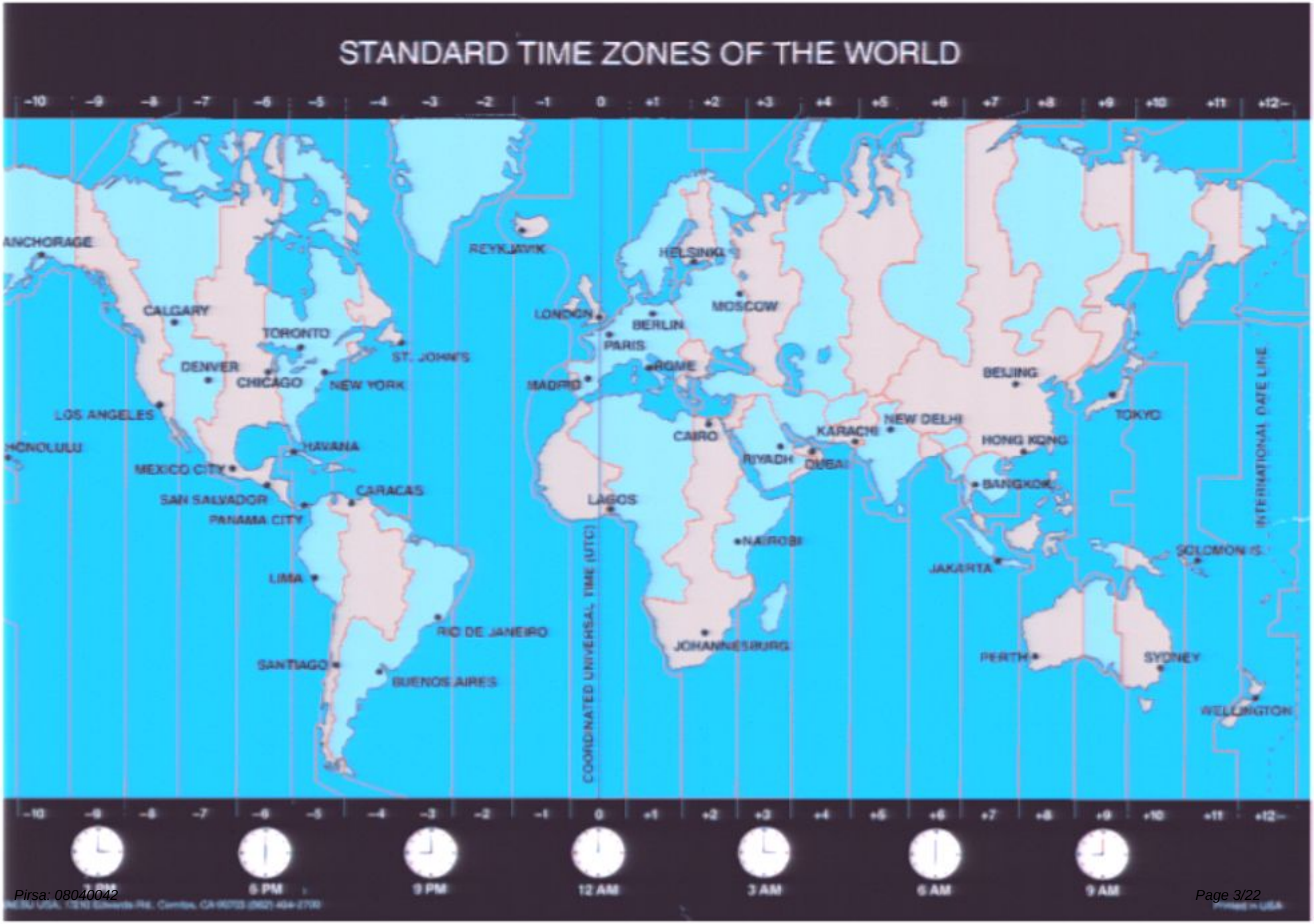
Title: Special Topics in Physics - Lecture 13B

Date: Apr 09, 2008 08:00 PM

URL: http://pirsa.org/08040042

Abstract: The Problem of Time in Quantum Gravity and Cosmology

Distant Simultaneity


STANDARD TIME ZONES OF THE WORLD
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10 +11 +12
ANCHORAGE
CALGARY
TORONTO
DENVER
CHICAGO
NEW YORK
ST. JOHN'S
LOS ANGELES
HONOLULU
HAVANA
MEXICO CITY
SAN SALVADOR
CARACAS
PANAMA CITY
LIMA
RIO DE JANEIRO
SANTIAGO
BUENOS AIRES
REYKJAVIK
LONDON
HELSINKI
MOSCOW
BERLIN
PARIS
ROME
MADRID
CAIRO
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NAIROBI
JOHANNESBURG
RIYADH
DUBAI
KARACHI
NEW DELHI
BEIJING
HONG KONG
BANGKOK
JAKARTA
TOKYO
SOLOMON IS.
PERTH
SYDNEY
WELLINGTON
INTERNATIONAL DATE LINE
COORDINATED UNIVERSAL TIME (UTC)
6 PM
9 PM
12 AM
3 AM
6 AM
9 AM

Time zones remind us

- that we spread time (phase) across space on grounds of convenience
- that as a result we may end up traveling backwards in time
- to ask what the "true" simultaneity is behind the convention

Synchronized separated clocks

or are they?

Time is (standardly) spread through space so that the one-way speed of light is the same in all directions (i.e. "isotropic").

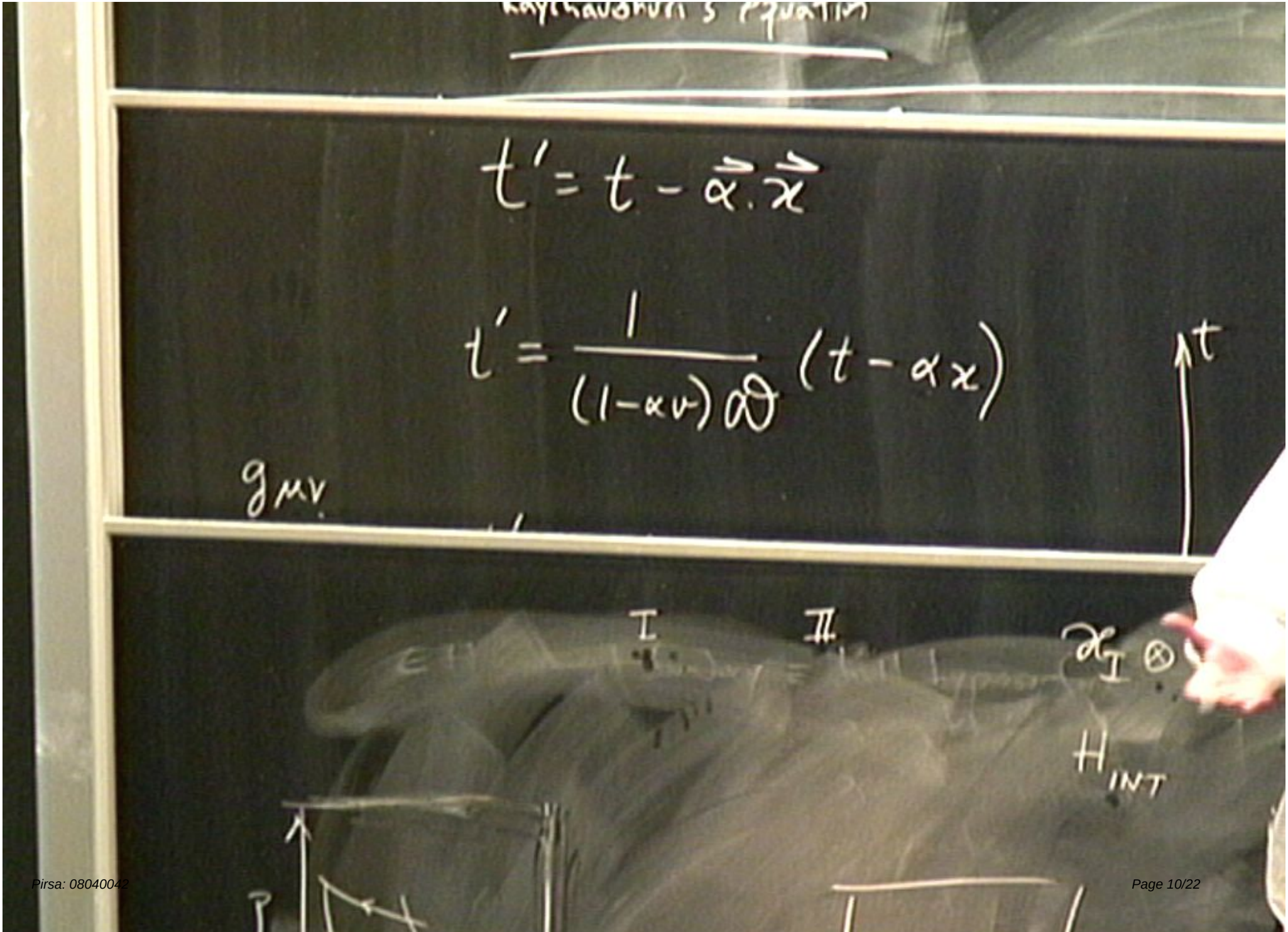
This is the Poincaré-Einstein convention for synchronizing distant clocks.

(Avoid thinking of it operationally!)

J. Henri Poincaré (1854–1912) Polymath

see Peter Galison,
Einstein's clocks, Poincaré's maps, 2004

- understood the conventional nature of distant simultaneity ~1900
- even in case of Newtonian mechanics!
- understood the relativity of simultaneity (H.A. Lorentz's "local time")
- anticipated Einstein's relativity principle and (along with H.A. Lorentz and J. Larmor) almost all the equations of Einstein's special theory of relativity


$t' = t - \vec{\alpha}.\vec{x}$
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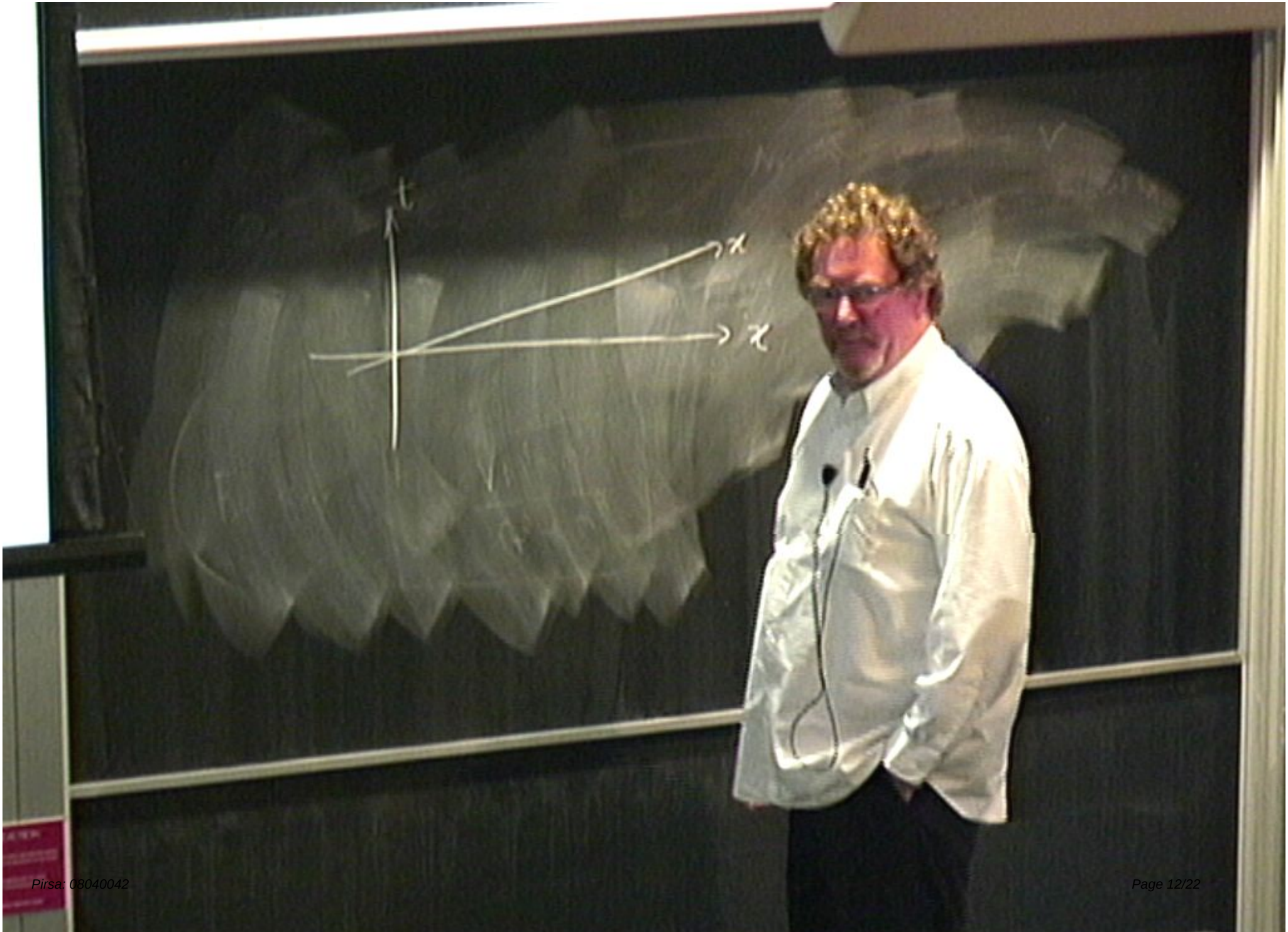
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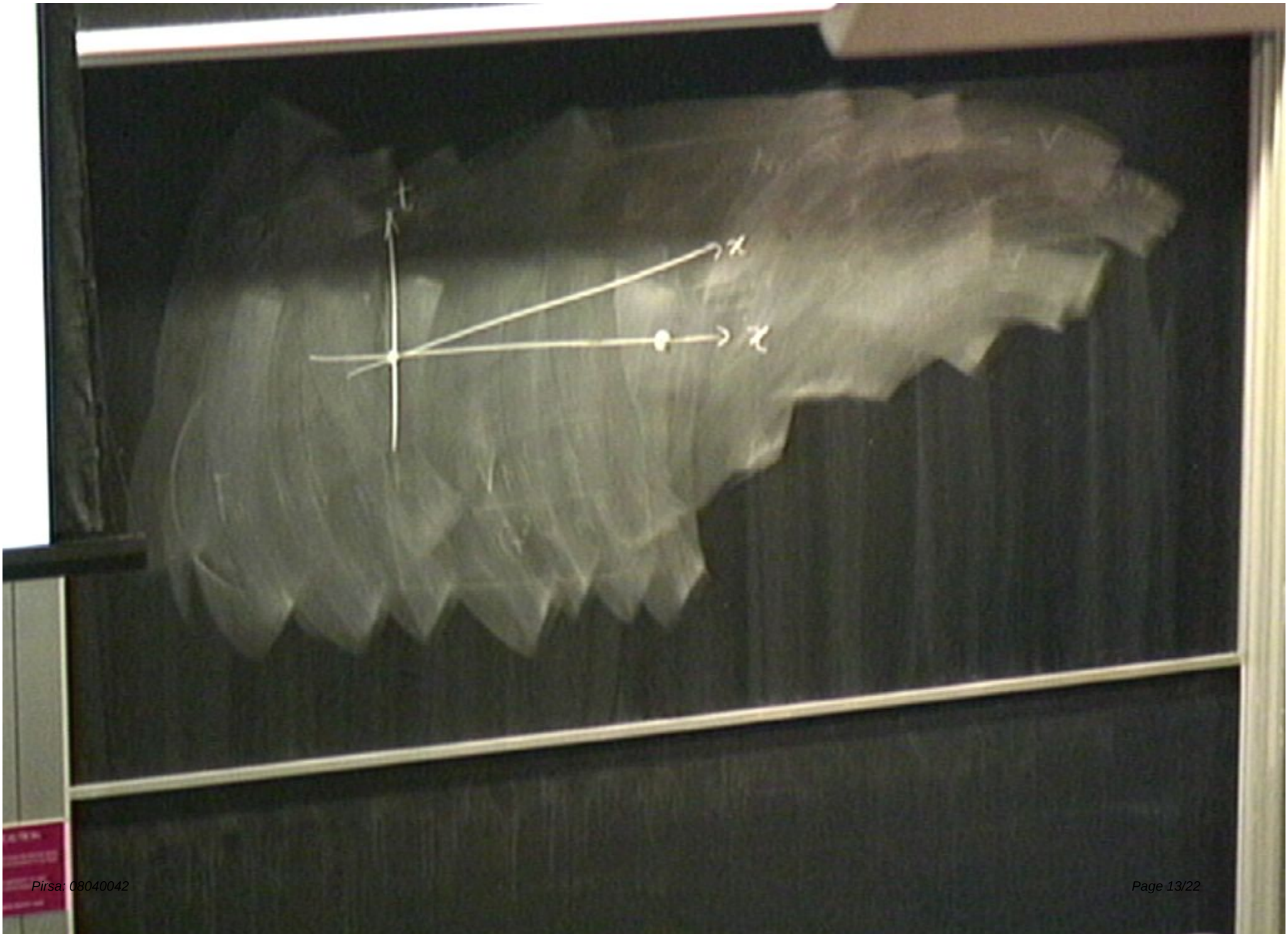
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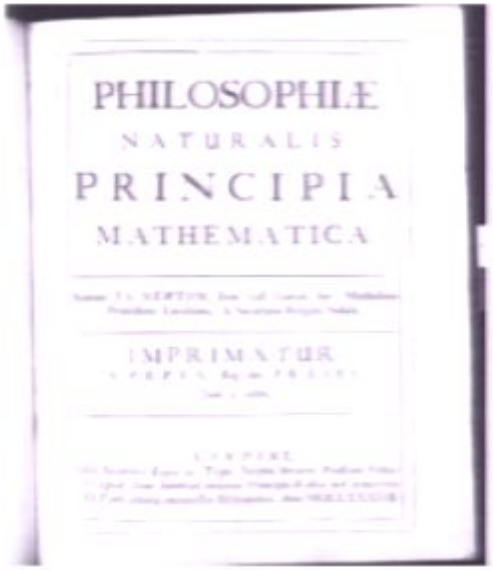
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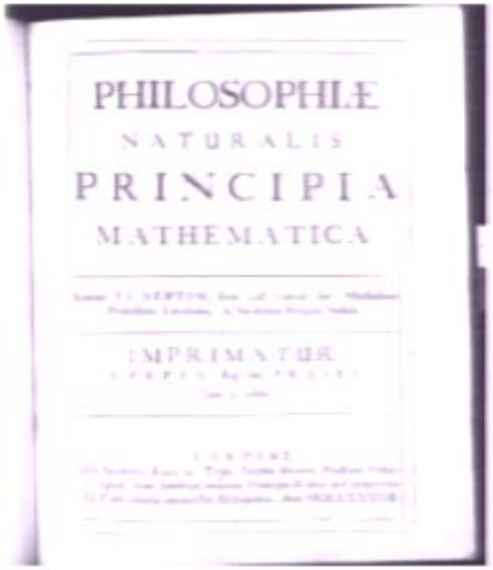
Newton and simultaneity

- Simultaneity is ill-defined until action-at-a-distance forces like gravity or magnetism are considered.
- Simultaneity can be defined by clock transport, or equivalently by making gravitational actions instantaneous in all directions.
- Other simultaneity conventions could still be used, but they would be inconvenient, or complicated (Poincaré). They would involve gravity acting backwards in time in some directions.
- There are no convincing grounds in Newtonian physics for the notion of the flow of time.



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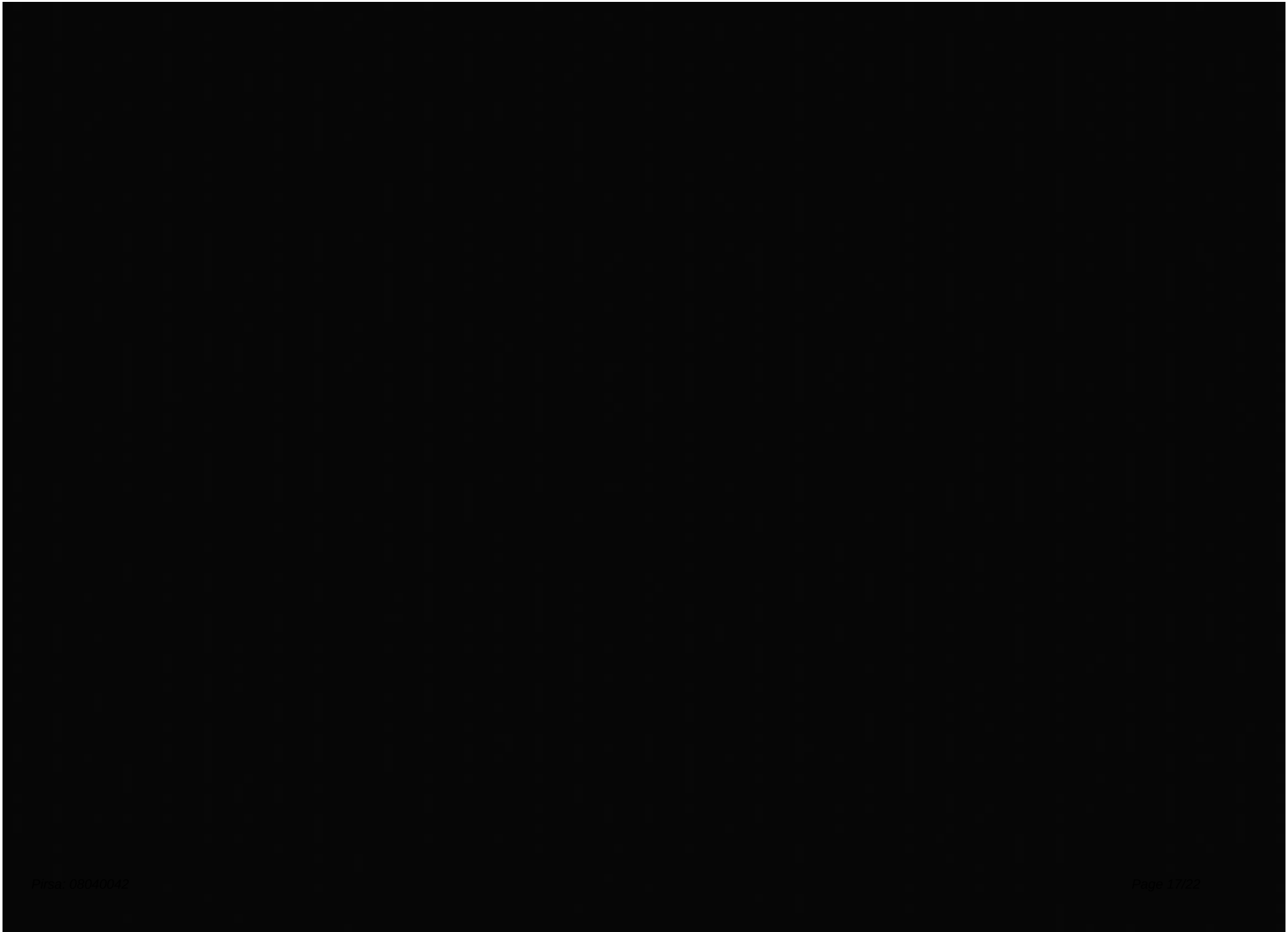
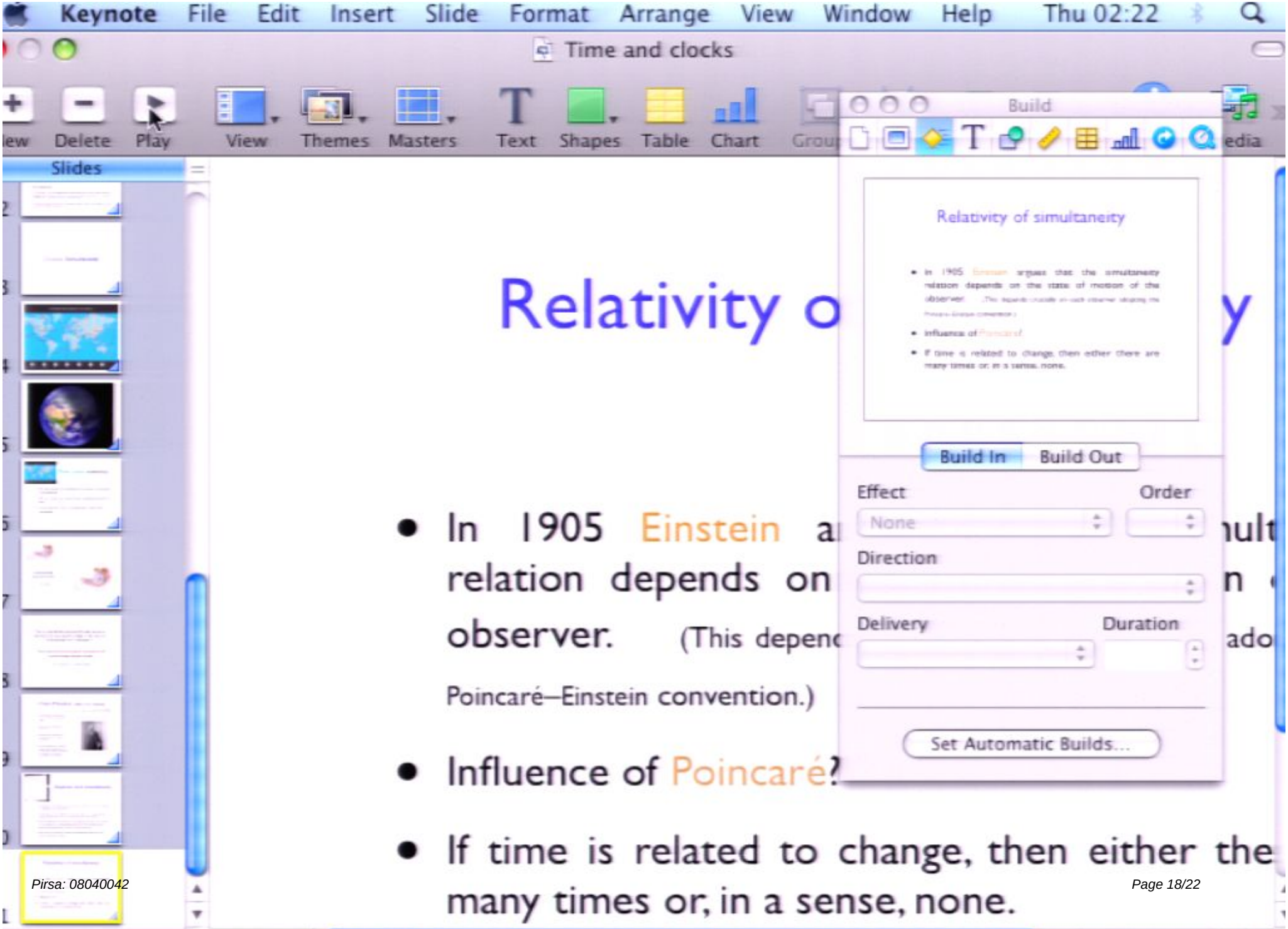
Relativity of simultaneity

- In 1905 Einstein argues that the simultaneity relation depends on the state of motion of the observer. (This depends crucially on each observer adopting the Poincaré–Einstein convention.)
- Influence of Poincaré?
- If time is related to change, then either there are many times or, in a sense, none.

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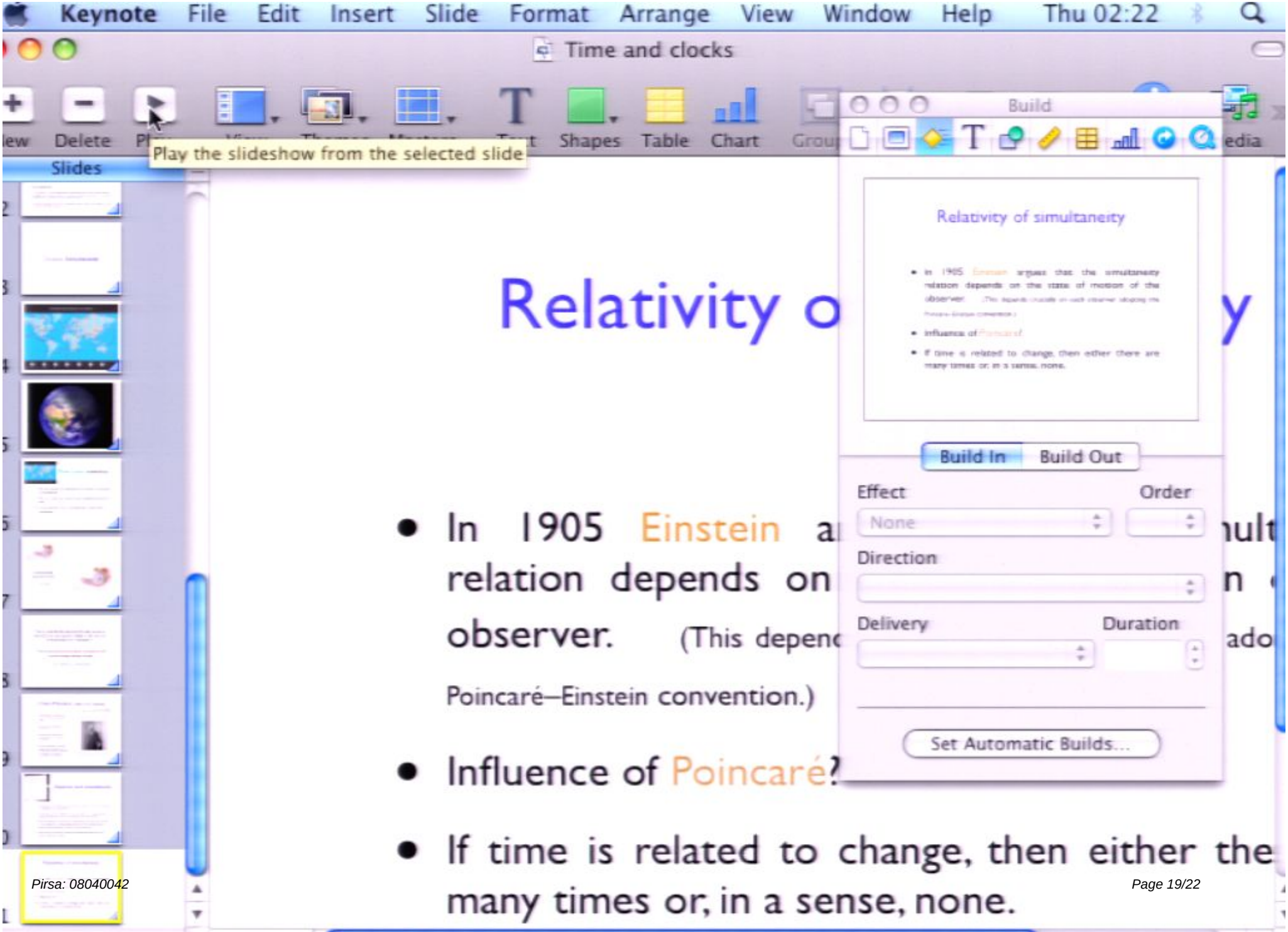
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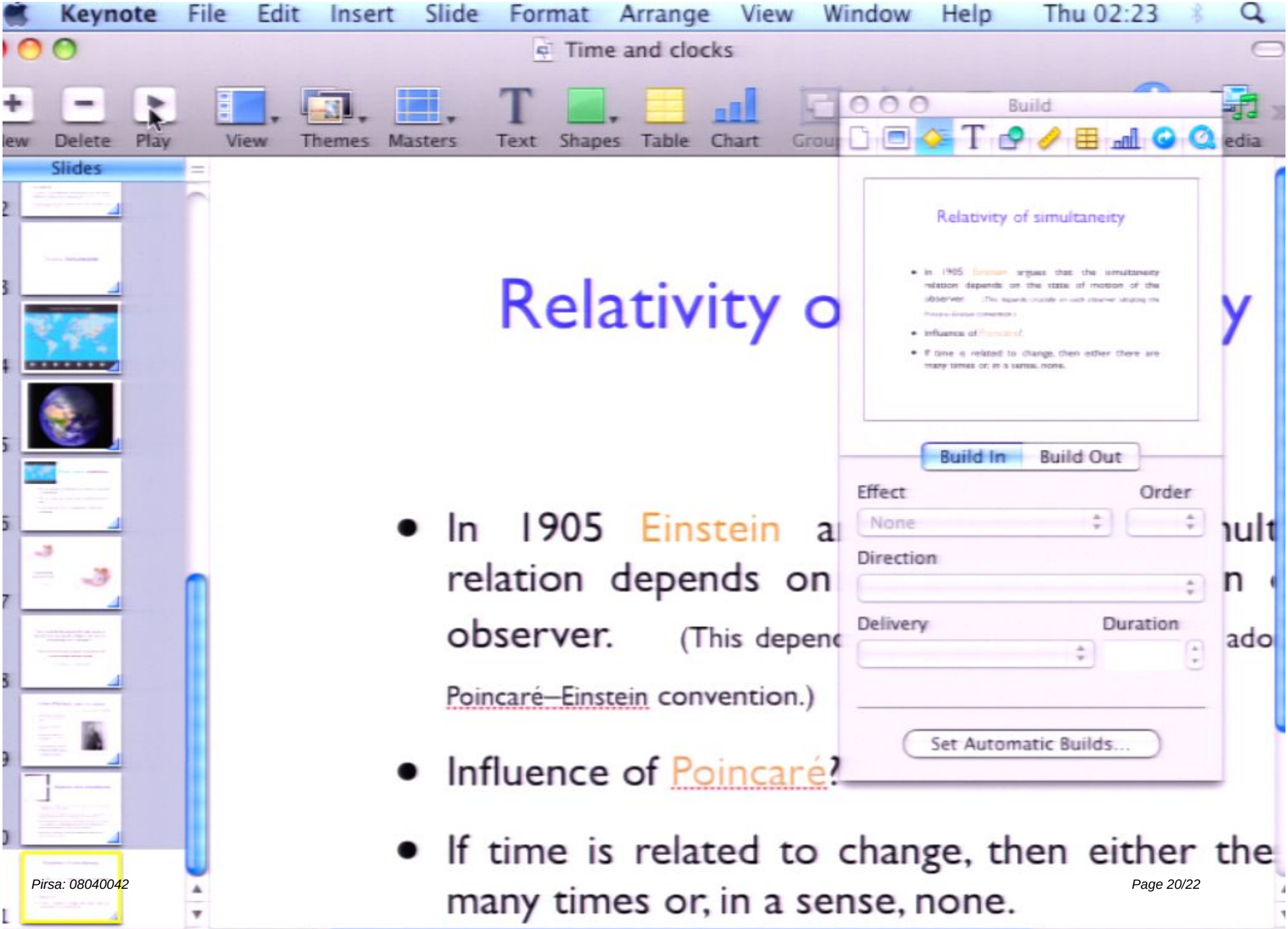
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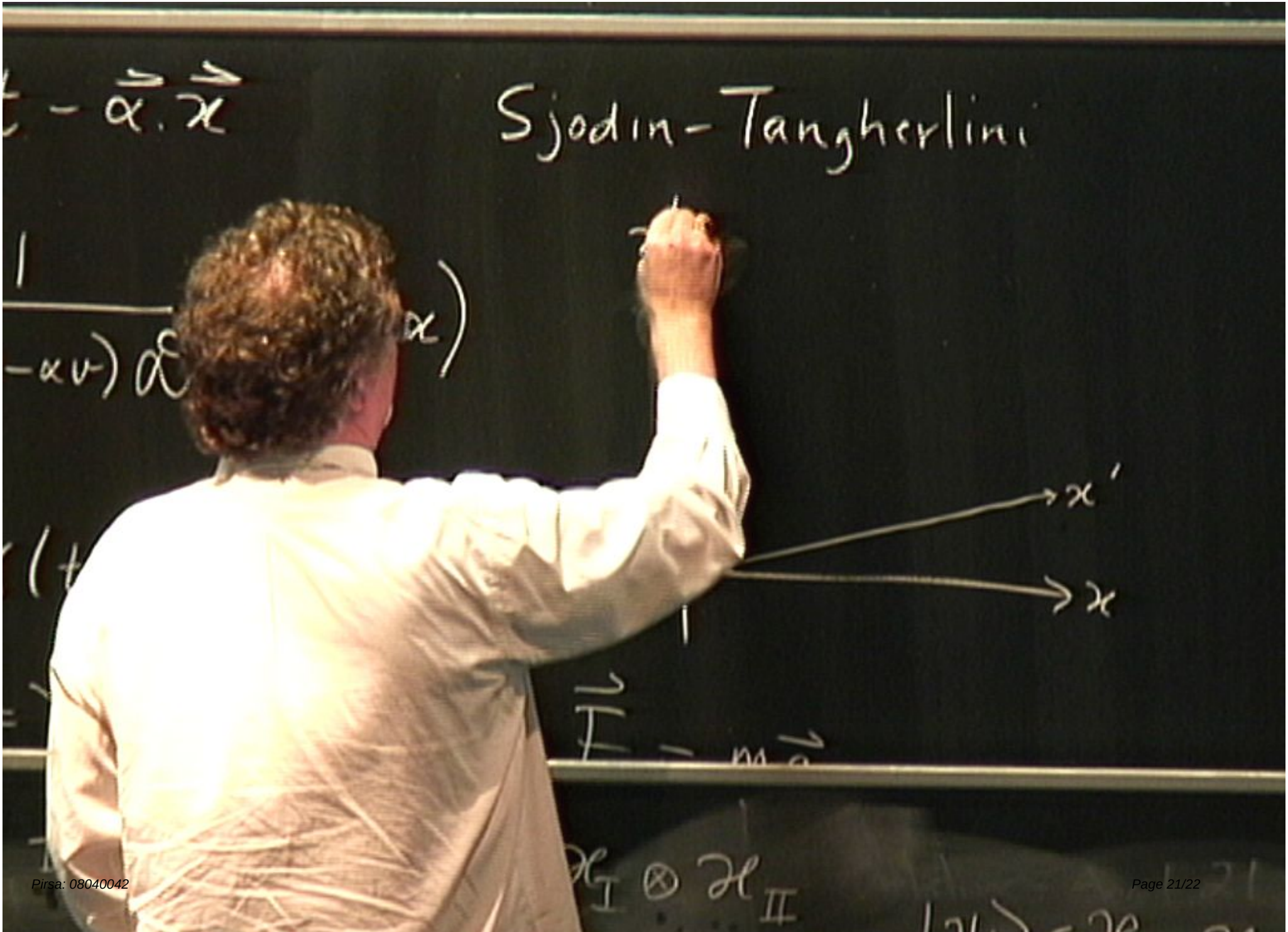
Sjodin-Tangherlini
x'
x

$t - \vec{\alpha}\cdot\vec{x}$

$\frac{1}{-\alpha v)\,\partial\theta}\,(t - \alpha x)$

$(t - vx/c^2)$

$= \gamma \qquad \alpha = v/c^2$

Sjodin-Tangherlini

$x' = \gamma(x - vt)$

$t' = \frac{1}{\gamma}t$

$\vec{F} = m\vec{a}$

I II

$\mathcal{H}_I \otimes \mathcal{H}_{II}$