Title: PSI 2015/2016 Quantum Gravity - Lecture 1

Date: Feb 22, 2016 10:15 AM

URL: http://pirsa.org/16020072

Abstract:

- Quantum Gravity -

Overview

We will focus on 3D Euclidean Gravity with a zero cosmological constant.

I. Introduction

II. Action principles - 1st order action

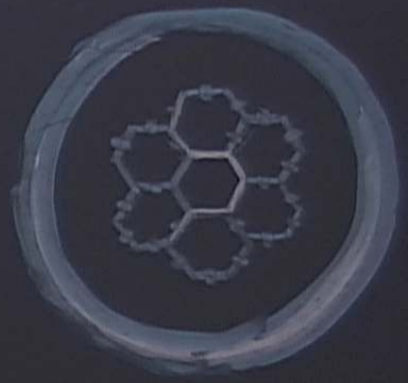
III. Symmetries Gauge symmetries

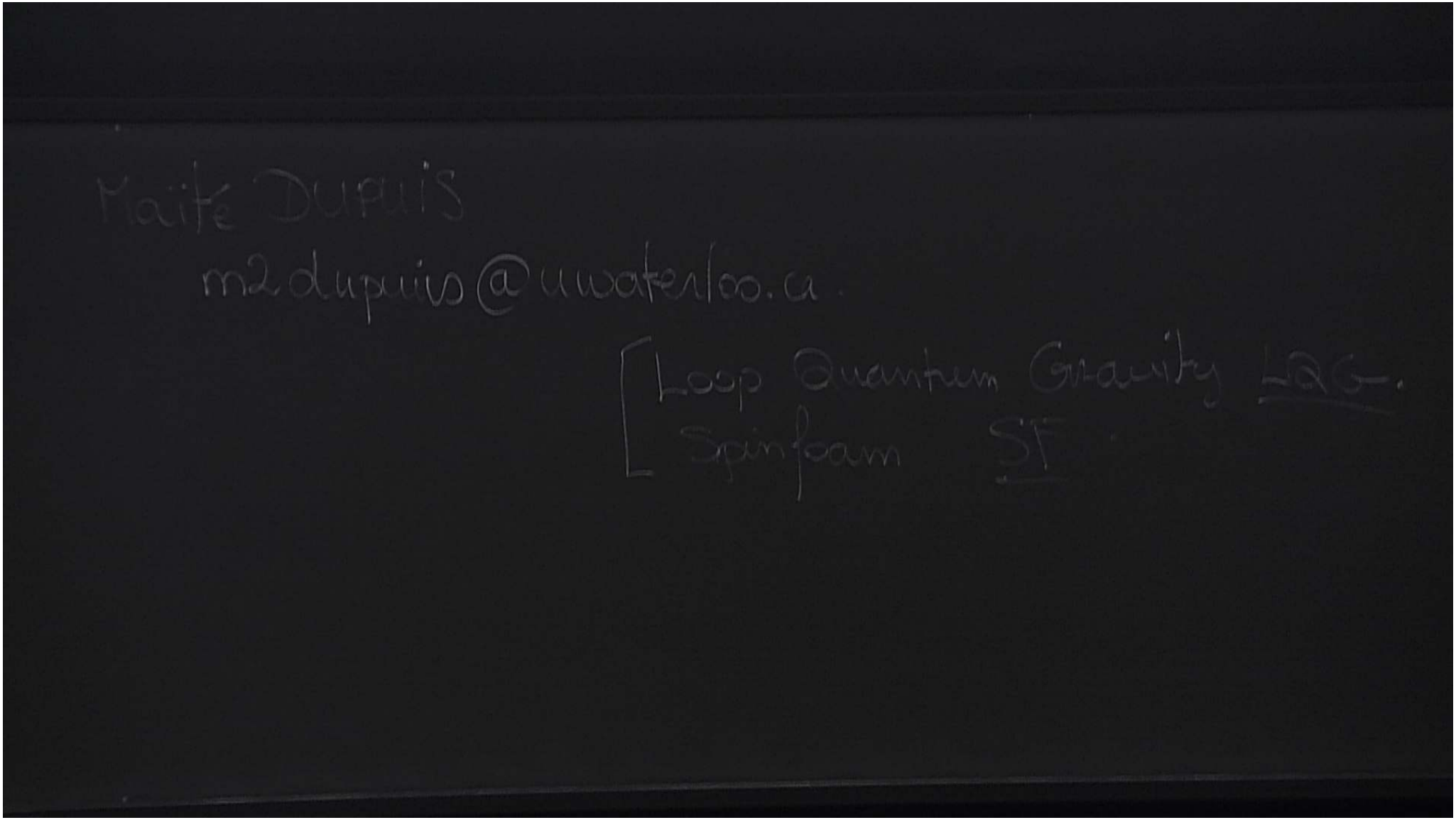
IV. Canonical Analysis - Equations of motion

V. Quantum Geometry.

VI Spinfoam model

VII. Outlook on 4D

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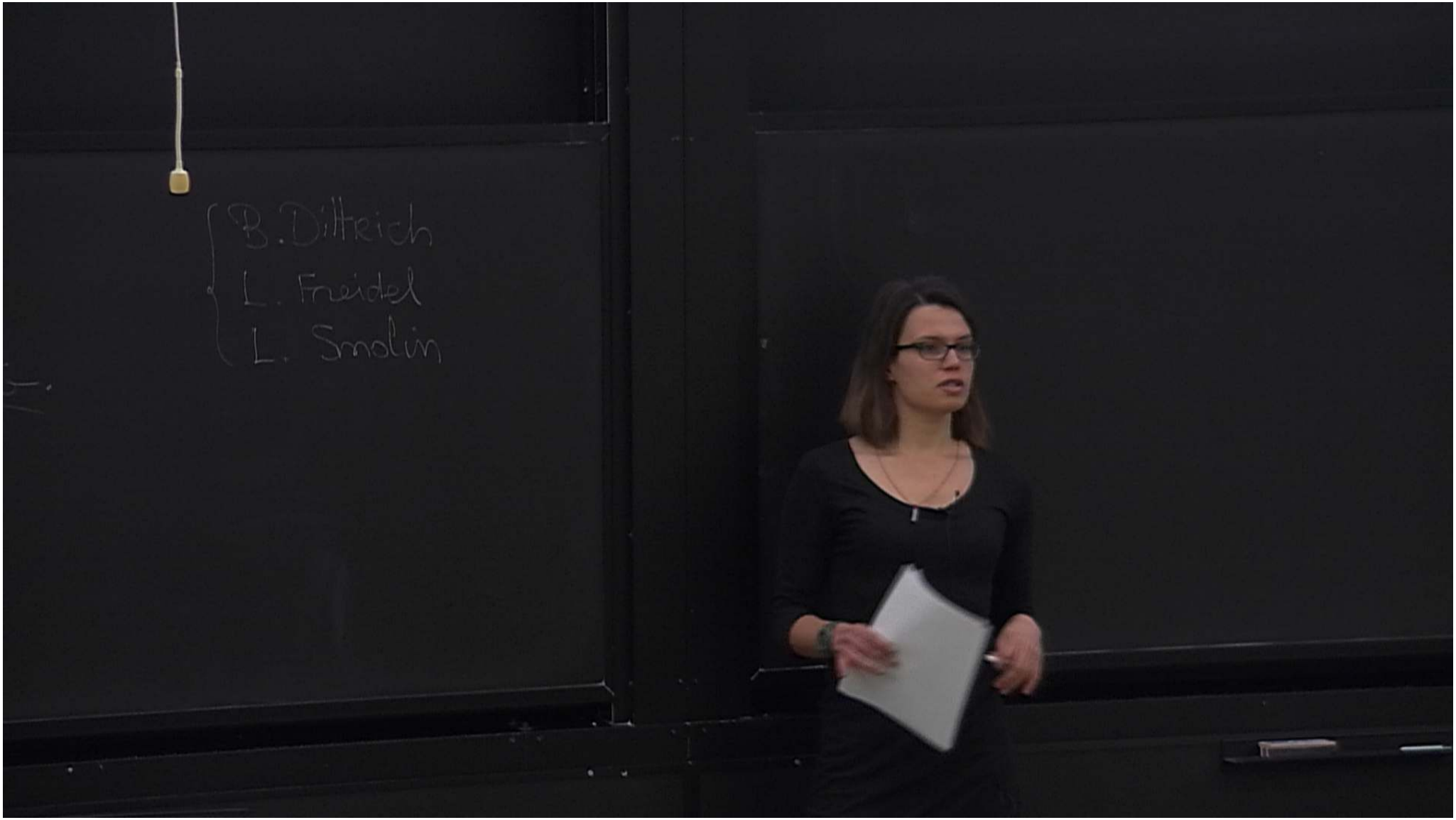
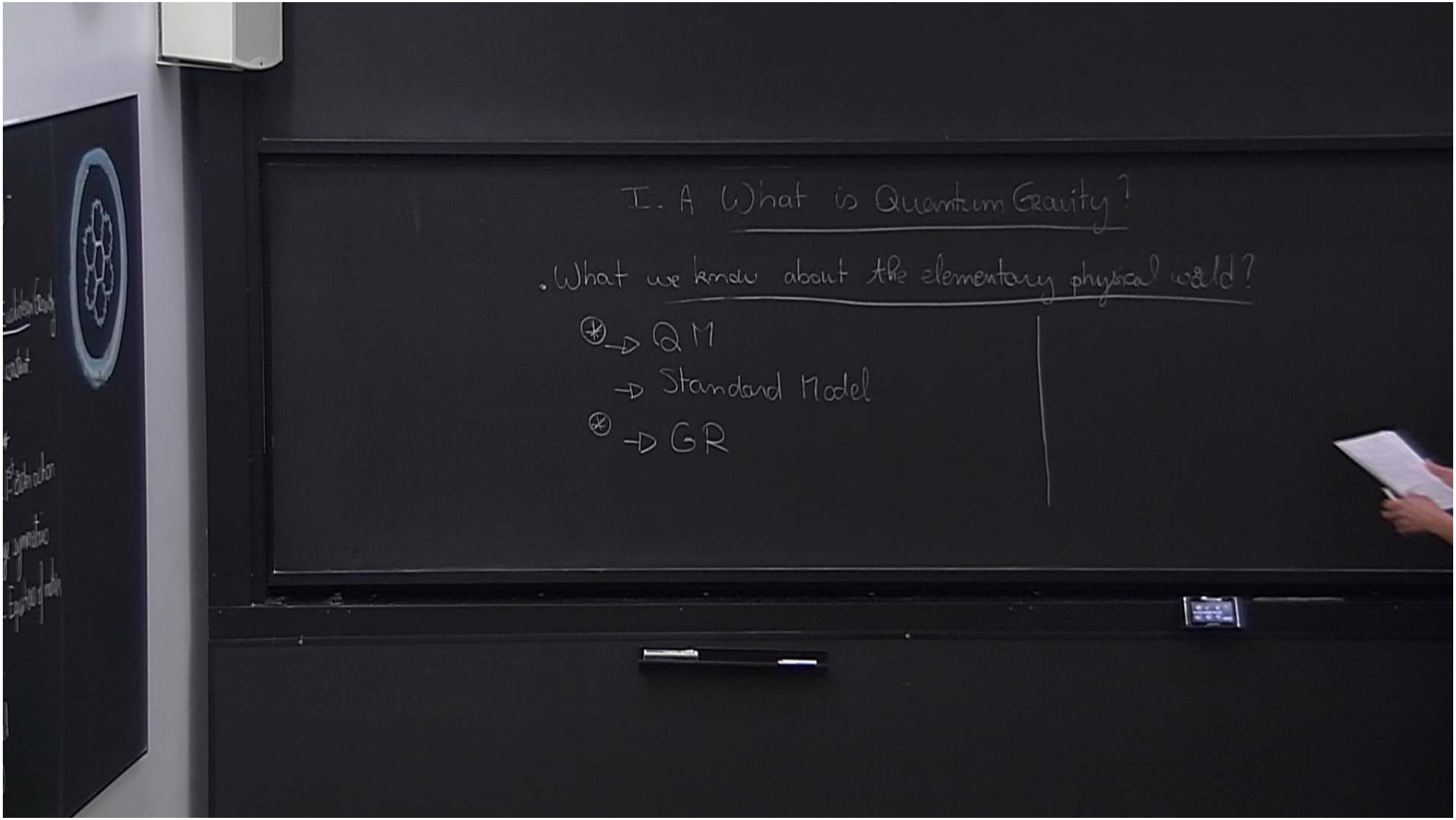
[Loop Quantum Gravity LQG.
Spinfoam SF


B. Dilthey
L. Freidel
L. Smolin


I. A What is Quantum Gravity?
. What we know about the elementary physical world?
QM
Standard Model
GR

I. A What is Quantum Gravity?

. What we know about the elementary physical world?

- ⊛ → QM
  - → Standard Model
- ⊛ → GR

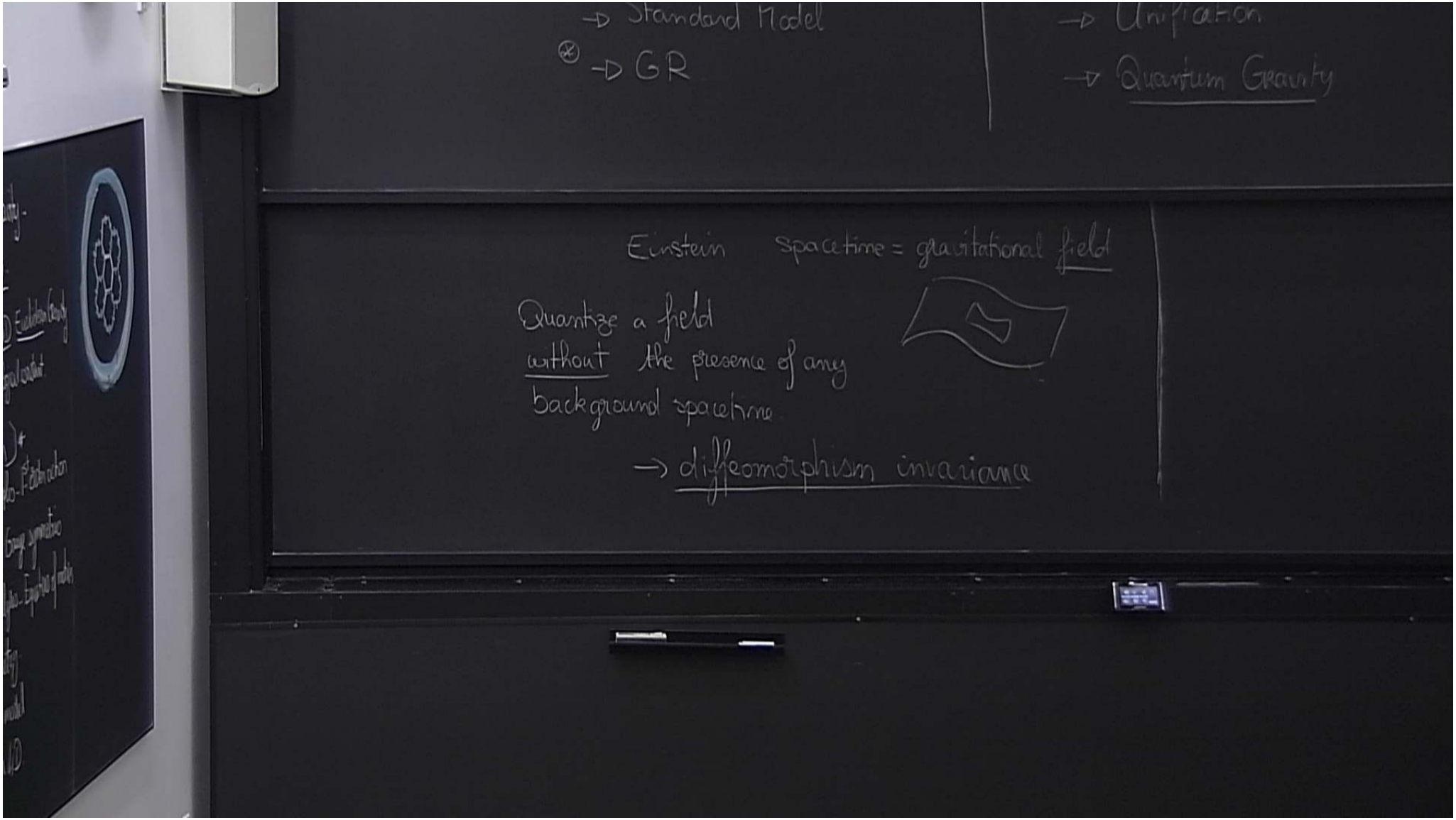
- → Dark matter.
- → Unification
- → Quantum Gravity

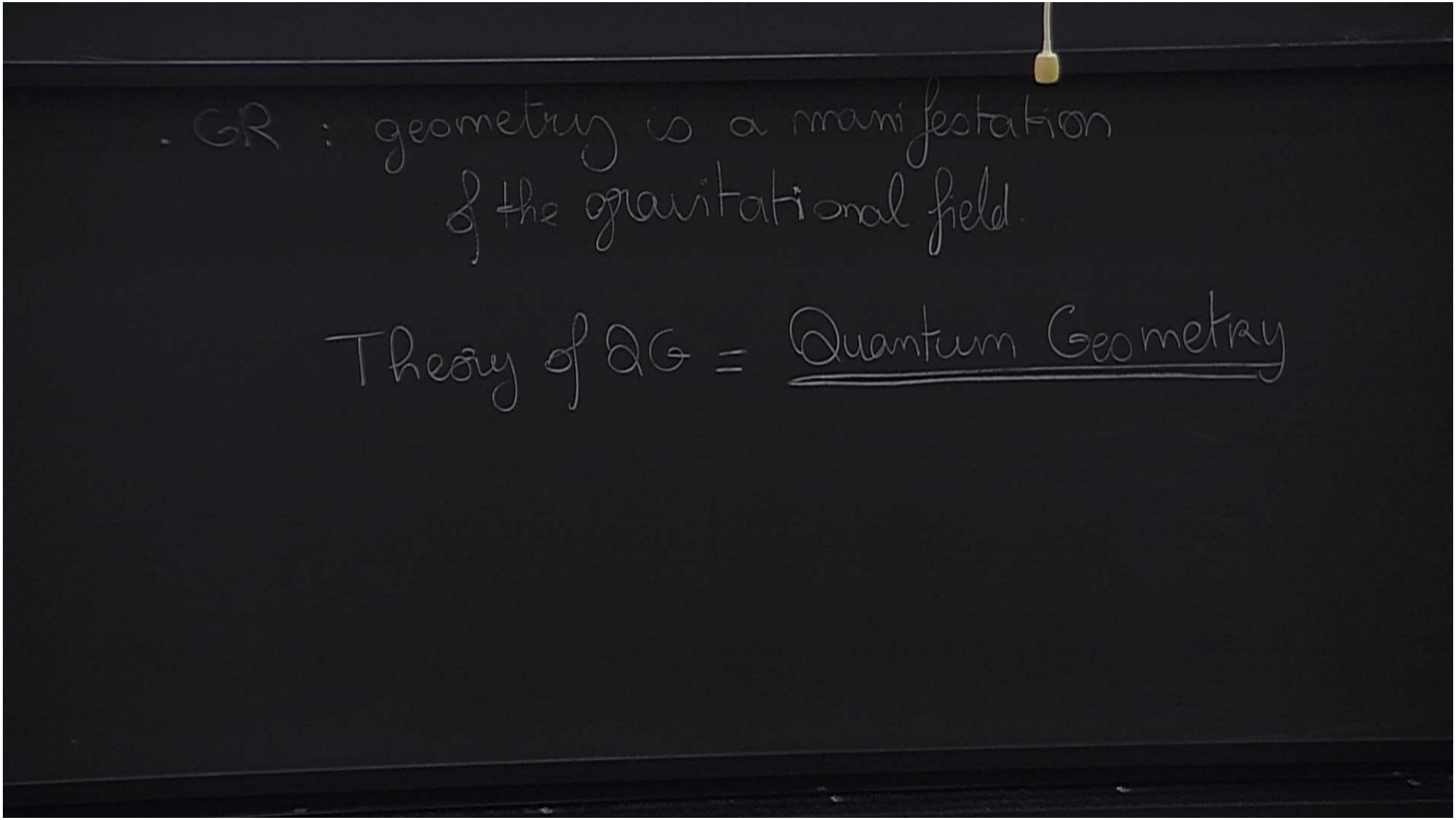
Einstein spacetime = gravitational field

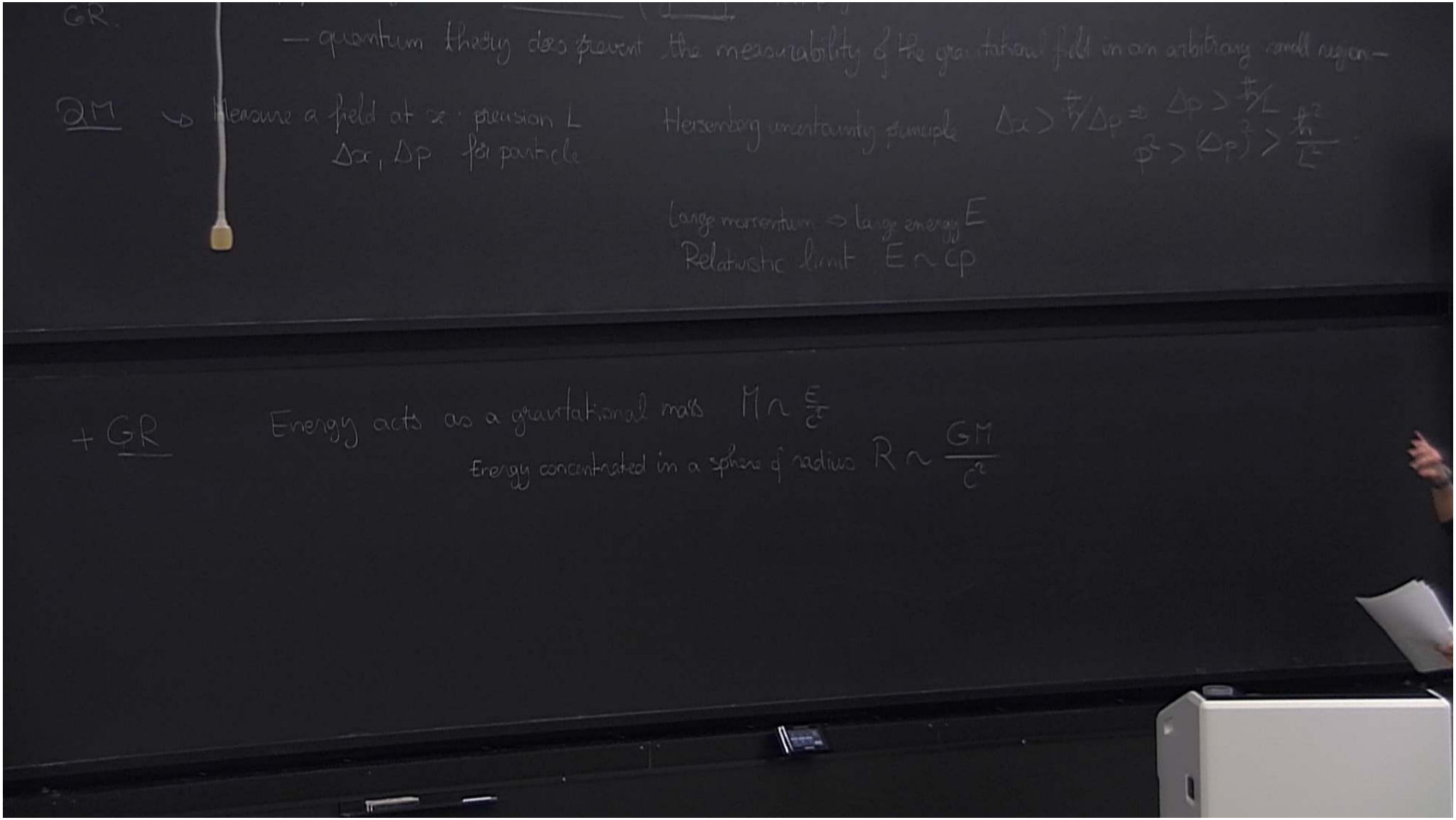
Gravity is a property of spacetime.

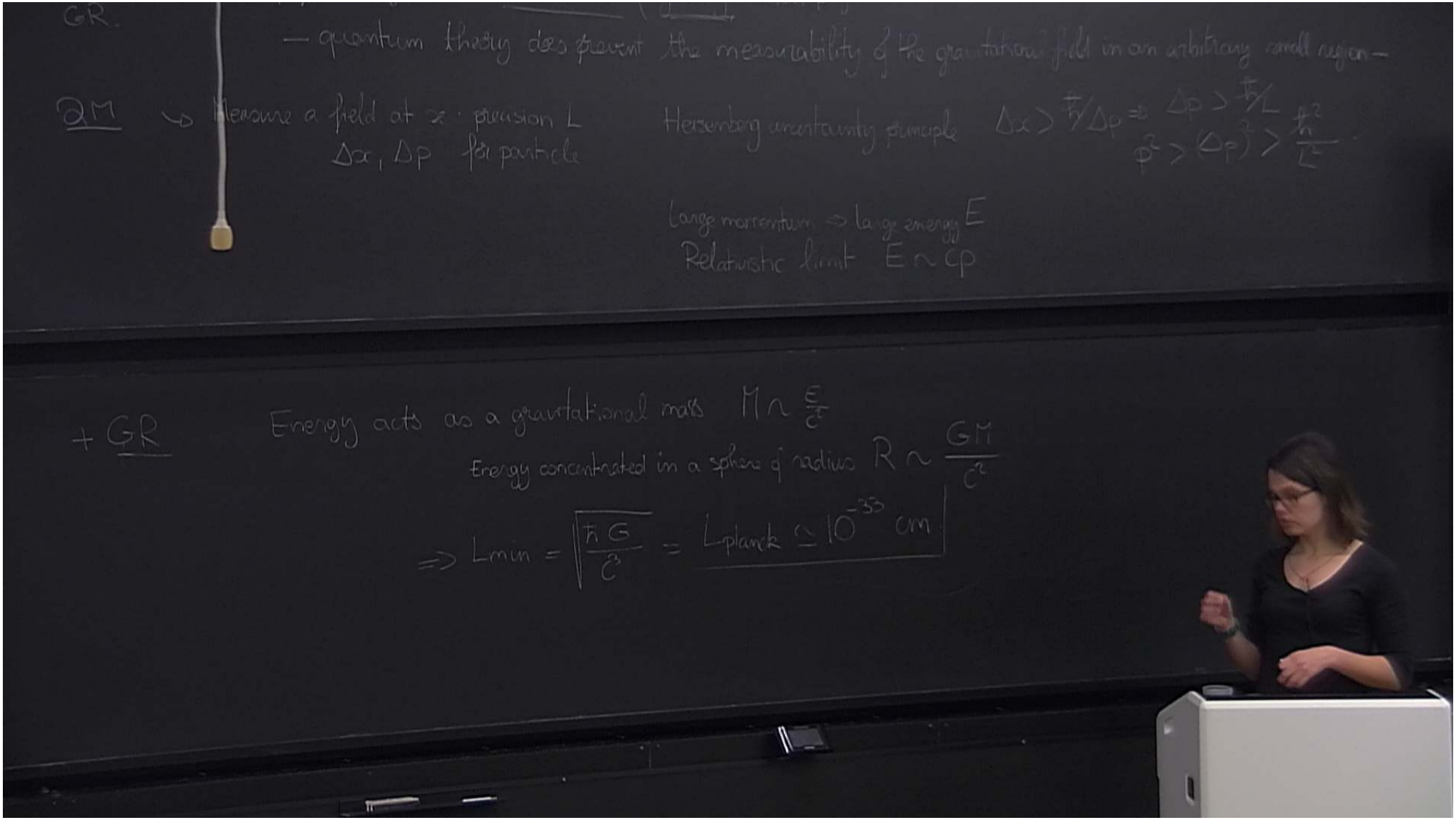
Quantum spacetime?

classical spacetime


→ Standard Model
⊗ → GR
→ Unification
→ Quantum Gravity
Einstein Spacetime = gravitational field
Quantize a field
without the presence of any
background spacetime
→ diffeomorphism invariance


. GR : geometry is a manifestation
of the gravitational field.
Theory of QG = Quantum Geometry


GR
— quantum theory does prevent the measurability of the gravitational field in an arbitrary small region —
QM
Measure a field at x · precision L
Δx, Δp for particle
Heisenberg uncertainty principle Δx > ħ/Δp ⇒ Δp > ħ/L
p² > ⟨p⟩² > ħ²/L²
large momentum ⇒ large energy E
Relativistic limit E ~ cp
+ GR
Energy acts as a gravitational mass M ~ E/c²
Energy concentrated in a sphere of radius R ~ GM/c²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Relativistic limit E ∼ cp
+ GR
Energy acts as a gravitational mass M ∼ E/c²
Energy concentrated in a sphere of radius R ∼ GM/c²
⇒ Lmin = √(ħG/c³) = Lplanck ≃ 10⁻³³ cm

Energy concentrated in a sphere of radius $R \sim \frac{GM}{c^2}$

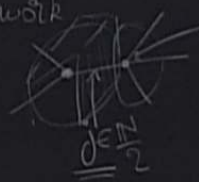
$\Rightarrow L_{min} = \sqrt{\frac{\hbar G}{c^3}} = L_{planck} \approx 10^{-33}$ cm

→ Spacetime as semi-classical approximation ⇒ Quantum space? Quantum time

Quantum state of spacetime → LQG (4D) SU(2)

Fundamental excitations of space

Spinnetwork



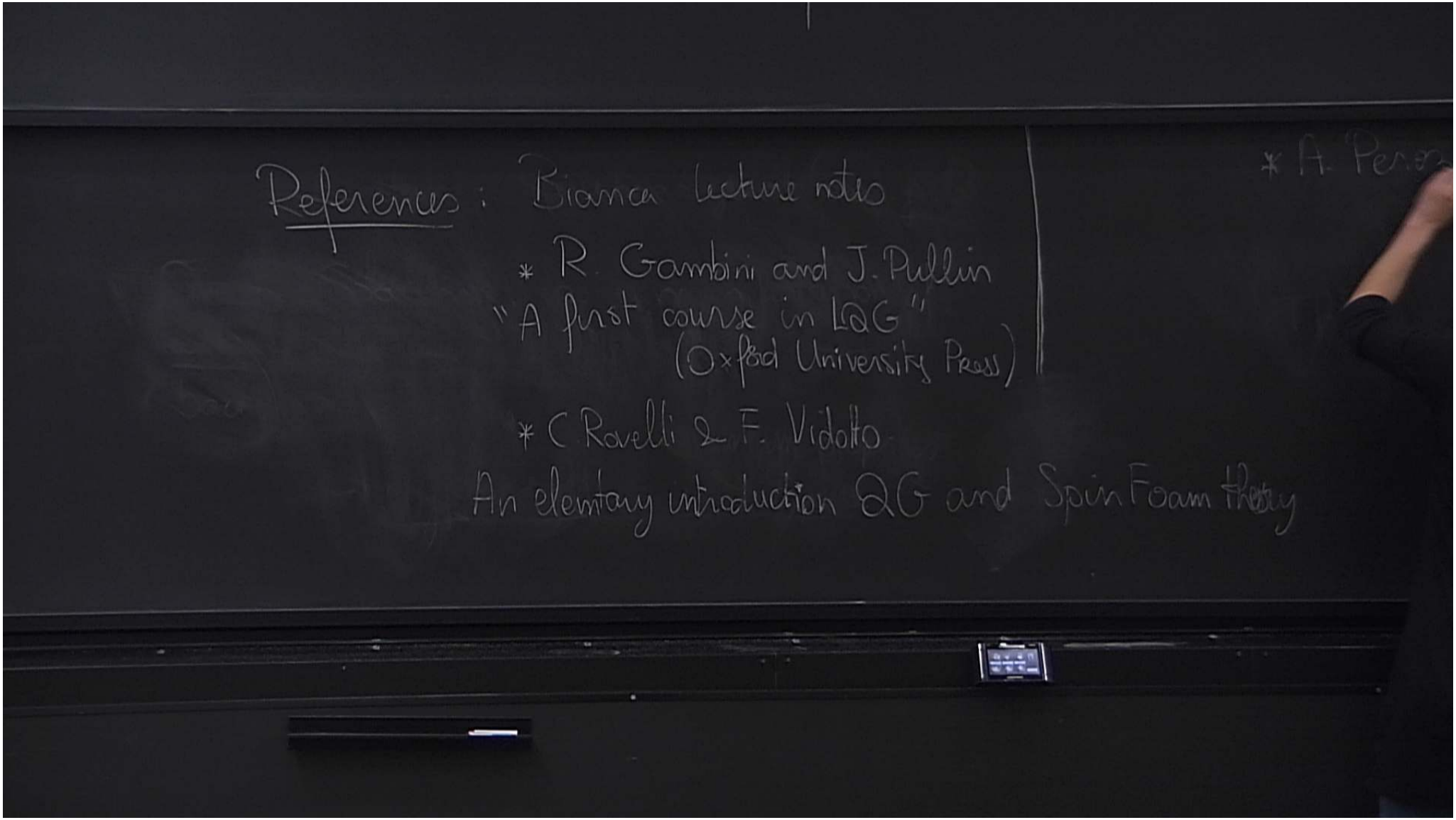
+ Dynamics?

↳ Spinfoam

I.3 Why QG?

→ no calls from experimentally accessible situations.

$$\frac{F_{grav}}{F_{electr}}(\text{proton-electron}) = 10^{-40}.$$


References : Bianca lecture notes
* R. Gambini and J. Pullin
"A first course in LQG"
(Oxford University Press)
* C Rovelli & F. Vidotto
An elemtary introduction QG and Spin Foam theory