Title: Keynote: Soap, Water, and Gravity

Date: Jul 06, 2015 09:15 AM

URL: http://pirsa.org/15070071

Abstract: Gravity is the force we most experience in daily life. It is also incredibly mysterious and challenging to understand at a fundamental level. This talk will explore some new ideas about the properties and nature of gravity and its connection to other facets of physics.

Fire Evacuation Plan

- Fire Wardens
  - Teacher facilitators
- Stairs to Atrium Level
  - Avoid the elevator, facilitators will assist
- Safe Meeting Area
  - Located out the front doors at PI
  - Located in front of Bricker Street Residence

Being at PI

- Quiet Voices
  - Hallways, Atrium, Common Areas
- Researcher Areas
  - Please respect areas near researcher offices
- Photos
  - Building, common areas, bistro
  - No photos of researchers unless given permission

EinsteinPlus, July 2015

Soap, Water, and Gravity

Niayesh Afshordi

UNIVERSITY OF WATERLOO
FACULTY OF SCIENCE
Department of Physics & Astronomy

PERIMETER INSTITUTE
FOR THEORETICAL PHYSICS

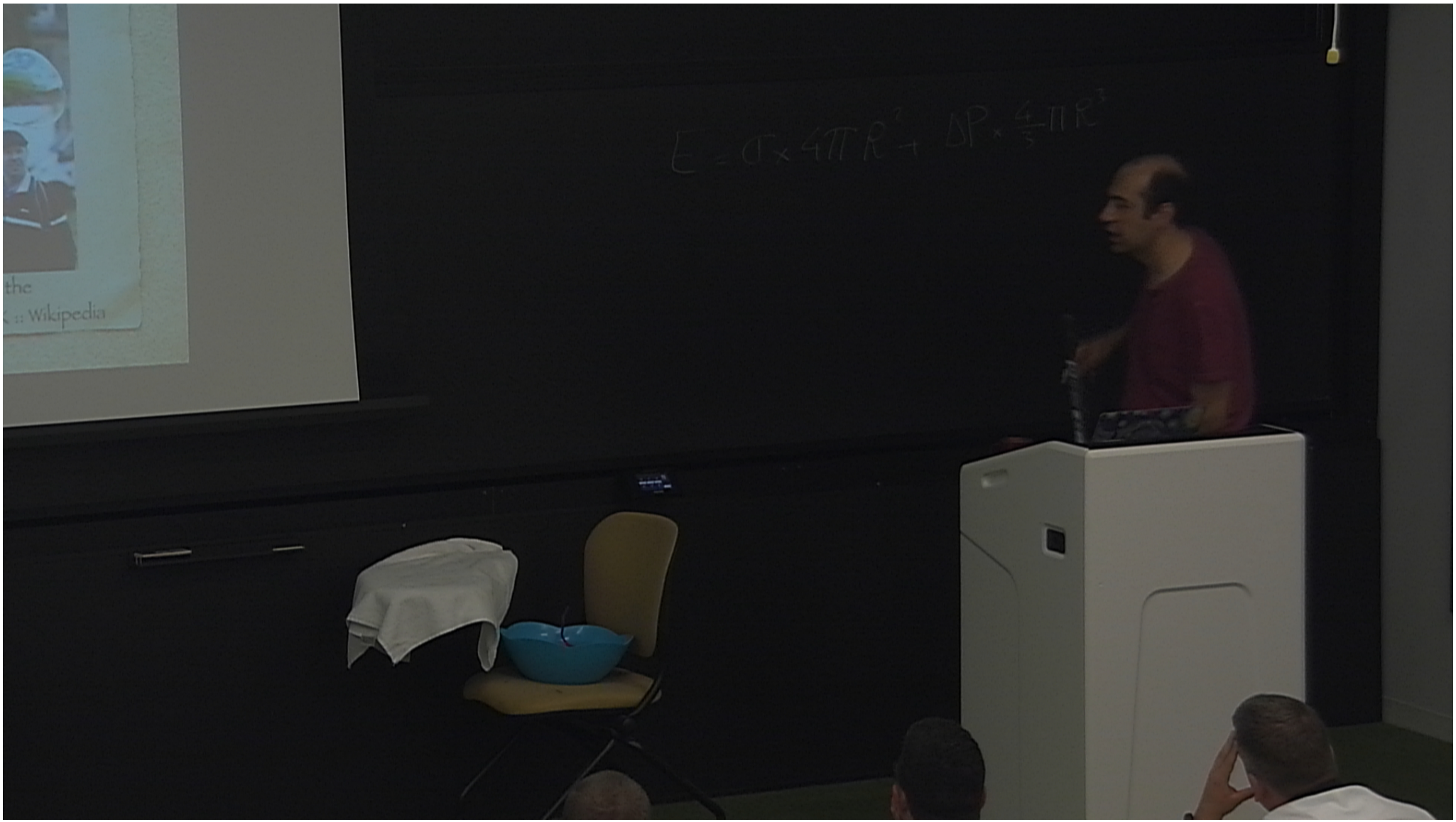
Soap Bubbles/films

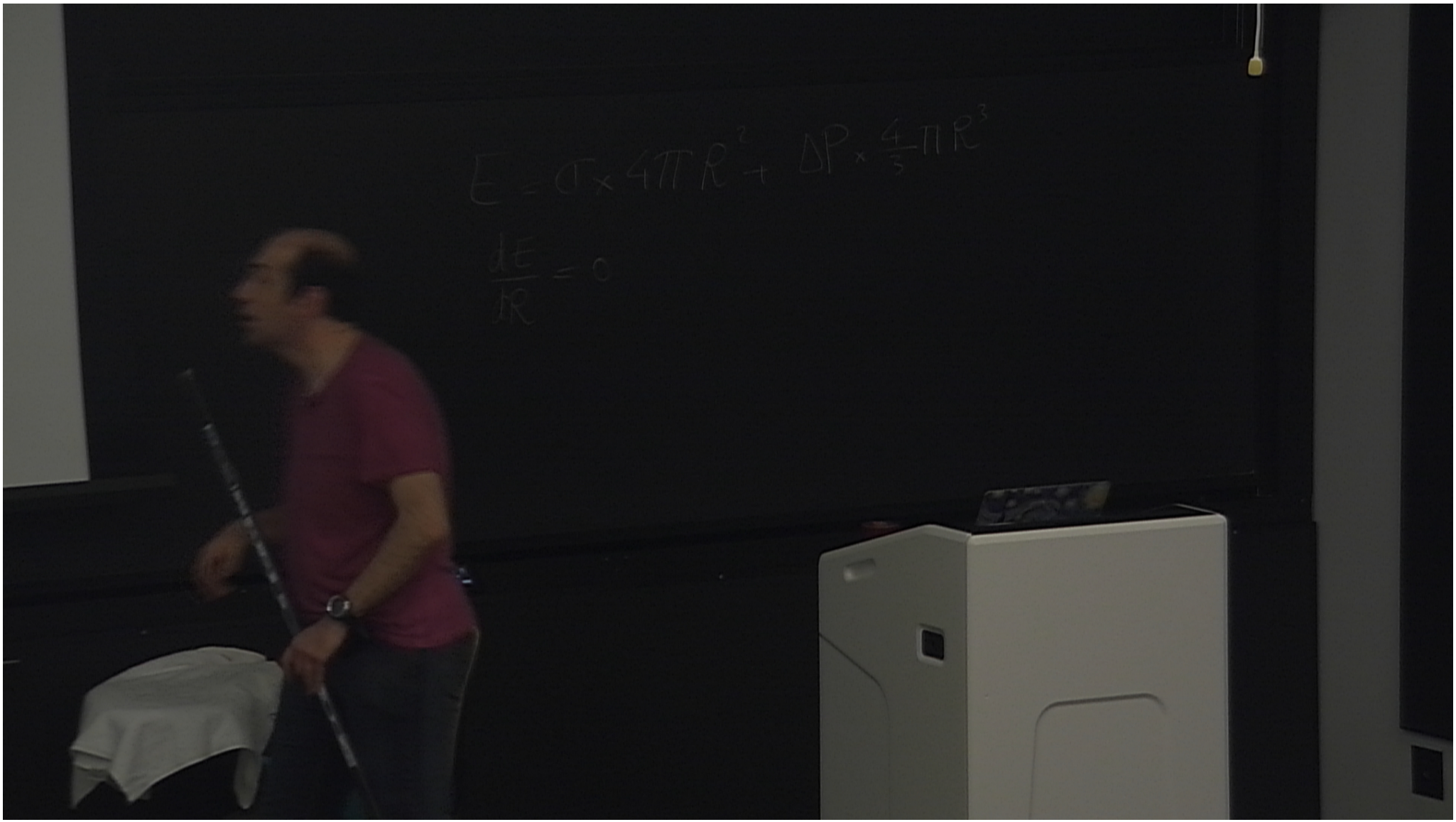
- Energy = Surface Tension x Area

  + Pressure Difference x Volume

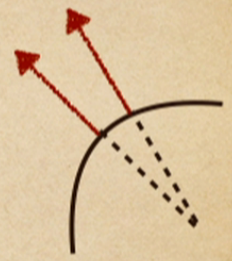
$$\sigma \times \frac{2}{R} = \Delta P$$

Professional 'bubbleologist' at the 2009 Strawberry Fair in Cambridge, UK :: Wikipedia

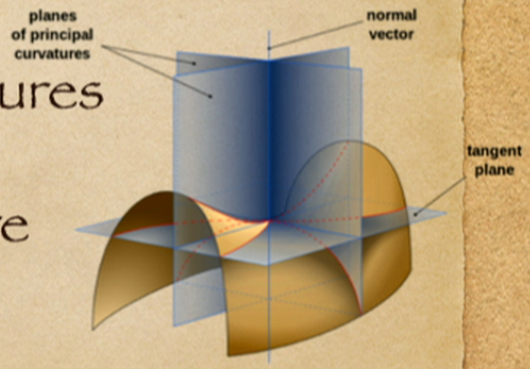

the
:: Wikipedia
$E = \sigma \times 4\pi R^2 + \Delta P \times \frac{4}{3}\pi R^3$


$E = \sigma \times 4\pi R^2 + \Delta P \times \frac{4}{3}\pi R^3$
$\frac{dE}{dR} = 0$

Extrinsic Curvature



- curvature =change in angle/distance
- K_{ab}:Extrinsic curvature matrix
- Its eigenvalues: principal curvatures
- It trace: mean extrinsic curvature



Constant Mean Curvature (CMC) surfaces

- Minimizing Energy of soap bubbles:

$$K = \frac{1}{R_1} + \frac{1}{R_2} = \frac{\Delta P}{\sigma} = \text{constant}$$

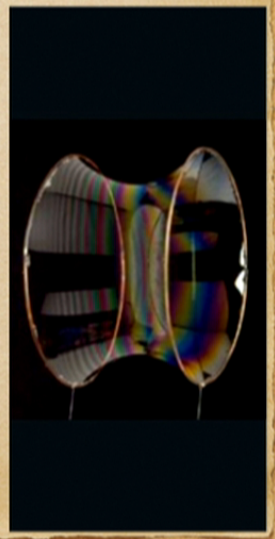
- Convex surface $R_1 \times R_2 > 0$
- Concave surface $R_1 \times R_2 < 0$
- Soap films are always concave, Why?

Constant Mean Curvature (CMC) surfaces

- Minimizing Energy of soap bubbles:

$$K = \frac{1}{R_1} + \frac{1}{R_2} = \frac{\Delta P}{\sigma} = \text{constant}$$

- Convex surface $R_1 \times R_2 > 0$
- Concave surface $R_1 \times R_2 < 0$
- Soap films are always concave, Why?

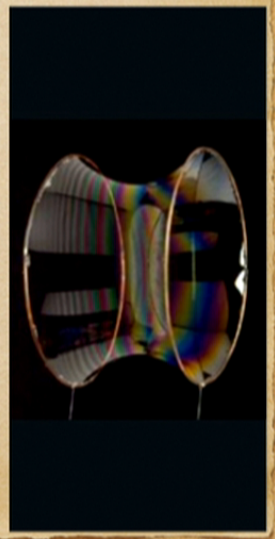


Constant Mean Curvature (CMC) surfaces

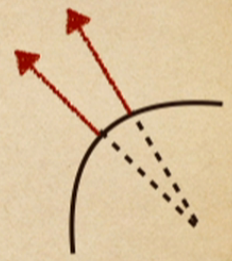
- Minimizing Energy of soap bubbles:

$$K = \frac{1}{R_1} + \frac{1}{R_2} = \frac{\Delta P}{\sigma} = \text{constant}$$

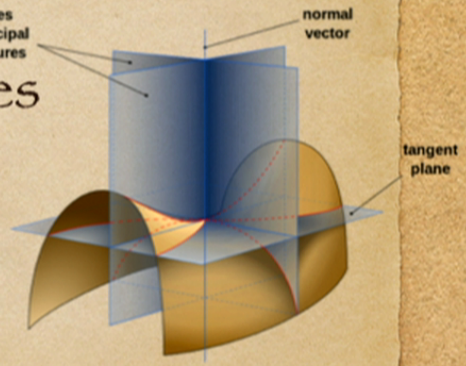
- Convex surface $R_1 \times R_2 > 0$
- Concave surface $R_1 \times R_2 < 0$
- Soap films are always concave, Why?



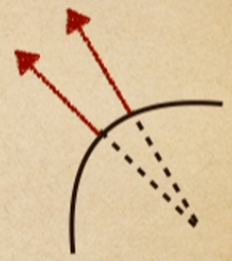
Extrinsic Curvature



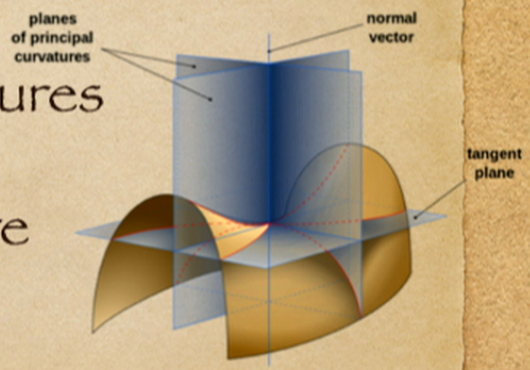
- curvature =change in angle/distance
- K_{ab}:Extrinsic curvature matrix
- Its eigenvalues: principal curvatures
- It trace: mean extrinsic curvature



Extrinsic Curvature



- curvature =change in angle/distance
- K_{ab}:Extrinsic curvature matrix
- Its eigenvalues: principal curvatures
- It trace: mean extrinsic curvature

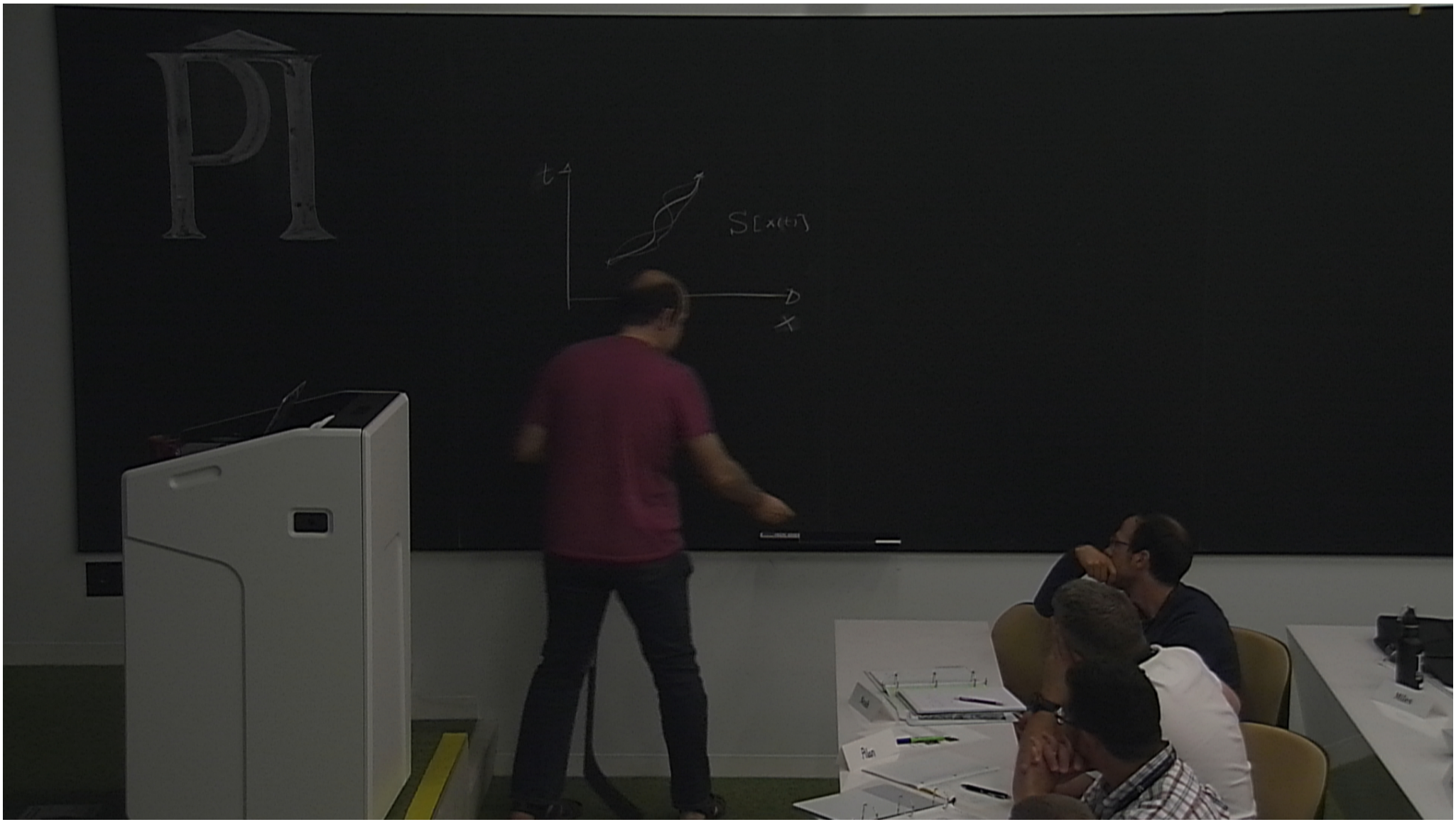


From space to spacetime

	Space	Spacetime
Distance	$x^2+y^2+z^2$	$x^2+y^2+z^2-(ct)^2$
What to extremize?	Energy	Action

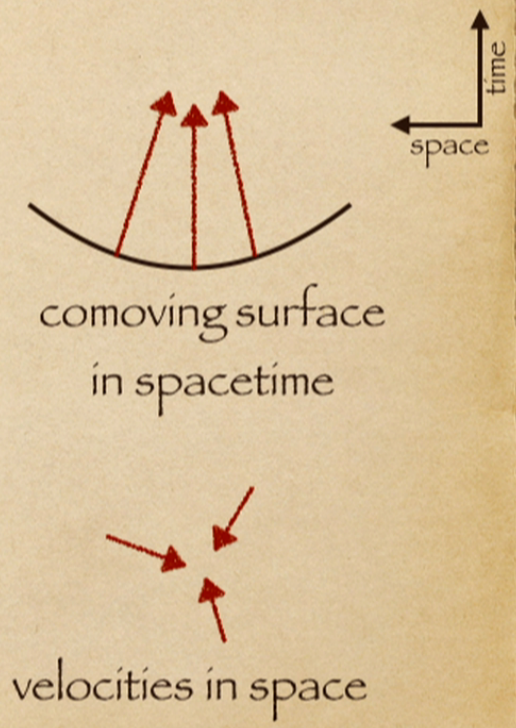
From space to spacetime

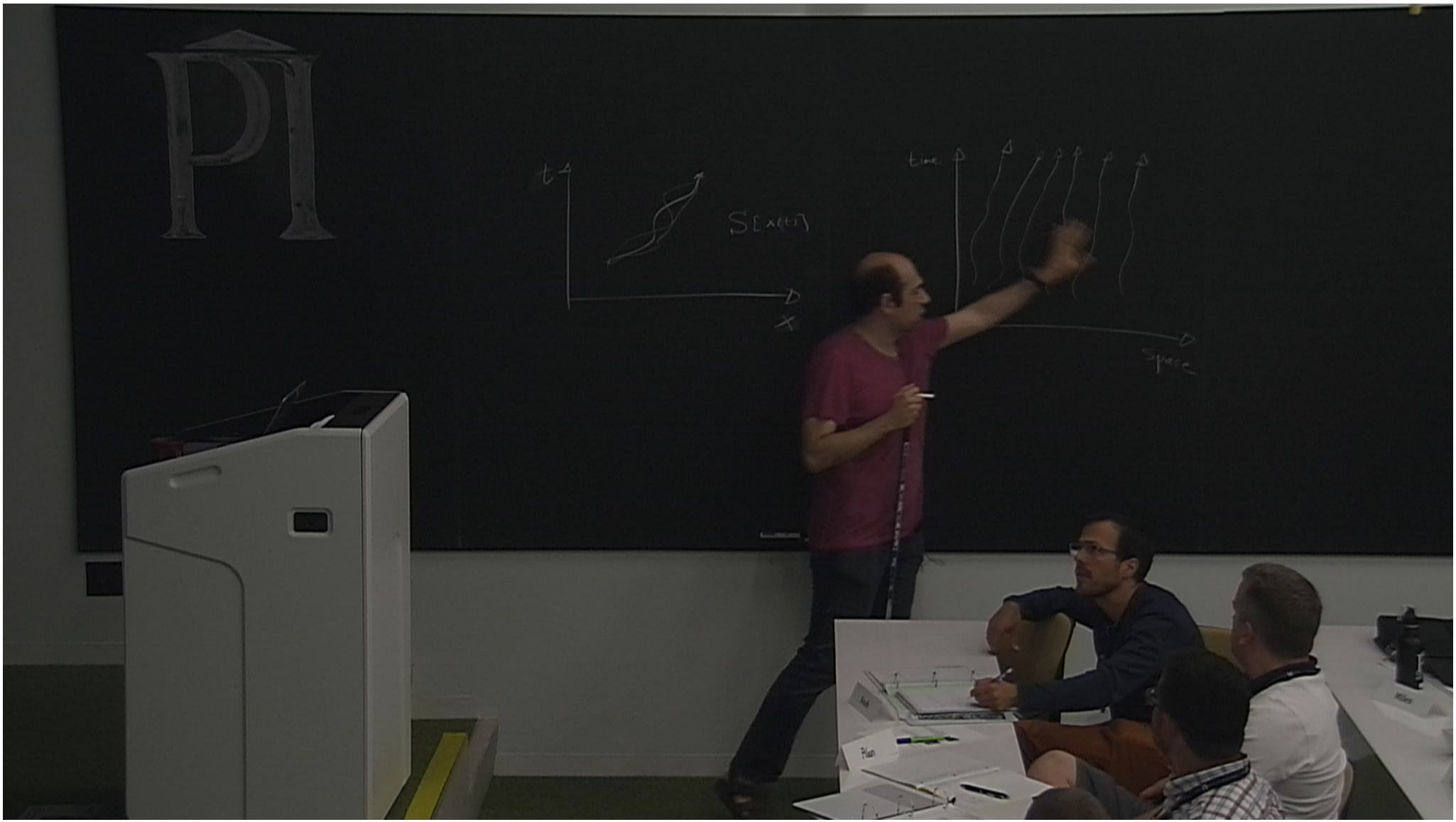
	Space	Spacetime
Distance	$x^2+y^2+z^2$	$x^2+y^2+z^2-(ct)^2$
What to extremize?	Energy	Action

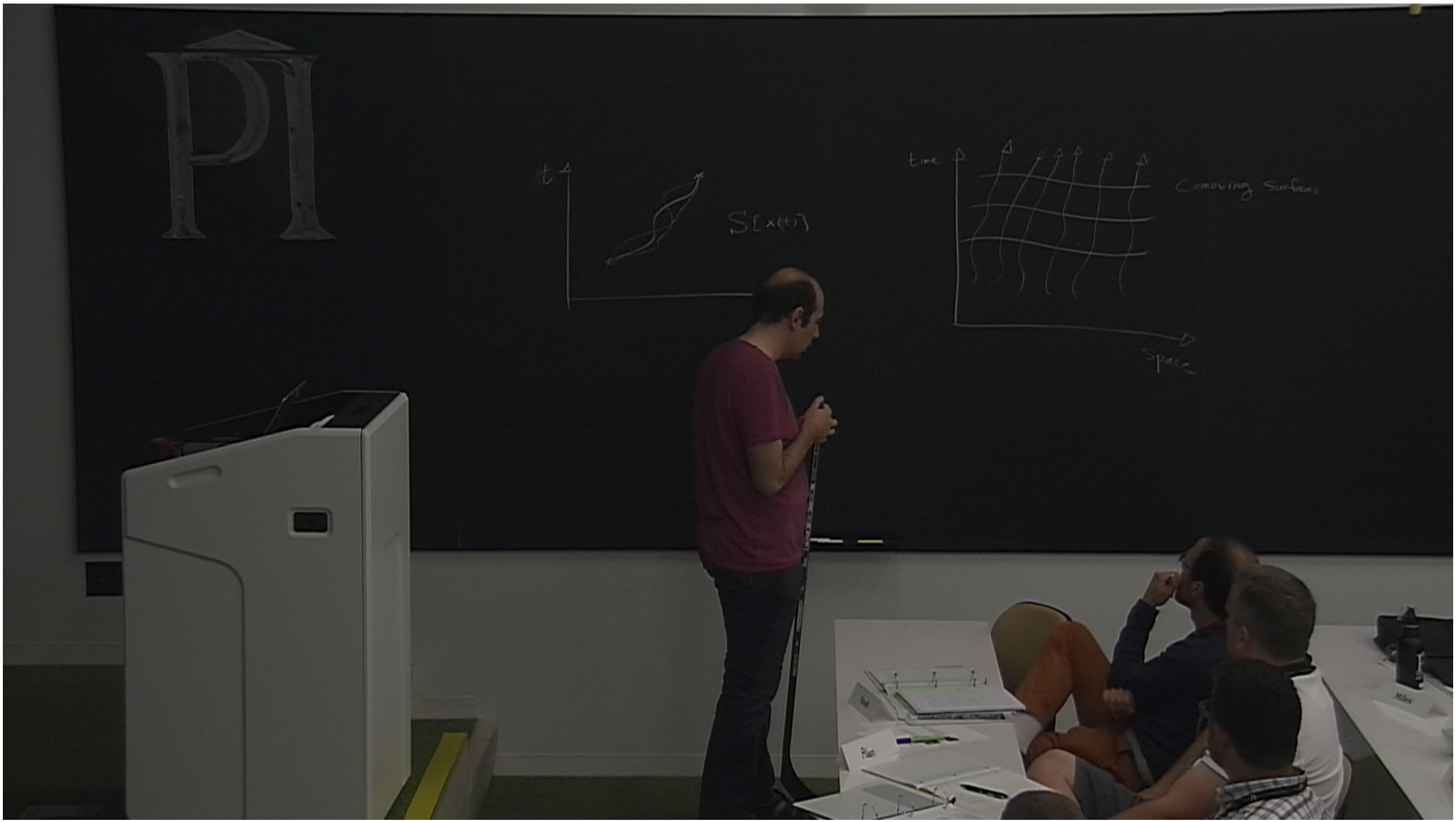

t
S[x(t)]
x

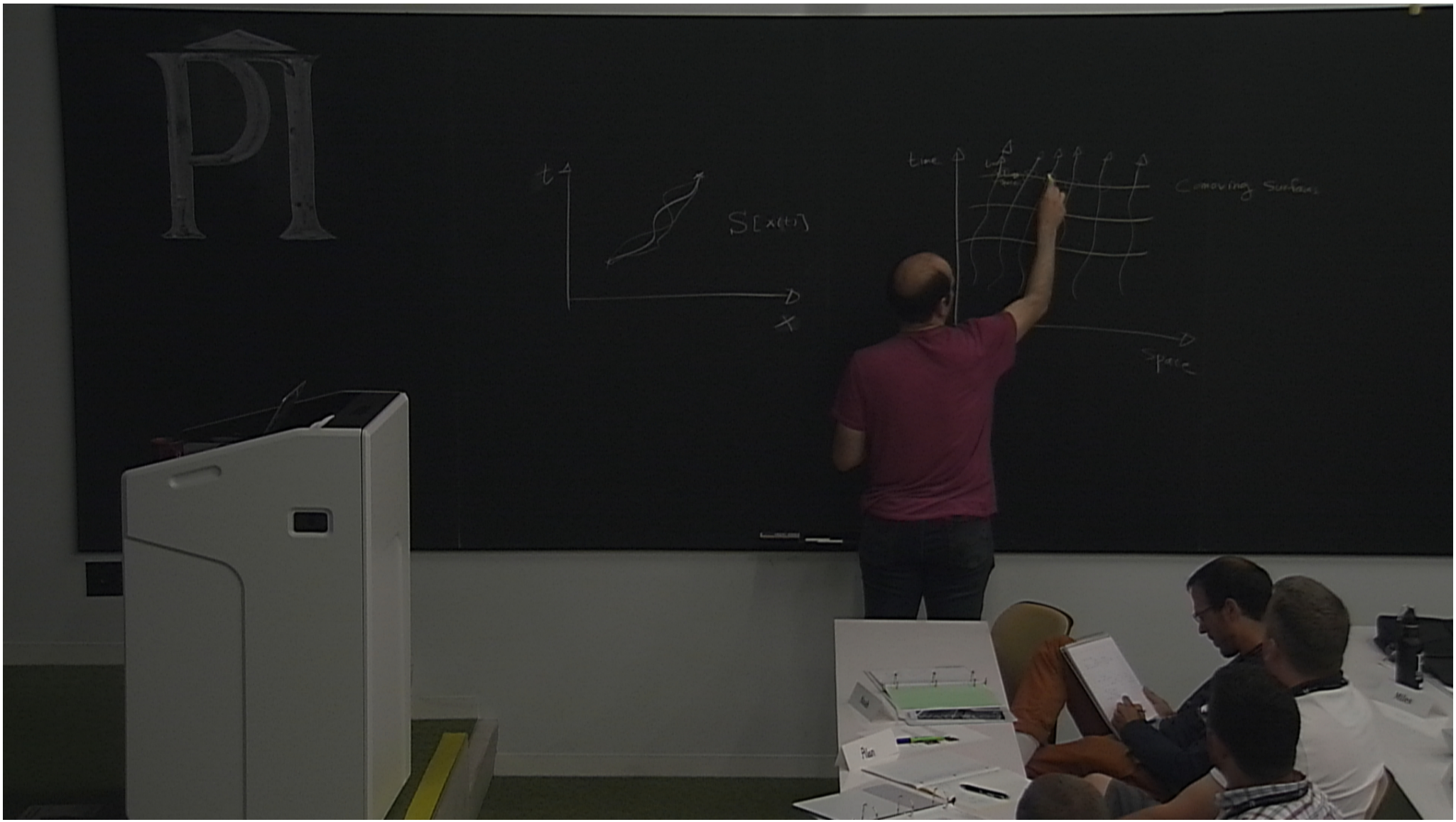
K≈Konvergence

- Mean extrinsic curvature of comoving surfaces of a fluid is spacetime, are equivalent to the convergence of the flow in space




t
S[x(t)]
x
time
space


t
S[x(t)]
time
Comoving Surfaces
space

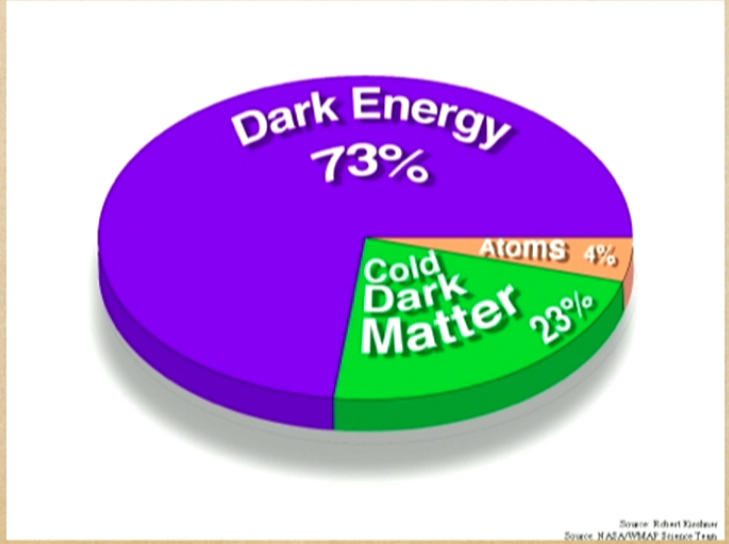

t
x
S[x(t)]
time
Comoving Surfaces
space

Incompressible clock fluid

- In General Relativity, every observer carries her/her own clock
- Global Time → Observers don't cross paths
- Incompressible clock field → K=0 (constant)
- Infinite speed of sound (but no signals)

Dark Energy

- Could cuscuton be responsible for cosmic accelerations?



Quantum Gravity

- Horava-Lifshitz gravity
- Superluminal propagation can make gravity consistent with Quantum Mechanics

Black Holes

- avoid singularities?