String Theory and Formal QFT at CERN-TH

W.Lerche, TH Retreat 2012

Actually, what is string theory and what it is good for?

For lack of experimental predictions, its focus had been shifting over time...

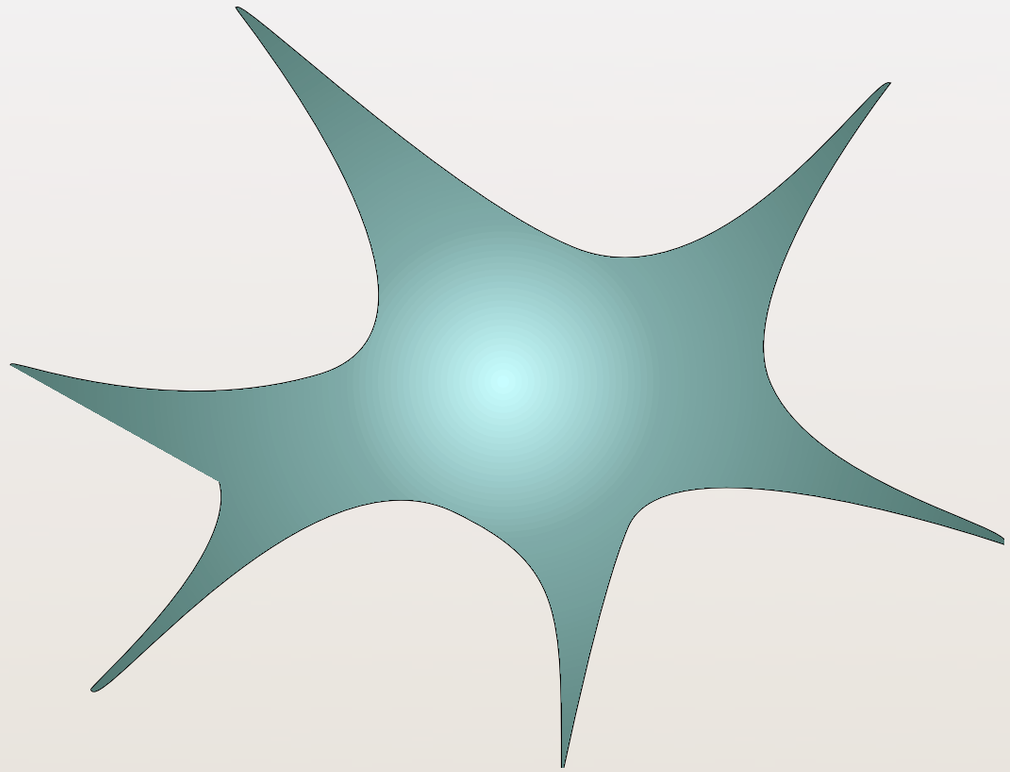
I think it is fair to say that string theory

★ provides a consistent and coherent framework for performing highly non-trivial and concrete toy model computations in susy gauge theories and gravity

★ provides conceptional explanations in such theories

★ provides inspiration and is a major generator of ideas for particle physics, GR and mathematics (SUSY, extra dimensions, branes, landscape, quantum geometry)

A well-working, consistent unification, but of what?



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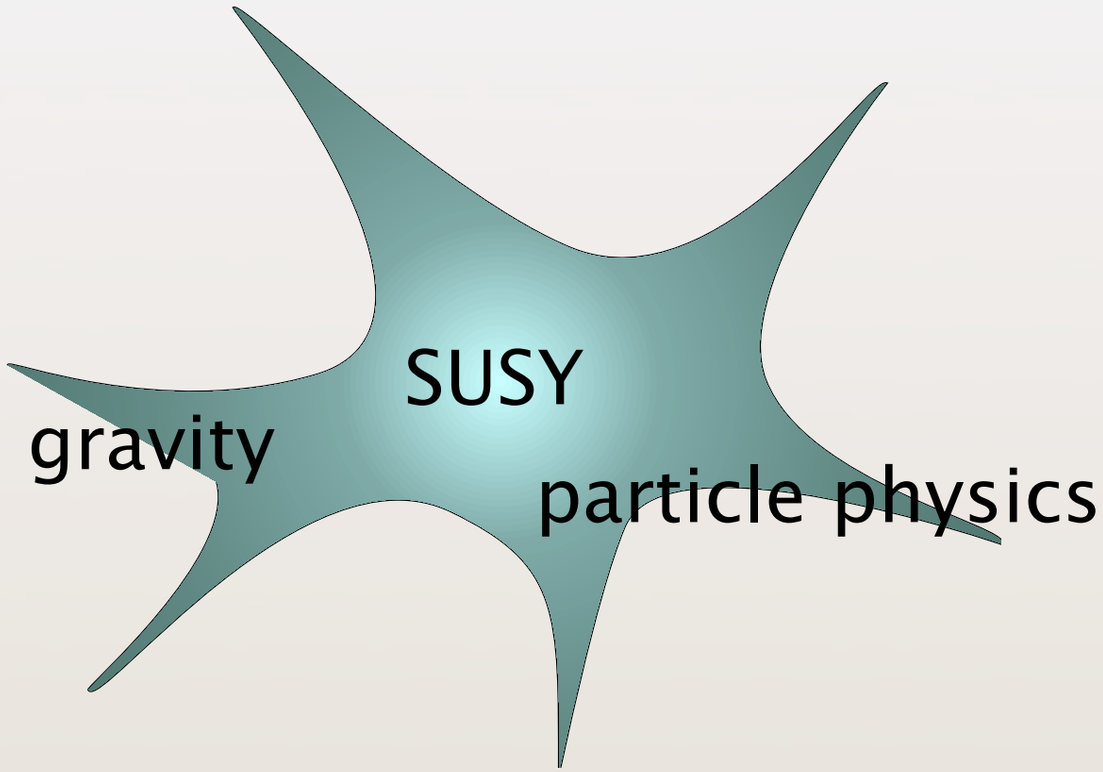

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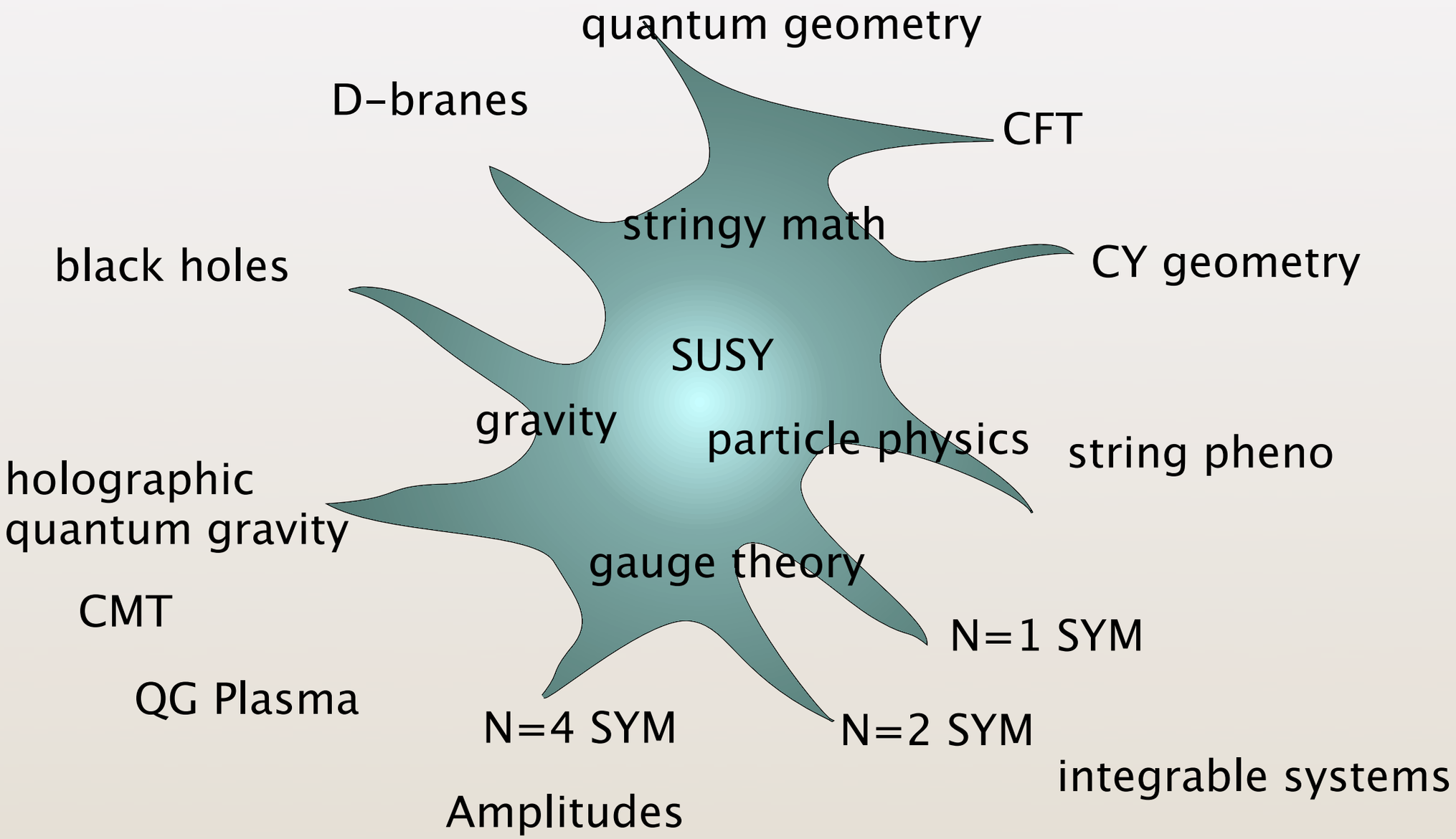

String Theory and Formal QFT at CERN-TH

.. a long tradition, reaching back to the very beginnings of SUSY and strings

Current staff (will speak):

Ignatios Antoniadis (broadly strings, pheno, BSM)

Luis Alvarez-Gaumé (general QFT, strings, gravity)

James Drummond (amplitudes)

Neil Lambert (M-theory and branes, supergravity)

Wolfgang Lerche (topological strings, geometry)

Boris Pioline (dualities, black holes, brane instantons)

Slava Rychkov (general QFT, CFT)

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Fellows in 2nd year:

Inaki Garcia-Etxebarria (D-branes, F-theory)

Alessio Marrani (supergravity)

Domenico Orlando, (branes and SUSY gauge theories)
Susanne Reffert

Alireza Tavanfar (QFT and strings in dS)

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New Fellows (will speak):

Henrik Johansson (amplitudes)

Stefan Hohenegger (dualities, (0,2) theory, ...)

Filippo Passerini (non-pert. susy gauge and string th.)

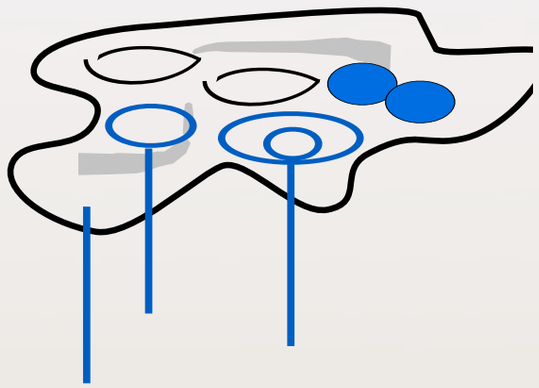
David Vegh (holographic liquids, quiver gauge th.)

Topological Strings

W.L.

Motivation:

Typical brane + flux configuration on a Calabi-Yau space



closed string (bulk) moduli t

open string (brane location + bundle) moduli u

3+1 dim world volume with effective N=1 SUSY theory

What are the exact effective superpotential, the vacuum states, gauge couplings, etc ?

$$\mathcal{W}_{\mathrm{eff}}(\Phi, t, u) \; = \; ?$$

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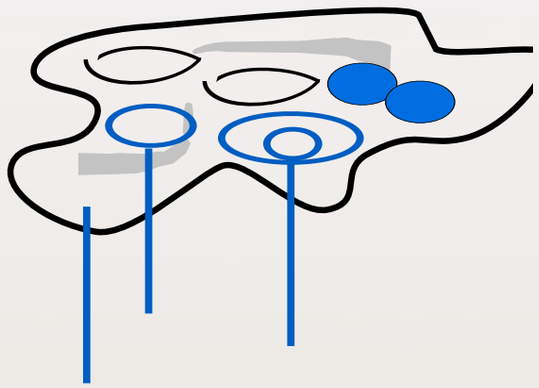

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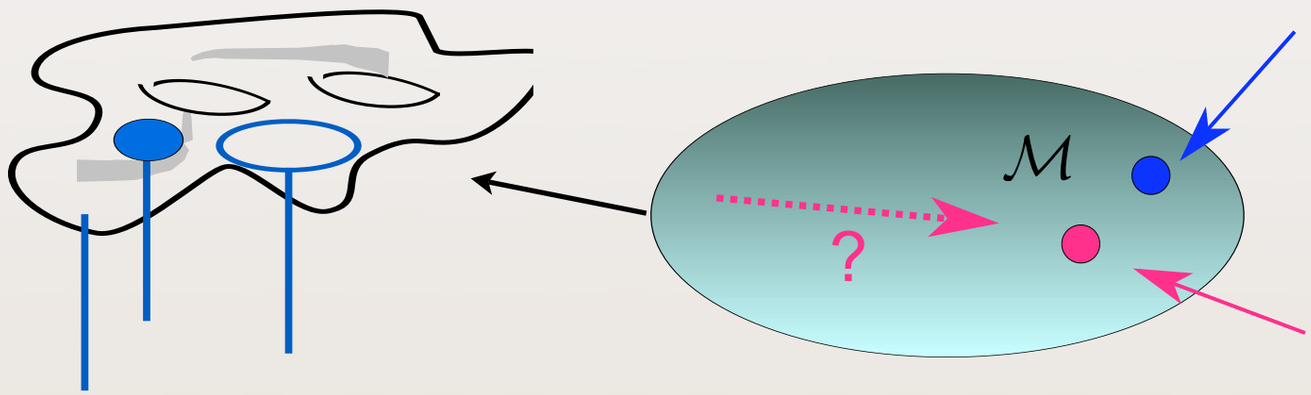
....well developed geometrical techniques mostly for non-generic brane configurations (non-compact, -intersecting) branes only !
(mirror symmetry, localization, matrix models...)

Classical versus Quantum Geometry

Classical geometry ("branes wrapping p-cycles", gauge bundle configurations on top of them) makes sense only at weak coupling/large radius!



"Gepner point"
(CFT description)

typ. symmetry between
0,2,4,6 cycles

"conifold point"
extra massles
states

Classical geometry:
cycles, gauge ("bundle")
configurations on them

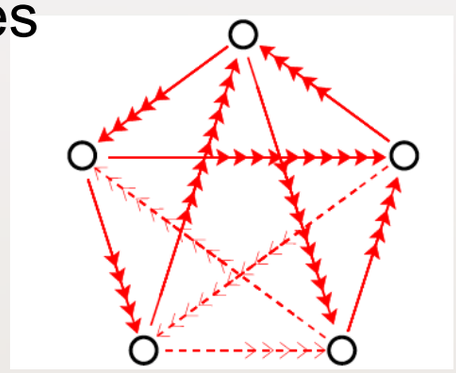
Quantum corrected geometry:
(instanton) corrections wipe out
notions of classical geometry

Most of string phenomenology deals with (semi-)classical regime!

Proper mathematical/physical language?

Important need to develop formalism capable of describing the physics of general D-brane configurations (here: topological D-branes)

Important concept (Kontsevich): derived/Fukaya categories



This is the only known language that is powerful enough to describe arbitrary brane configuration in arbitrary regimes!

What does it buy for physicists:

- more general than cohomology/ K-theory (RR charges) keeps track of moduli/brane positions
- describes bound state formation/tachyon condensation (triangulated category)
- Translate math. language to physics:
  homological mirror symmetry
  boundary Landau-Ginzburg theory/matrix factorizations

$$Q(x) \cdot Q(x) = W_{LG}(x)\, 1$$