Frontiers of Theoretical Physics

Lecturers:
David Mateos (coordinator) and Joan Solà

Frontiers of theoretical physics

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

Part 1:
David Mateos

- Grand unified theories.
- Phenomenology of supersymmetric theories.
- Open problems in cosmology.

Part II:
Joan Solà

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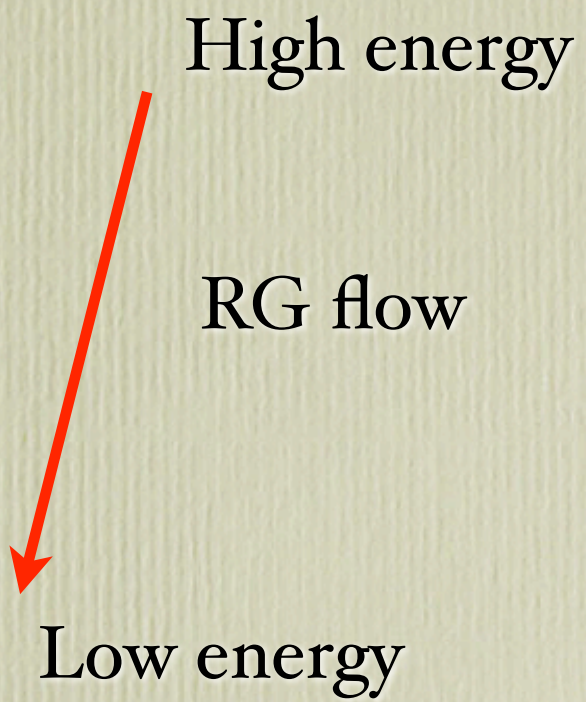
Recommended background:

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

Renormalization group

David Mateos

- Physics is organized by scales:



Renormalization group

David Mateos

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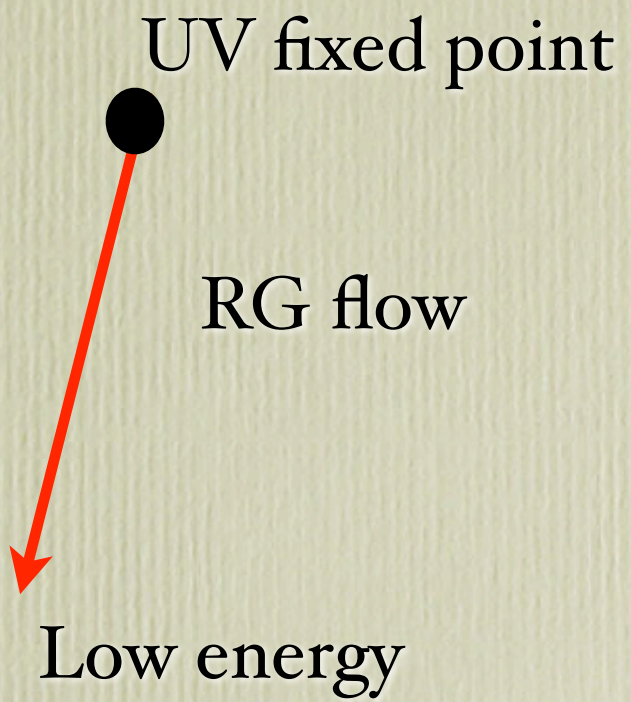
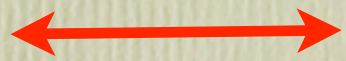


- Modern definition of QFT.

Introduction to supersymmetry

David Mateos

- Fundamental symmetry:

Bosons  Fermions

- Essential ingredient in e.g. string theory.

Phenomenology of supersymmetric theories

Joan Solà

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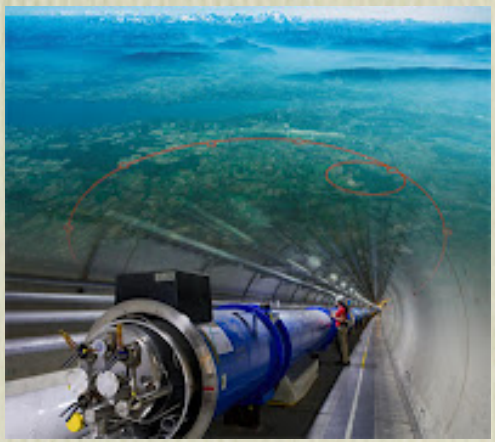
- Supersymmetry predicts new particles!
  - Direct SUSY signals: Find new particles.



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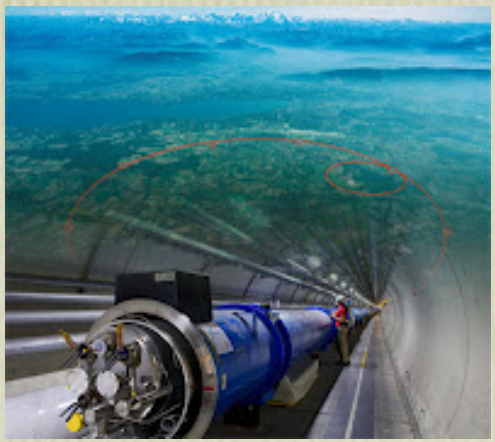
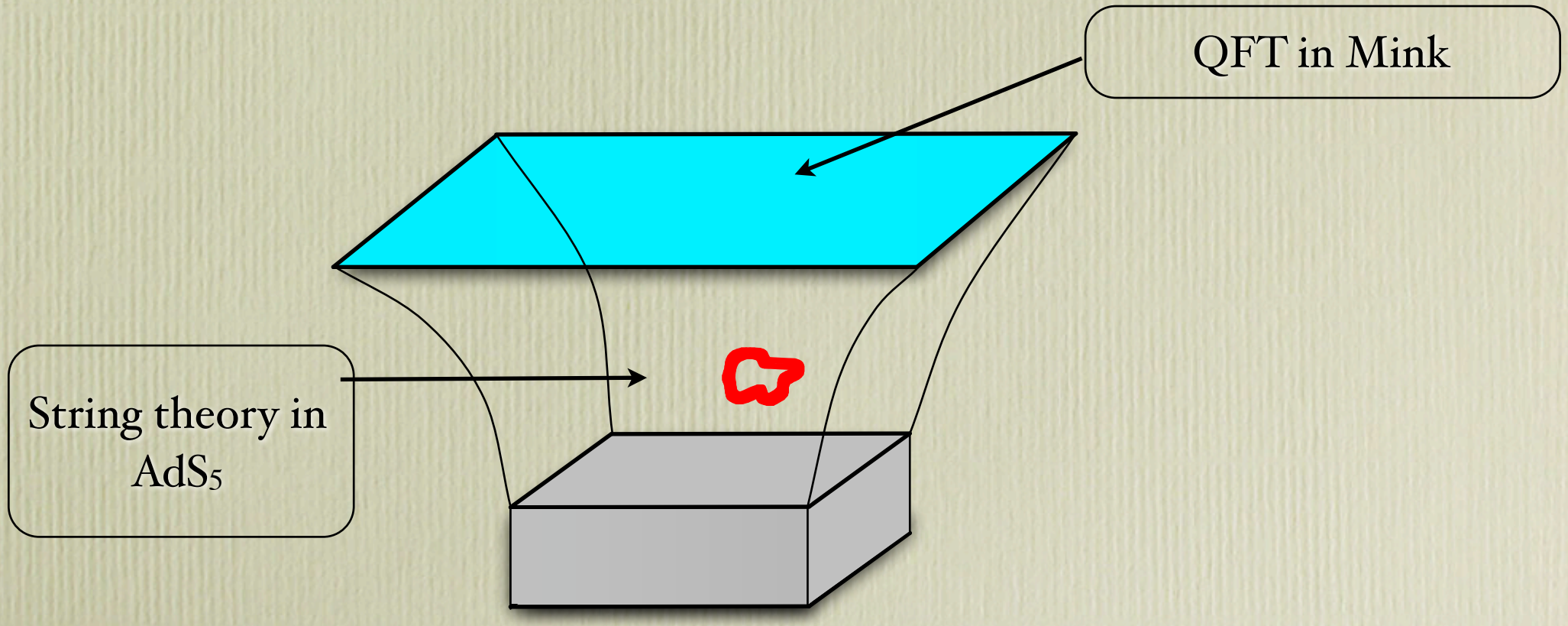


  - Indirect SUSY signals: quantum effects to precision physics.

Gauge/gravity correspondence

David Mateos

- Profound equivalence.
- Best definition of Quantum Gravity:



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Joan Solà

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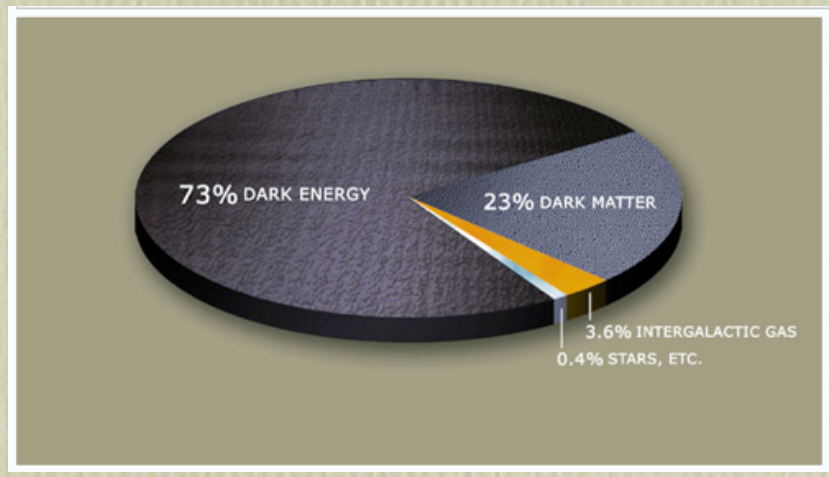
- Unification conditions for SM group.
- New physical phenomena: proton decay.
- Unification conditions in SUSY models.

Open problems in cosmology

Joan Solà



- Cosmological constant and dark energy: beyond the standard LCDM model.
- Current weaknesses and tensions of the standard LCDM model.
- Dynamical vacuum energy models.
- Quintessence and phantom dynamical dark energy.
- Dark matter and WIMPS: candidates and thermal history in the early universe.
- Vacuum energy in QFT, formal aspects.

Practical details

- **Language**: English.
- **Schedule**: Mon-Thu from 11:40 to 12:40, room V12M.
- **Duration (approximately):** 12 weeks from Feb to May.
- **Distribution:** 6 weeks for each part
- **Evaluation**:
  - Exercise sheets and/or final interview and/or final exam.
    Sheets must be handed in on time or they will NOT be accepted!
  - Must pass each part separately.
  - If so then the final grade is the average.
- **Re-evaluation**: In September with similar rules.
- **Bibliography and detailed syllabus:** Each lecturer will tell you.

Questions welcome!