

Frontiers of Theoretical Physics

Lecturers:

David Mateos, Jaume Guasch and Joan Solà

Frontiers of theoretical physics

- Renormalization group.
- Introduction to supersymmetry.
- Gauge/string correspondence.



Part I:
David Mateos

- Grand unified theories.
- Phenomenology of supersymmetric theories.



Part II:
Jaume Guasch

- Open problems in cosmology.



Part III:
Joan Solà

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Recommended background:

- ▶ Basic GR and QFT.
- ▶ Elementary Particles
- ▶ Standard Model (simultaneous)

Frontiers of theoretical physics

Accurate!

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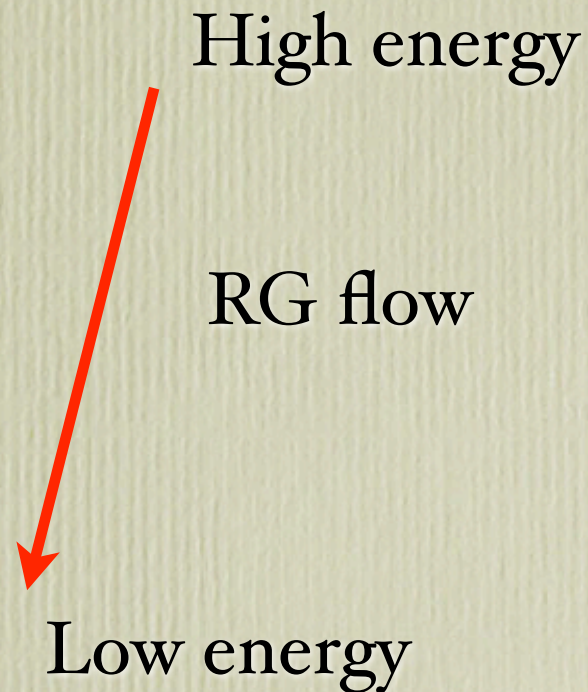
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Renormalization group

David Mateos

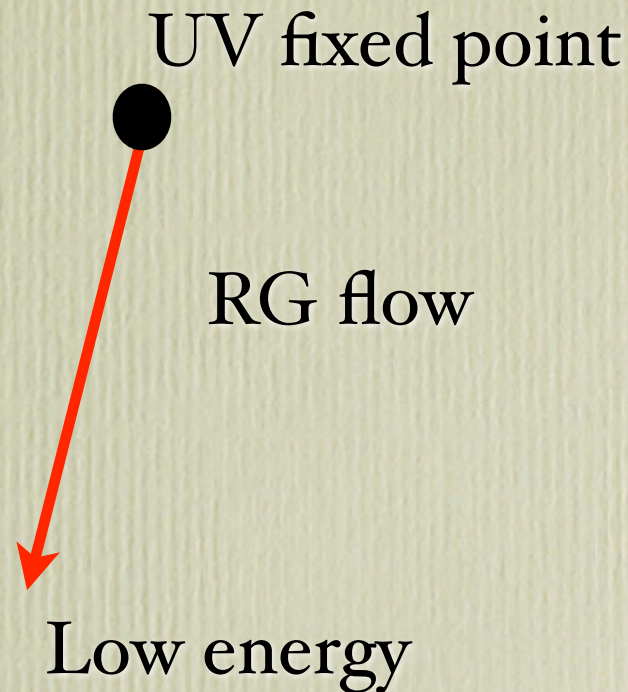
- Physics is organized by scales:



Renormalization group

David Mateos

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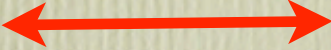


- Modern definition of QFT.

Introduction to supersymmetry

David Mateos

- Fundamental symmetry:

Bosons  Fermions

- Essential ingredient in e.g. string theory.

Phenomenology of supersymmetric theories Jaume Guasch

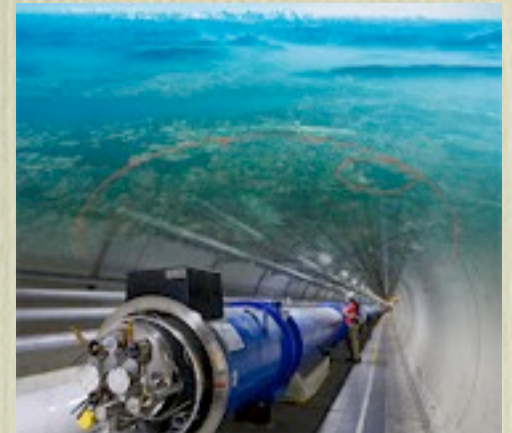
- Supersymmetry is a nice theory, but how do we “see” it?

Phenomenology of supersymmetric theories Jaume Guasch

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- Supersymmetry predicts new particles!
 - ▶ Direct SUSY signals: Find new particles and measure their masses and couplings. Possible signals at the LHC.

 - ▶ SUSY has a naturally light Higgs boson!



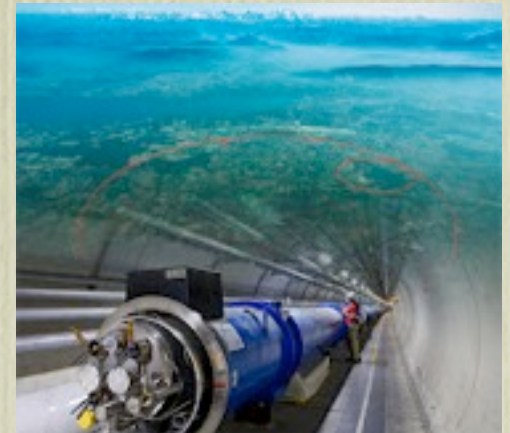
Phenomenology of supersymmetric theories Jaume Guasch

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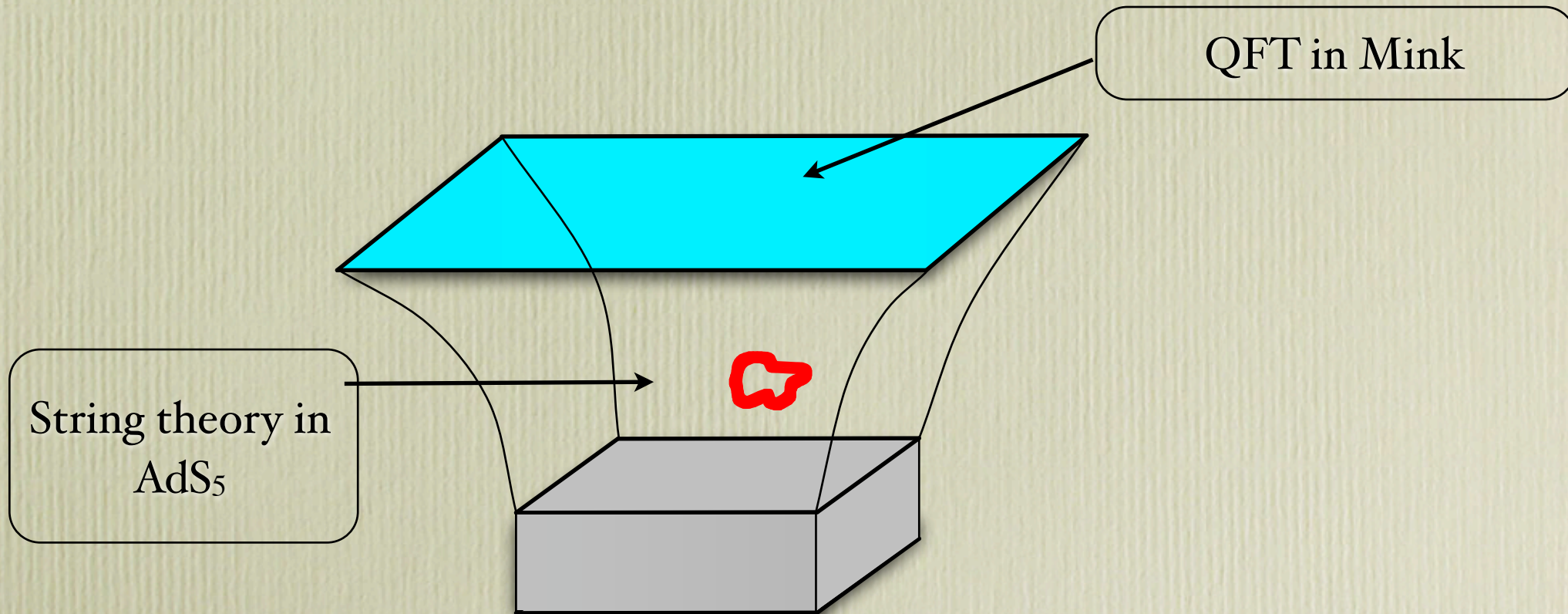
 - ▶ Indirect SUSY signals: quantum effects to precision physics.



Gauge/gravity correspondence

David Mateos

- Profound equivalence.
- Best definition of Quantum Gravity:



Grand unified theories

Jaume Guasch

- Standard Model has 3 independent interactions (couplings).
- Is it possible to unify some (or all) the couplings?

Grand unified theories

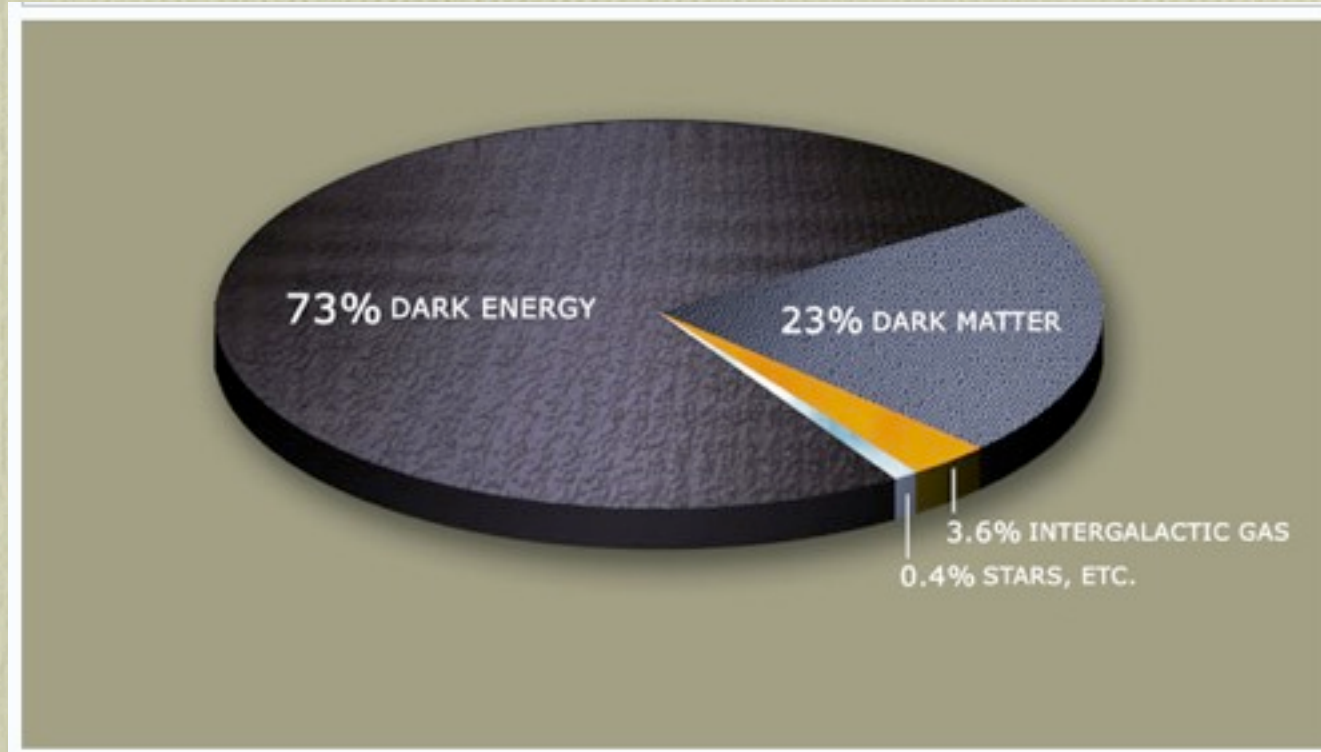
Jaume Guasch

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- Example:
 - ▶ Electricity: $\frac{1}{4\pi\epsilon_0}$
 - ▶ Magnetism: $\frac{\mu_0}{4\pi}$
 - ▶ Maxwell's Electromagnetism: $\mu_0\epsilon_0 = \frac{1}{c^2}$

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- Unification conditions for SM group.
- New physical phenomena: proton decay.
- Unification conditions in SUSY models.

Open problems in cosmology

Joan Solà



Practical details

- **Language:** English.
- **Schedule:** Mon-Wed from 10:20 to 11:40, room V12M.
- **Duration:** 12 weeks from Feb 10 to May 14 (no lectures on April 14-27).
- **Approximate distribution:**
 - ▶ Part I (6 weeks): Feb 10-March 19
 - ▶ Part II (4 weeks): March 24-April 30
 - ▶ Part III (2 weeks): May 5-14
- **Evaluation:**
 - ▶ Exercise sheets and/or final interview.
Sheets must be handed in on time or they will NOT be accepted!
 - ▶ Must pass each of the 3 parts separately.
 - ▶ If so then the final grade is a weighted average 3:2:1.
 - ▶ Evaluation completed by June 27.
- **Re-evaluation:** In September with similar rules.
- **Bibliography and detailed syllabus:** Each lecturer will tell you.

Questions welcome!