GÖTEBORG THEORY GROUP PRESENTATION

PARTIKELDAGARNA 2007

In 2005 the Department of Fundamental Physics was established at Chalmers with Björn Jonson as Head of Department.

The department consists of three separate groups:

- Subatomic Physics, (in a different section of SFS)
- Mathematical Physics (Bengt EW Nilsson, Martin Cederwall, Gabriele Ferretti, Ulf Gran)
- Particle Physics (Lars Brink, Robert Marnelius, Per Salomonsson, Måns Henningsson, Niclas Wyllard)

Currently counting 1 postdoc (Dario Francia) and 3 Ph.D. students (Ling Bao, Viktor Bengtsson, Christoffer Petersson)

PLAN

- Brief review of the recent activities of the members.
- Some comments about the general theme underlying (most of) these investigations: Supersymmetry.

Dario Francia, Robert Marnelius:

Higher Spin Theory.

- Naturally arising in String Theory as massive fields. (Conjecture : spontaneous breaking of a massless, higher spin phase?)
- In the context of the AdS/CFT correspondence correspond to interesting gauge invariant operators.
- Yang–Mills and Einstein equations have a deep geometrical meaning. Is it possible to find any analogous, geometric description for higher-spins?

Martin Cederwall, Bengt E. W. Nilsson,
Ling Bao, Viktor Bengtsson:

- Topological M-theory. Natural generalization of topological string theory.
- Higher derivative corrections and automorphic functions. Almost unexplored territory, exciting connections with pure mathematics.

Måns Henningson, Niclas Wyllard:

Maximally supersymmetric Yang-Mills theory.

Finding a non-perturbative formulation in which e.g. the strong-weak coupling S-duality would be manifest.

Lars Brink:

Quantum Properties of N=8 Supergravity.

Relation between N=4 Yang-Mills theory and N=8 Supergravity.

Ulf Gran:

Classification of supersymmetric geometries.

- Understand how supersymmetry shapes the geometry of classical solutions to the field equations.
- This problem can now be systematically studied using a method developed in collaboration with Gillard and Papadopoulos.
- Classification of all supersymmetric geometries in Type I supergravity in ten dimensions. (Collaboration with Papadopoulos, Roest and Sloane).

Per Salomonsson:

Massless, infinite spin particles.

(With Marnelius)
Wigner's classification allows for such irreducible representation of Poincare' group. Study the dynamics.

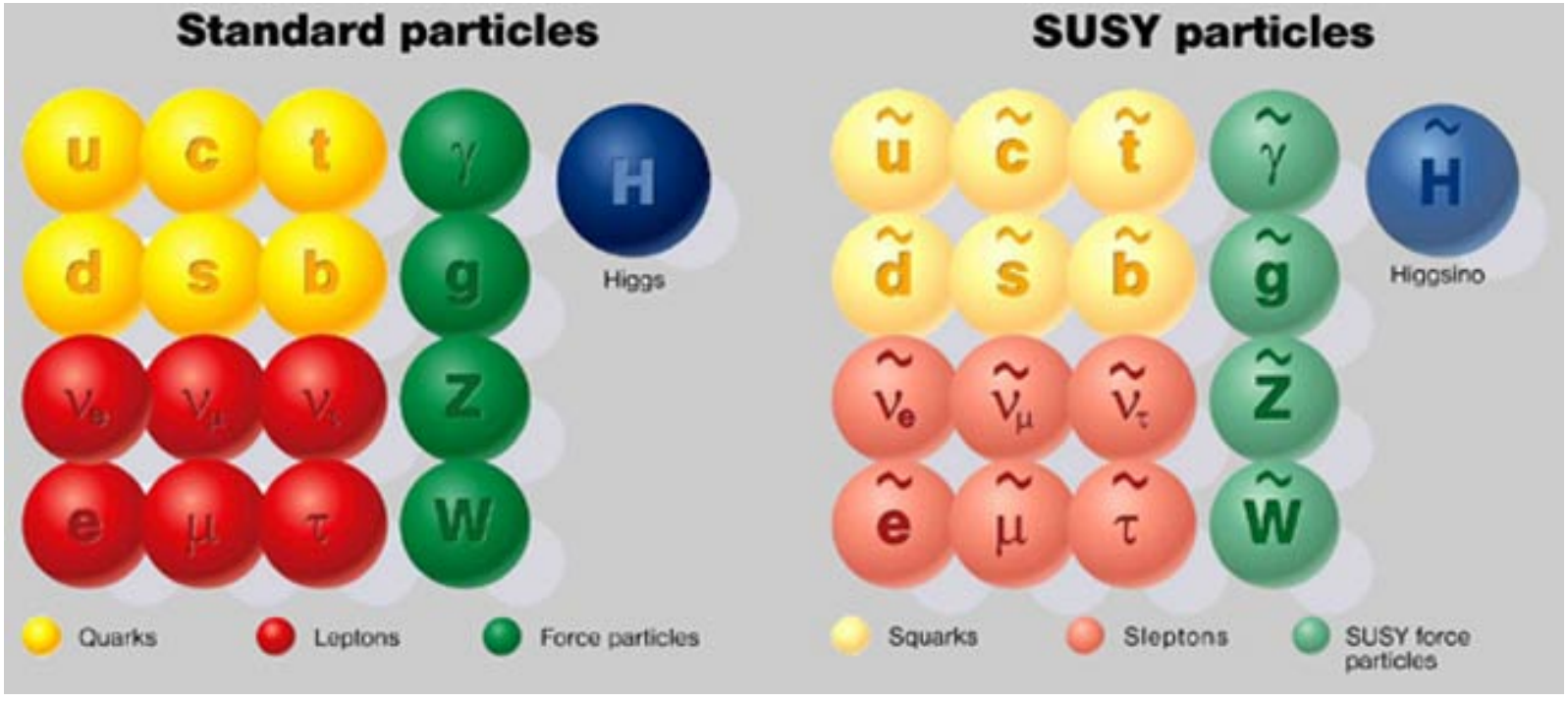
Gabriele Ferretti, Christoffer Petersson:

Stringy instantons. (Collaboration with Argurio, Bertolini and Lerda)

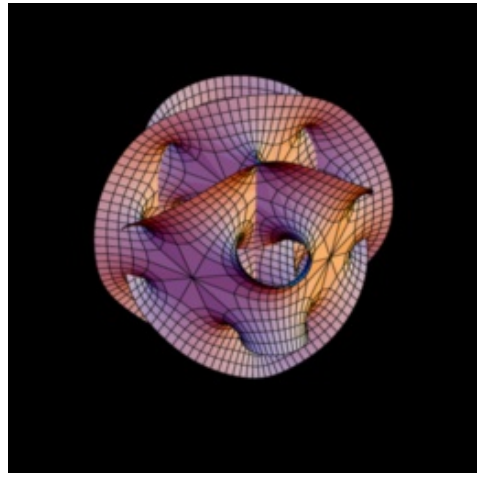
- Novel non-perturbative effects giving rise to corrections to the superpotential.
- Might be involved in SUSY breaking.

The common denominator is

Supersymmetry.

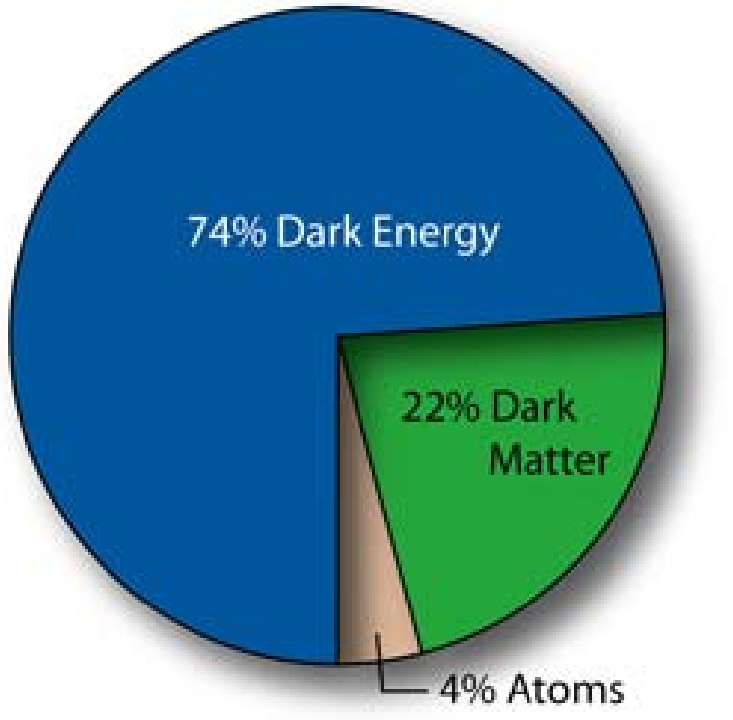


Deep connections from pure mathematics ...



... to experiment

... not to mention that our cosmologist friends tell us that the Universe energy balance looks like:



At LHC we have a real shot at finding SUSY !

If LHC finds SUSY, it will almost certainly be a *rigid, $\mathcal{N} = 1$, broken SUSY gauge theory*.
Such theories are characterized (before SUSY breaking) by:

- A gauge group G ("gluons & gluinos")
- matter multiplets Φ ("quarks & squarks")
- a superpotential $W(\Phi)$ (Potential $\propto |\nabla W|^2$)

- On the phenomenological side:
  - Non-renormalization theorems give rise to a much better quantum behavior, "explaining" the lightness of the (still to be found!) Higgs.
  - Neutralinos provide a good candidate for Dark Matter.
  - Improved GUT behavior.
- On the formal side:
  - Techniques to compute the exact quantum corrections to the superpotential.

However, SUSY must be broken!

- Explicitly, via "Soft" term dim ≤ 3 operators, (e.g. gaugino masses). Phenomenological way of parameterizing our "ignorance".
- Spontaneously,
  - *Tree level* O' Raifeartaigh, Fayet-Iliopoulos mechanisms. Problematic...
  - *Perturbatively* Impossible!
  - *Non-perturbatively* Interesting! (Stringy instantons might help.)

Challenges

- Trace formulas: $\mathrm{tr}|M_0|^2 - 2\mathrm{tr}|M_{1/2}|^2 + 3\mathrm{tr}|M_1|^2 = 0$ and the need for gaugino masses require a "Hidden Sector" with dim > 4 operators.
- Witten index: $\mathrm{tr}(-1)^F \neq 0$ forbids SUSY breaking in many interesting theories.
- R-symmetry:
  - If explicitly broken, "tends" to prevent SUSY breaking.
  - If spontaneously broken, gives rise to a R-axion.
  - If unbroken, forbids gaugino masses.
- Goldstino: Must be "eaten up", leading to SUGRA.

Many recent developments ...

Current Situation:

Good luck LHC!