from the N=4 supersymmetric fixed point to a different infrared fixed point with lower or no supersymmetry

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20 operators of dimension 2

20 operators of dimension 3

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In N=8 5D supergravity the deformation is found by solving the classical equations of motion of the Lagrangian containing the metric and the scalars. Schematically:

$$L_{N=8\ Sugra} = R(g) - G_{PQ}(\chi) D_m \chi^P D^m \chi^Q - V(\chi)$$

To preserve 4D Poincaré symmetry the ansatz for the metric is

$$ds^2 = dT^2 + e^{2\phi(T)}\eta_{mn}dx^m dx^n$$

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THE NULL ENERGY CONDITION $V^M G_{MN} V^N \geq 0$ specialized to our ansatz and to the null vector $V^M = (e^{-\phi},1,0,0,0)$

V^0 V^T

implies $d^2\phi/dT^2 \leq 0$

The central charge in holographic theories is $c = \left(d\phi/dT\right)^{-3}$

HENCE THE HOLOGRAPHIC C-THEOREM $dc/dT \geq 0$

NOVEL LOCAL CFTs AND EXACT RESULTS ON PERTURBATIONS OF N=4 SUPER YANG-MILLS FROM ADS DYNAMICS, JHEP 12 (1998) 022, hep-th/9810126

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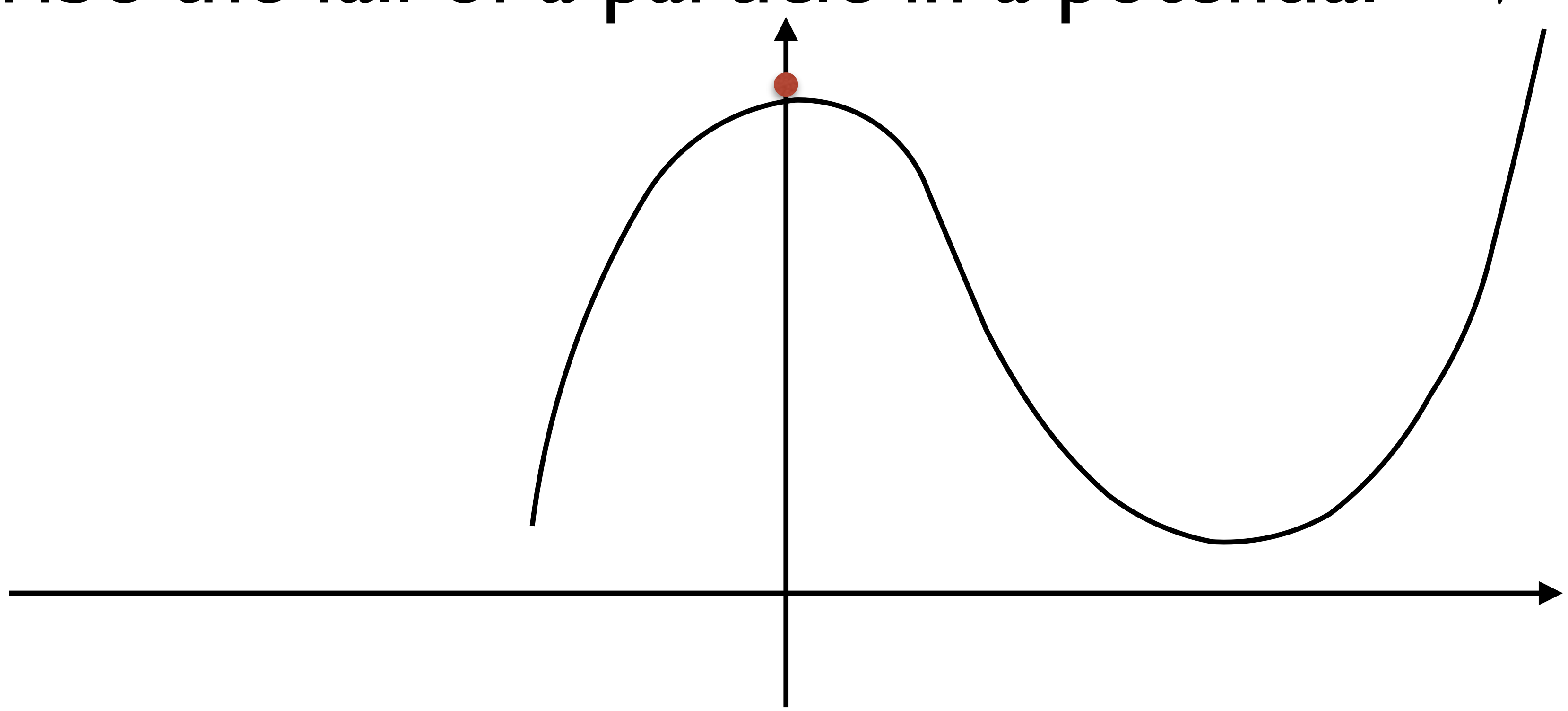
describe the fall of a particle in a potential $-V$ with friction



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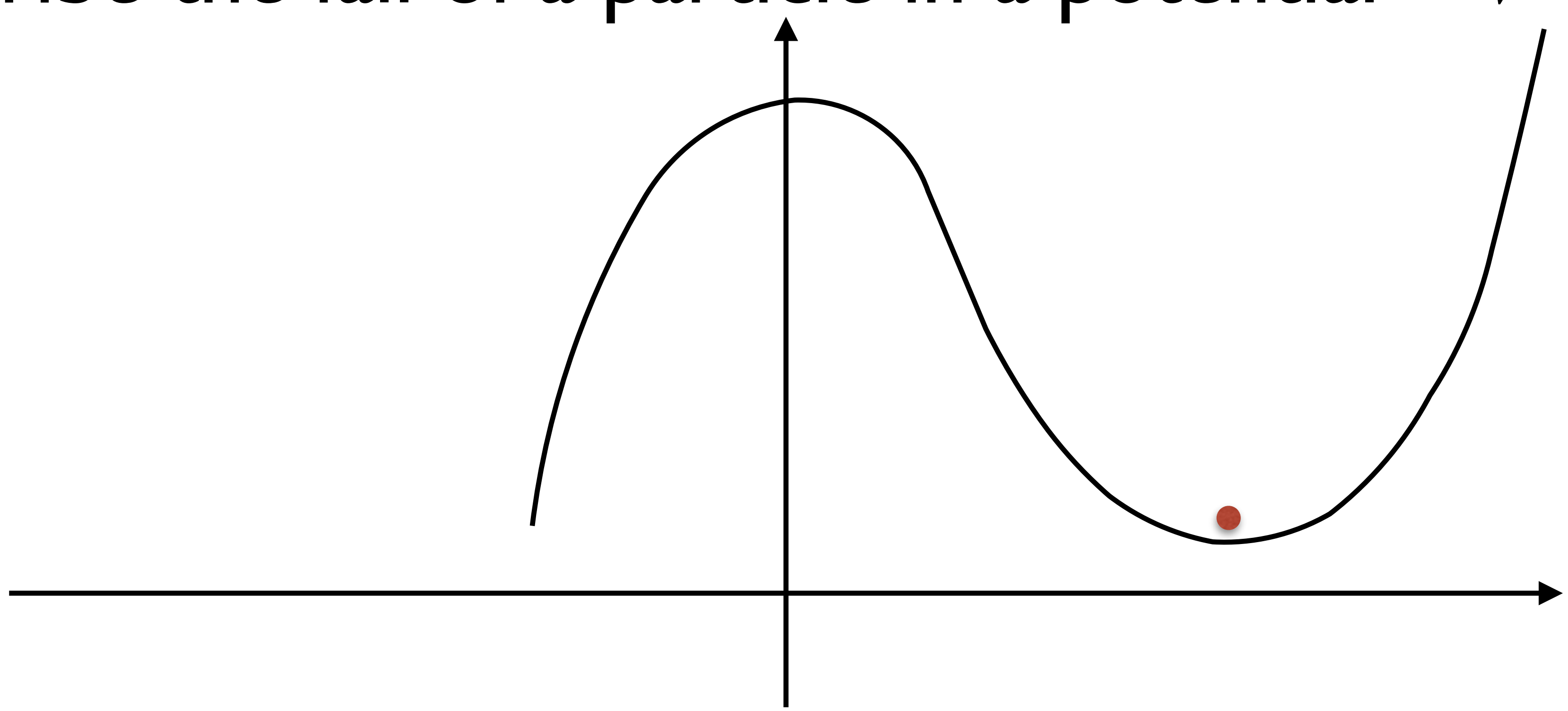

THE SUPERGRAVITY DUAL OF N=1 SUPER YANG-MILLS THEORY, Nucl. Phys B569 (2000) 45, hep-th/9909047

Write N=4 SYM in terms of N=1 supermultiplets. They are:

1) a vector multiplet V with field strength $W_\alpha = \bar{D}^2 e^{-V} D_\alpha e^V$ with first component λ^4

2) 3 scalar multiplets $\Phi^I, \quad I = 1,2,3$ with fermionic components λ^I

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$$L_{N=4} + m_{IJ} \int d^2\theta \mathrm{Tr}\, \Phi^I \Phi^J$$

is a relevant, N=1 preserving deformation of the N=4 Lagrangian

Choose $m_{IJ} = \delta^{IJ} m$ to preserve $SO(3) \subset SU(3) \subset SO(6)$

The scalars in the 10 of SO(6) decompose under SO(3) as

$$10 \to (5+1) + 3 + 1$$

THE HOLOGRAPHIC DUAL

We kept SO(3) unbroken so we can set to zero all the scalars that are not SO(3) singlets

There are only two such (complex) scalars in 5D N=8 SUGRA

1) m , whose boundary value is the source of $\delta_{IJ}\mathrm{Tr}\,\lambda^I\lambda^J$

2) σ, whose boundary value is the source of $\mathrm{Tr}\,\lambda^4\lambda^4$

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Since supersymmetry is preserved there exist a supersymmetry transformation that leaves all bulk fermions invariant.
So the equations of motion describing the evolution of the metric and scalars in the radial coordinate T can be replaced by the condition $\delta\Psi = 0$.
This gives a set of first-order differential equations in T

$$\frac{d\chi^P}{dT} = \frac{1}{2}\frac{\partial W}{\partial \chi P}, \quad \frac{d\phi}{dT} = -\frac{1}{3}W, \quad W = \frac{3}{4}\left[\cosh\frac{2m}{\sqrt{3}} + \cosh 2\sigma\right]$$

THE EXACT SOLUTION IS

$$m(T) = \frac{\sqrt{3}}{2} \log \frac{1 + Ae^{-T}}{1 - Ae^{-T}}, \quad m(T) \to \sqrt{3} A e^{-T} \quad \text{for T large}$$

The decay at large T corresponds to a nonzero source for the operator sourced by m_{IJ} : $\mathrm{Tr}\, \lambda^I \lambda^J$

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$$\sigma(T) = \frac{1}{2} \log \frac{1 + Be^{-3T}}{1 - Be^{-3T}}, \quad \sigma(T) \to Be^{-3T} \quad \text{for T large}$$

The decay at large T corresponds to a nonzero expectation value for the operator sourced by σ : $\mathrm{Tr}\,\lambda^4 \lambda^4$

This operator is the N=1 gaugino condensate

Quite different VEVs than at weak coupling, where they lie on a circle!

I could have described many other papers written with Luciano and many collaborators, who often became also good friends but these examples should suffice to give a glimpse of the range of his interests

Collaborating with Luciano was always fun and instructive. I never felt like a student, not even when I first met Luciano in via Celoria to ask him a thesis in 1983. In fact it was often the opposite. Luciano never ceased to be genuinely pleased to lear something new from his collaborators

The one thing that Luciano taught me, and I am sure all others that worked with him, was to look beyond the confines of our own circle, be it a research group, a department, or even a country, and look for worthwhile ideas and problems far and wide. He had a "nose" for finding good physics problems that is vey hard to imitate… Maybe it was a reflection of his good taste in many other aspects of life besides physics —Poussin excepted, of course!

Luciano would have been horrified in seeing himself described as a teacher imparting lessons about life *ex cathedra* and in fact his favorite method was rather an "invisible hand". He was more like Pat Morita teaching Ralph Macchio in *Karate Kid*
[Luciano would never get this reference, by the way]

I count having known and worked with Luciano as one of the great strikes of luck of my life. Sergio Ferrara and Luciano share the greatest responsibility for the path followed by much of my scientific career

The number of former students collected here today is proof that his low pressure, Zen-like teaching method did work very well indeed.

It doesn't make much sense to address directly a dead fellow atheist, but let me say it anyway: Thank you for the time we spent together and all the great memories, Luciano!