1st ILP Day
Paris, 13 March 2011

LPTHE $\longleftrightarrow$ ILP

The view from particle physics

Matteo Cacciari
LPTHE

(Partly recycled from talk at inaugural meeting of ILP in November 2011)

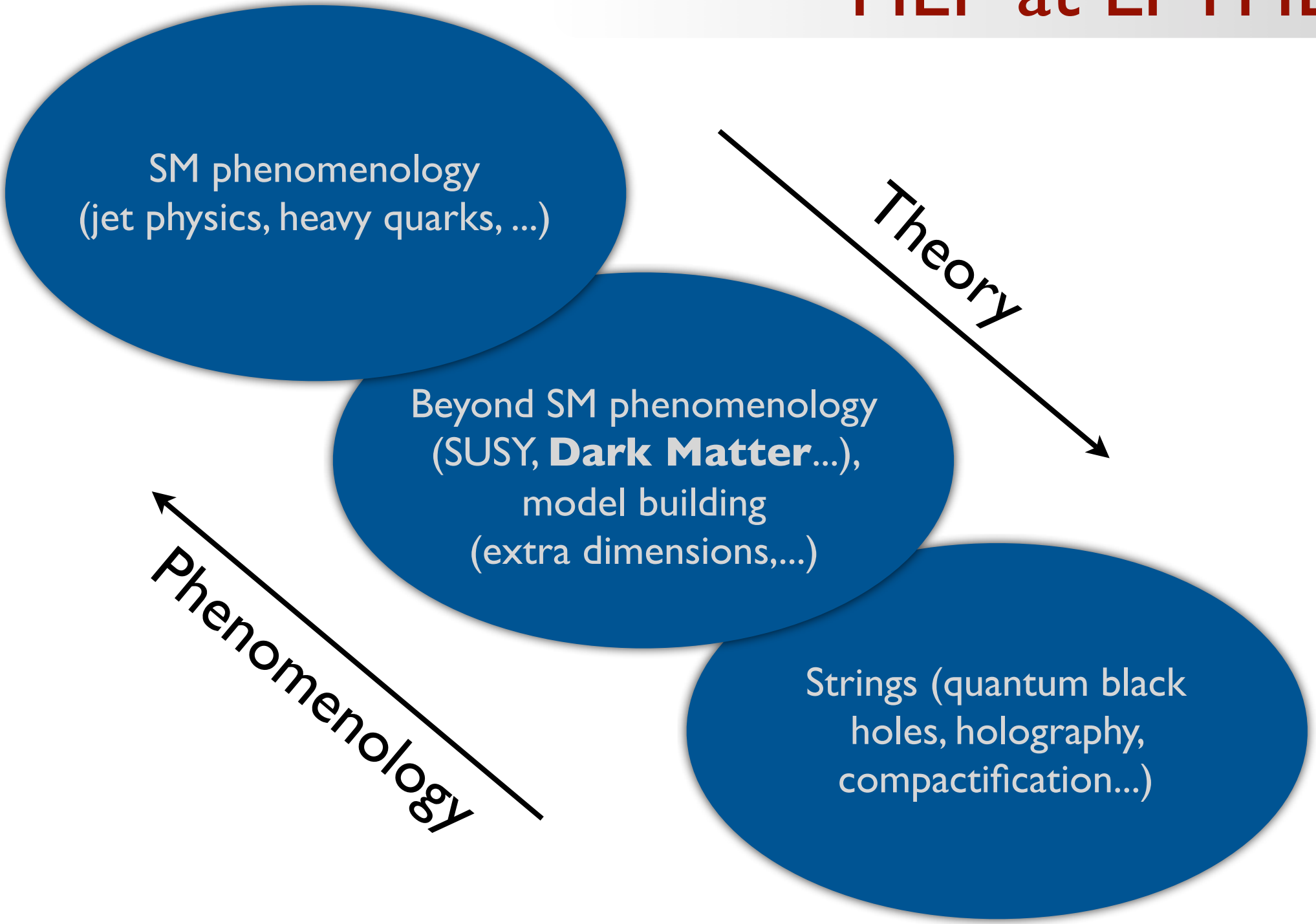
Synergies?

"Until cosmology and particle physics can be brought together in the same context, there is not much hope for real progress in cosmology"

Niels Bohr
(1939)

[Extracted from a talk by E. Kolb, https://indico.cern.ch/event/148069/material/slides/1.pdf]

HEP at LPTHE


SM phenomenology
(jet physics, heavy quarks, ...)
Beyond SM phenomenology
(SUSY, **Dark Matter**...),
model building
(extra dimensions,...)
Strings (quantum black
holes, holography,
compactification...)
Theory
Phenomenology

Particle physics ILP Fellows at LPTHE

- Robert Ziegler (postdoc, BSM)
- Luc Darmé (PhD, BSM)
- Frédéric Dreyer (PhD, SM phenomenology)

Dark Matter

Many candidates: primordial black holes, axions, WIMPs,....

Best ones (or, rather, where we have more freedom) are probably the WIMPs.
A WIMP candidate could be a 'sterile heavy neutrino', however making it stable is contrived.

A better option is the lightest superparticle (LSP) in a supersymmetric model with exact R-parity (to make the LSP stable).

$\Rightarrow$ sneutrinos or neutralinos

Need to be uncomfortably heavy to make good candidates

Most commonly studied candidate

Dark Matter

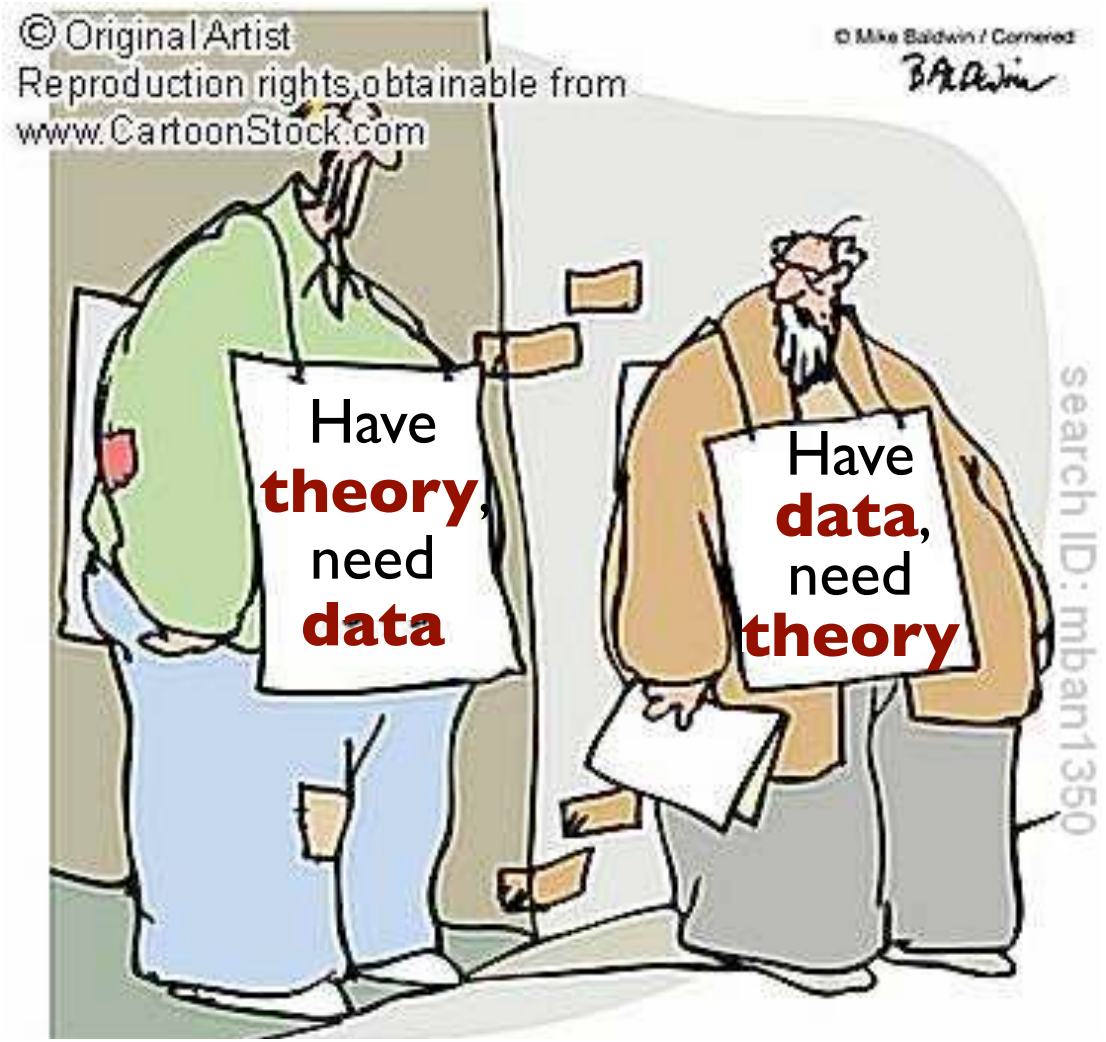
Theory has produced (and produces) many DM candidates.
The ball is now in the experimentalist's field: we need to find them.

Besides proposing candidates, the contribution from the theory side is in the accurate phenomenological studies needed in searches, e.g. of SUSY at the LHC, and often in global fits to experimental data

LHC SUSY determination + direct and indirect searches likely needed to pinpoint DM properties

Particle physics and cosmology have a lot in common

Particle physics



Cosmology

Twins?

Cosmology and particle physics
are both looking for a fundamental scalar field

Found?

We seem to live in a world where minimal scalar fields are very relevant.
Does this mean something special?

Small numbers

THE COSMOLOGICAL CONSTANT AND THE STRING LANDSCAPE

hep-th/0603249

JOSEPH POLCHINSKI

Kavli Institute for Theoretical Physics
University of California
Santa Barbara, CA 93106-4030

Polchinski draws a parallel with the 1947 Shelter Island conference

Then, people had measured a small but non zero quantity, the Lamb shift, but calculations gave infinity.
Eventually, people learned how to calculate it.

Today, the cosmological constant is small but non zero, and similarly we cannot calculate it.

He seems to suggest that the difficulty must be temporary and, like the calculation of the Lamb shift which was eventually possible in QFT, we'll be able to calculate the cosmological constant in string theory.

In other words, we are only facing a little cloud...

Clouds?

THE

LONDON, EDINBURGH, AND DUBLIN

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE

[SIXTH SERIES.]

JULY 1901.

I. *Nineteenth Century Clouds over the Dynamical Theory of Heat and Light* *. *By* The Right. Hon. Lord KELVIN, *G.C.V.O., D.C.L., LL.D., F.R.S., M.R.I.* †.

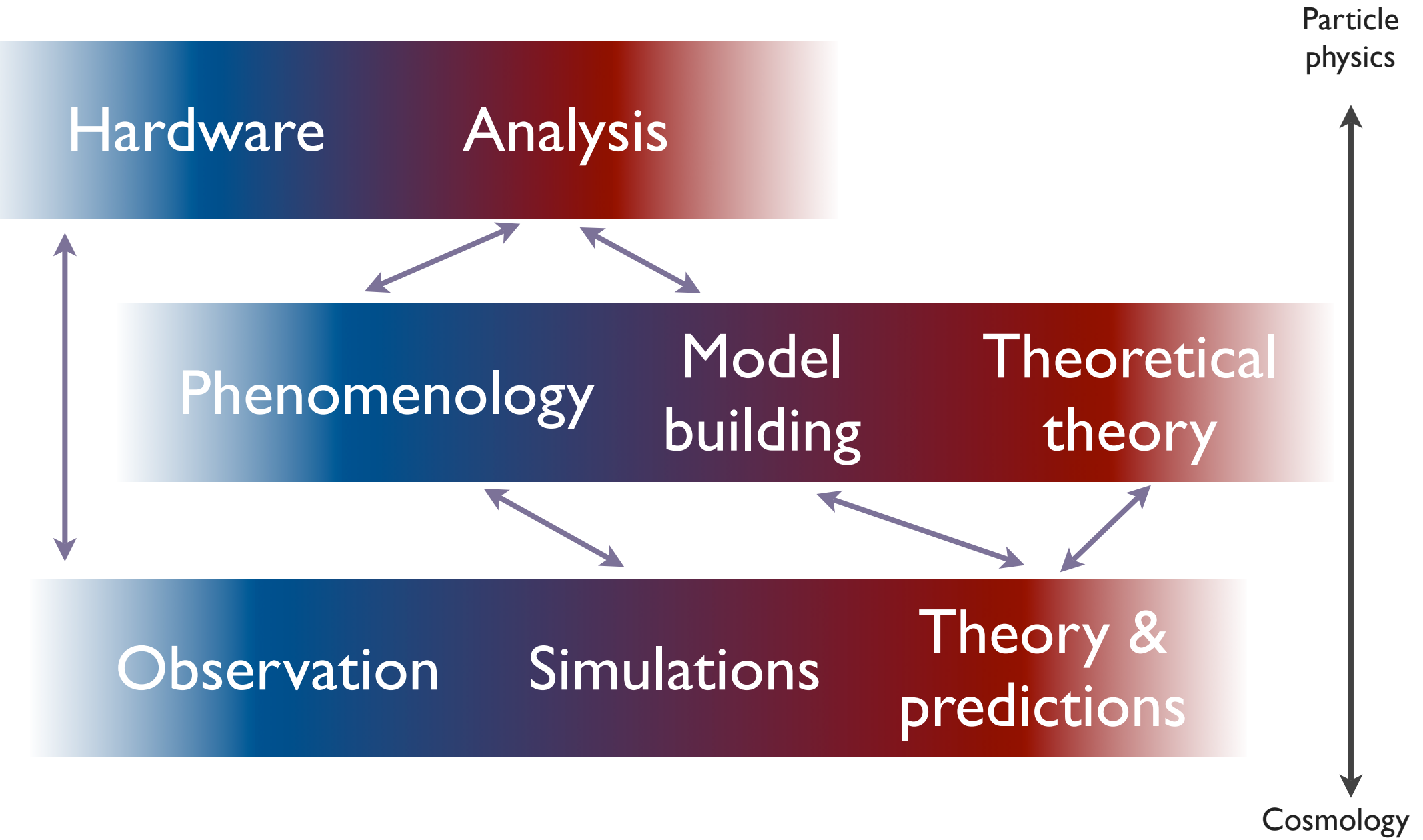
"The beauty and clearness of the dynamical theory, which asserts heat and light to be modes of motion, ***is at present obscured by two clouds****. I. The first came into existence with the undulatory theory of light, and was dealt with by Fresnel and Dr. Thomas Young; it involved the question, how could the earth move through an elastic solid, such as essentially is the luminiferous ether? II. The second is the Maxwell–Boltzmann doctrine regarding the partition of energy. [...]*
I am afraid we must still regard Cloud No. I as very dense."

Wisdom?

- Despite Bohr's thoughts, I think that cosmologists are actually doing fine without particle physicists. However, ultimate progress will indeed likely have to come from collaboration and convergence from both sides

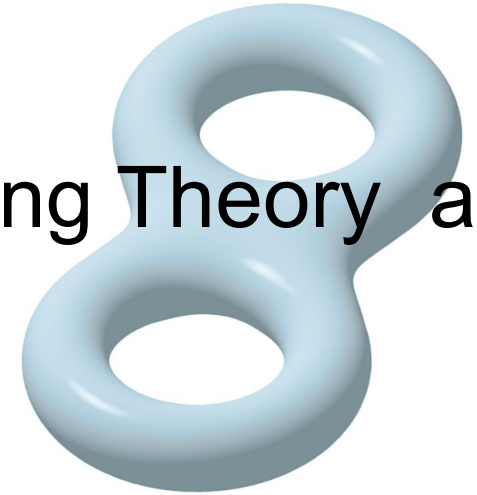
- IAP, LERMA, LPNHE, LPNHE are perfectly complementary in ILP in terms of expertise
  - Each is presently benefiting from ILP in terms of students and postdocs in their own domains
  - Preservation of individual strengths is valuable, but we should probably also look for the potential added value of developing direct collaborations

Opportunities for cross-talk



ILP day, 13 March 2014

String Theory at ILP



Staff members

- Laurent Baulieu
- Atish Dabholkar,
- Nick Halmagyi,
- Dan Israël,
- Michela Petrini,
- Boris Pioline (on leave at CERN),
- Paul Windey.

ILP fellows, past, present & future

ILP PhD fellows :

- Teresa Bautista (w. Atish Dabholkar) since 2013
- Oscar de Felice (w. Dan Israël & Michela Petrini) will start in 2014

ILP Invited professors

- Simon Ross (Durham U) in 2013

ILP postdoctoral fellows

- Sébastien Renaux-Petel since 2012, lot of interactions with the string theory group
- Erik Eik Svanes (from Oxford U) will start in Sept. 2014 (string compactifications)

Courses by ILP fellows

- Sébastien Renaux-Petel gave a series of l*ectures on inflation*
  → wide following among LPTHE people
- Simon Ross lectured a *course on AdS/CFT correspondence*
  → attended by a largely non-string-theory audience

⇨ successful actions made possible by ILP

Some research achievements

- Quantum supersymmetric black holes :

  BH microstates counting → checks of entropy formulae at *finite* charge & new mathematical structures

- Supersymmetric black holes in Anti-de Sitter Space :

  New classes of solutions → Understand BH entropy using holography

- (A)dS compactifications :

  Supersymmetric compactifications with moduli stabilization, negative cosmological constant & high extra-dimensions energy scales

- Heterotic compactifications with fluxes :

  Microscopic models of flux compactifications & their duality properties

  → both will help to build realistic models of particle physics & cosmology

Collaborations, past & future

- The level of collaboration of our group with other ILP partners needs to be improved

  ⇨ one reason being that the string theory group focuses more on formal/fundamental aspects (rather than phenomenologically oriented) of quantum gravity & string theory

<u>Possible overlapping interests</u>

- with IAP : inflation & bounce models, alternative gravity theories & accelerating universe
- with LPNHE : dark matter, more generally physics beyond the standard model

Some (long-term) theoretical challenges for ILP

- How to define quantum gravity with a positive cosmological constant ? *(we have already understood that the step from $\Lambda=0$ to $\Lambda<0$ involves a complete change of paradigm, i.e. AdS/CFT correspondence)*
- What drives inflation ?
- How can we deal with space-like singularities, such as the big-bang ? *(studies of quantum black holes have helped to understand time-like singularities)*

ILP actions for the future ?

- Courses : renew the very positive experience, involving ILP fellows & the permanent staff
- Thematic days *(more suitable than regular seminars due to the already overcrowded schedule)* on subjects of common interest such as inflation, dark matter etc... alternating speakers from the different groups
- Mailing list/newsletter with course, workshops & seminar announcements, a list of current ILP visitors is very helpful