

Title: Faster than the Speed of Light - Could the laws of physics change?

Date: Jun 23, 2006 07:00 PM

URL: <http://pirsa.org/06060057>

Abstract: The laws of physics are usually meant to be set in stone; variability is not usually part of physics. Yet contradicting Einstein's tenet of the constancy of the speed of light raises nothing less than that possibility. I will discuss some of the more dramatic implications of a varying speed of light. João Magueijo is Professor of Physics at Imperial College London. He is currently visiting Perimeter Institute and the Canadian Institute for Theoretical Astrophysics in Toronto. He received his doctorate in theoretical physics at Cambridge University, and has been a visiting scientist at the University of California at Berkeley and Princeton University. <kw> Joao Magueijo, Theory of Relativity, speed of light, VSL, varying speed of light, Dirac, cosmology, geometry, dimensional, dimensionless, Bekenstein, Brans-Dicke, varying constant, Einstein, time dilation, length contraction, horizons, Big Bang, grand-unified theory, Planck length, Planck time, gravity, space, time, quantum gravity, varying alpha, Kelvin, quasar, laws of physics </kw>



João Magueijo
*Imperial College London
& Perimeter Institute*

**Faster than the
Speed of Light –
Could the Laws of
Physics Change?**

**Special Guelph Lecture:
Rozanski Hall
University of Guelph
Campus**

June 23, 2006

Could the laws of physics change? A varying speed of light

João Magueijo

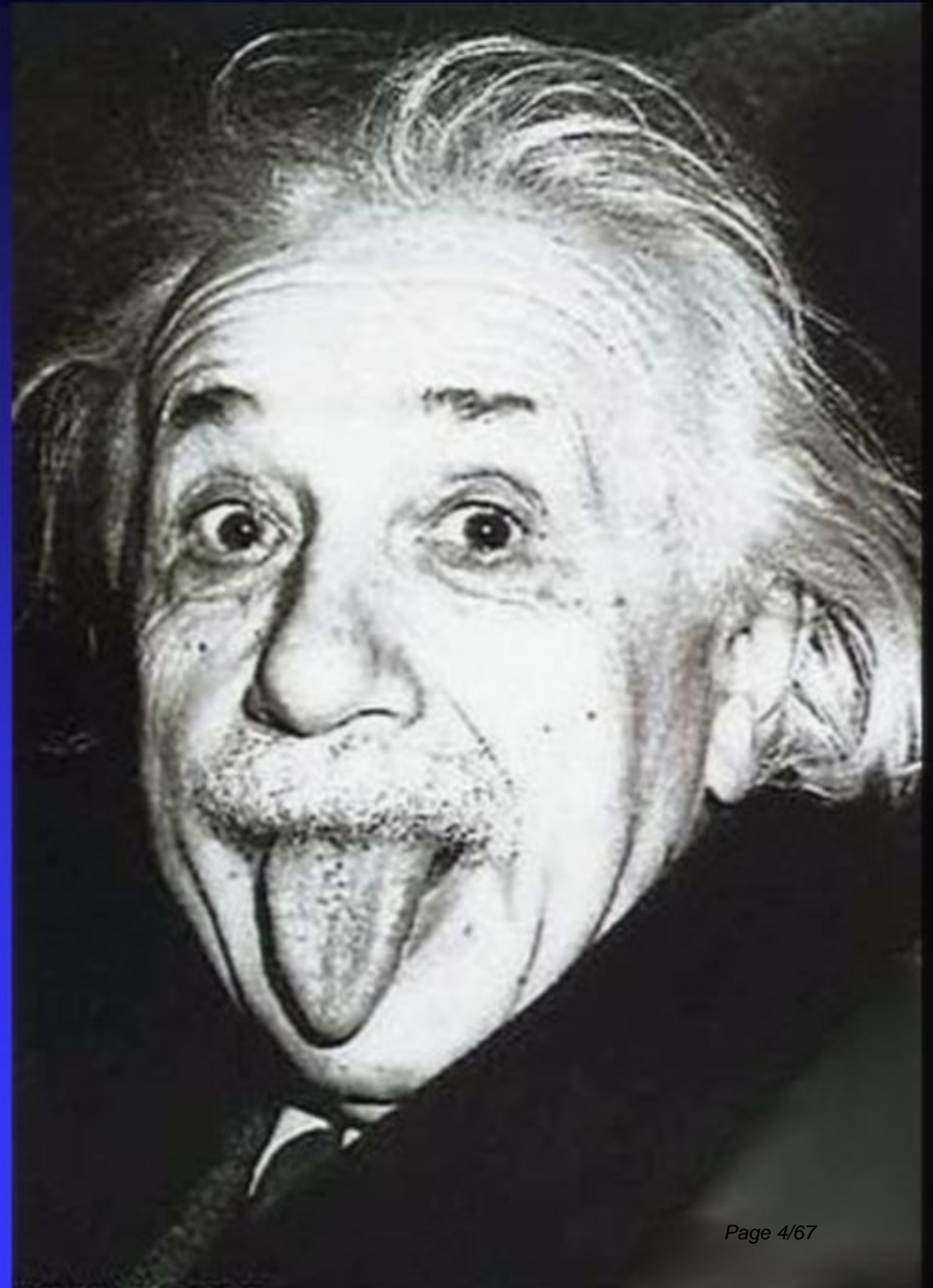
2006

Perimeter Institute, Canada

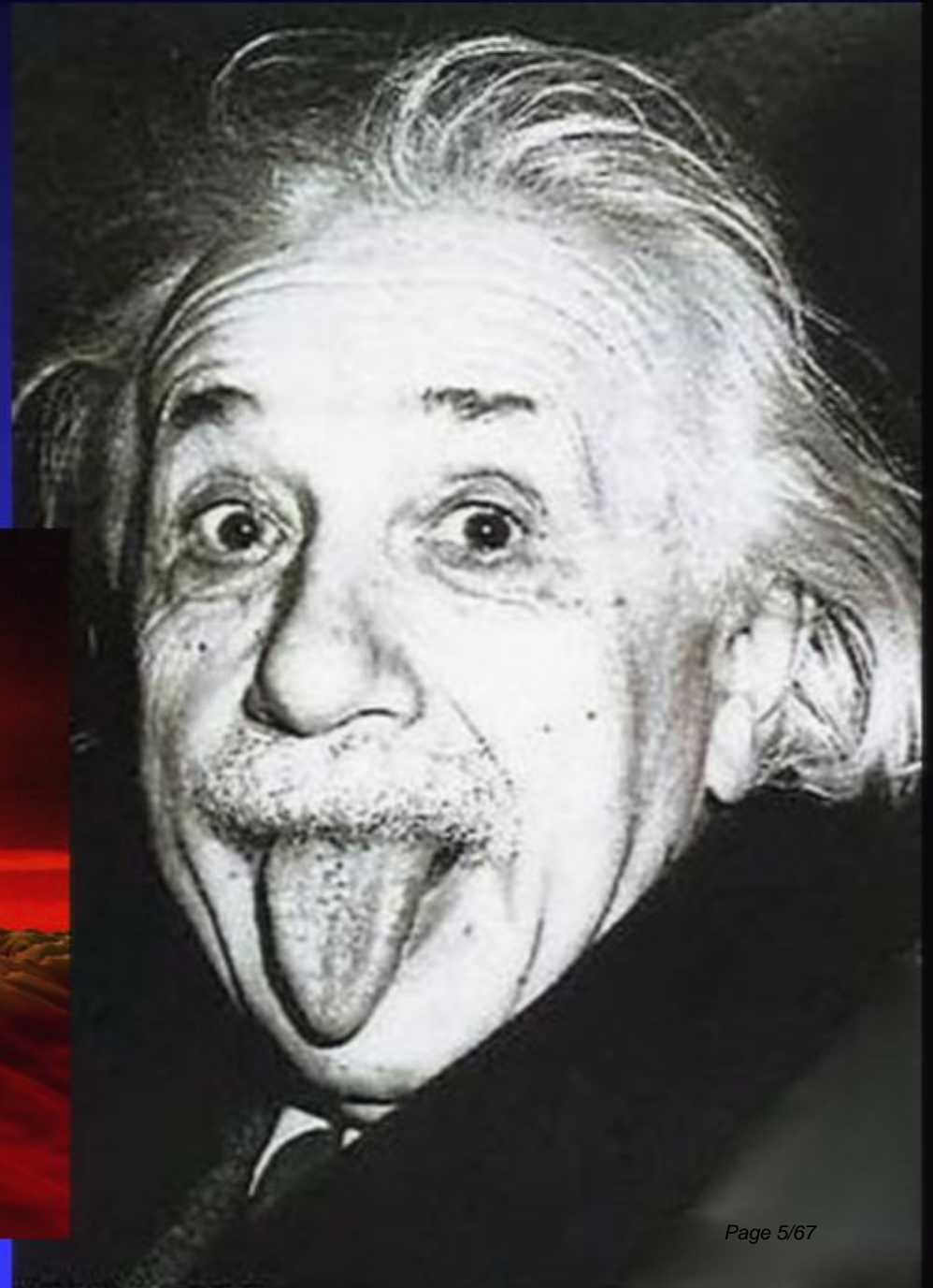
and

Imperial College, London

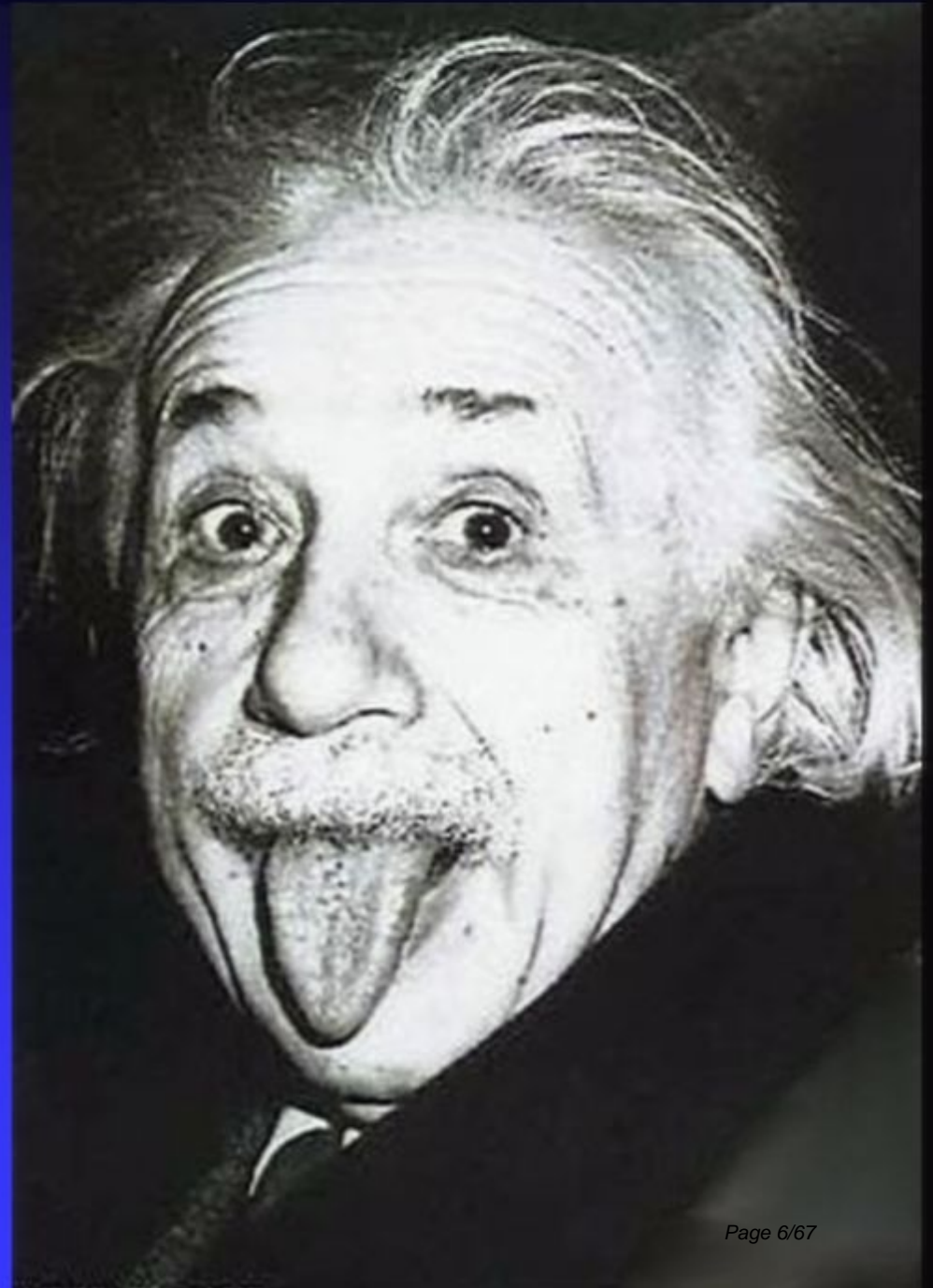
THE THEORY OF RELATIVITY



THE THEORY OF RELATIVITY



THE THEORY OF RELATIVITY

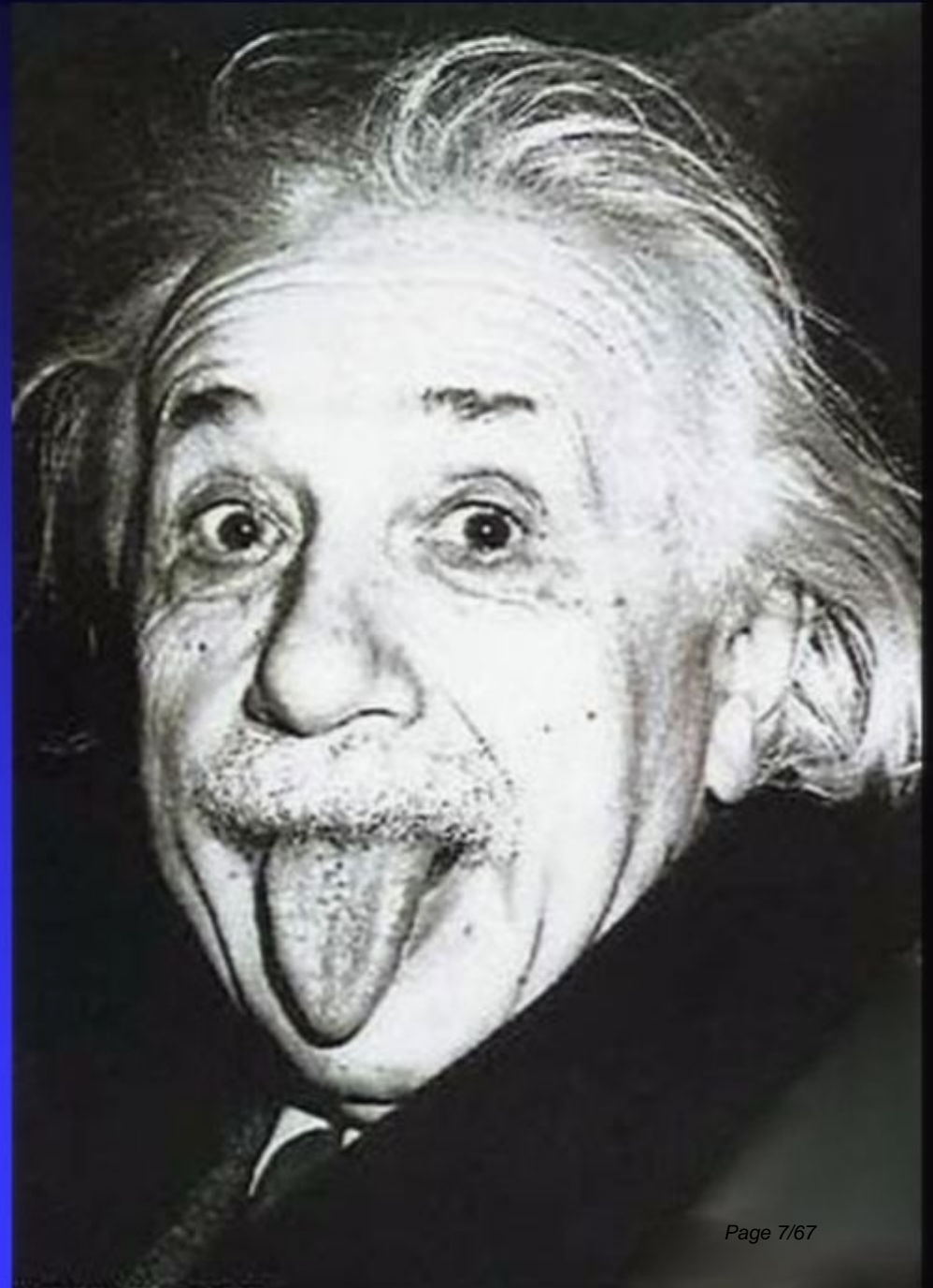


THE THEORY OF RELATIVITY

THE SPEED OF LIGHT

C

IS CONSTANT



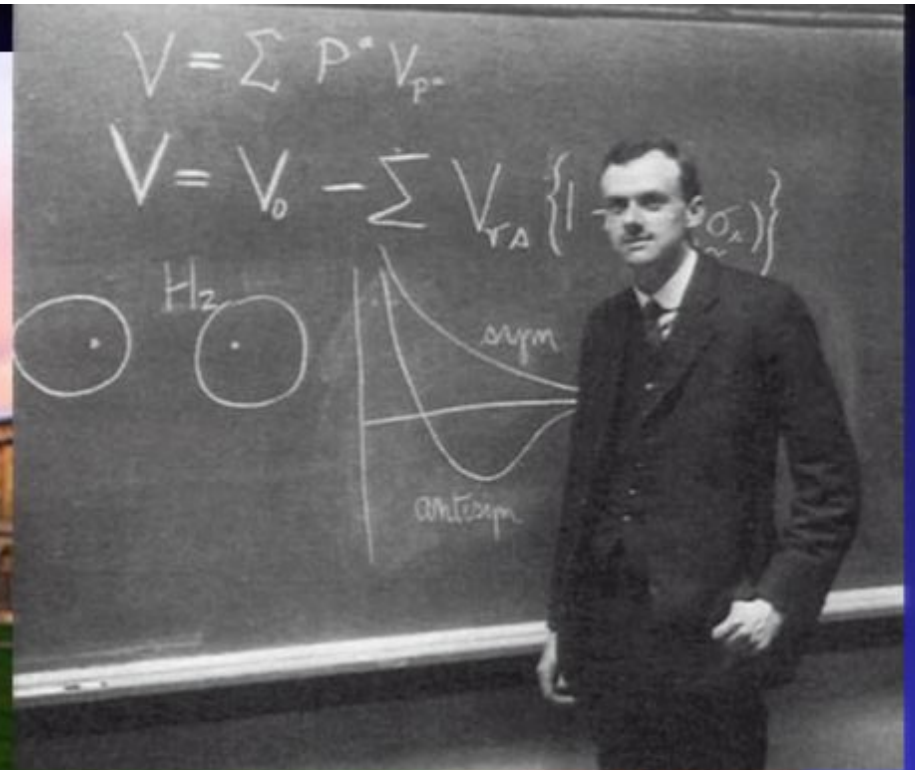
VSL=

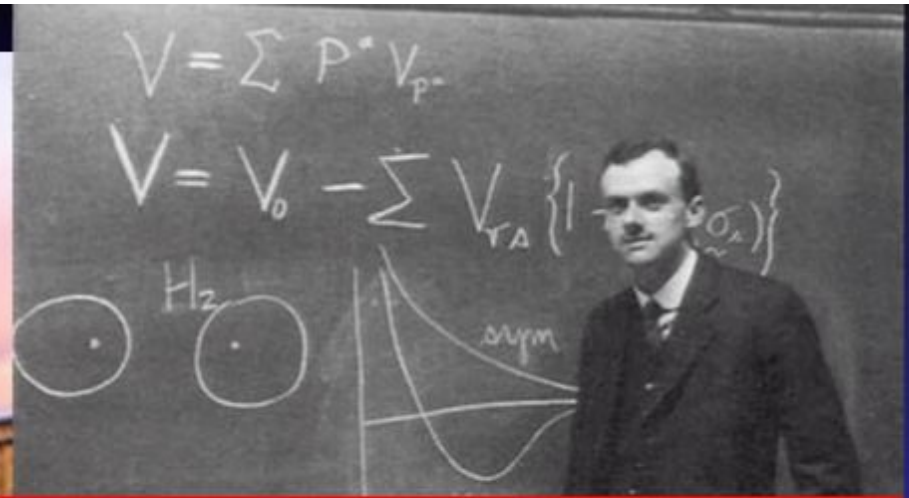
varying speed of light

VSL=









One field of work in which there has been too much speculation is cosmology. There are very few hard facts to go on, but theoretical workers have been busy constructing various models for the universe, based on any assumptions that they fancy. These models are probably all wrong. It is usually assumed that the laws of nature have always been the same as they are now. There is no justification for this. The laws may be changing, and in particular quantities which are considered to be constants of nature may be varying with cosmological time. Such variations would completely upset the model makers.

Paul Dirac

Why do constants of nature take their values?

$$\alpha = \frac{e^2}{\hbar c} \approx \frac{1}{137}$$

Explanations:

We do know what Pi is what it is
* Geometry

$$\alpha \approx \frac{\pi}{2^4 3^3} \approx \frac{1}{137}$$

$$\alpha \approx \frac{9}{8\pi^4} \left[\frac{\pi^5}{2^4 5!} \right]^{1/4}$$

Explanations:

We do know what Pi is what it is
* Geometry

THEY'RE NOT CONSTANT!

E



it is

They are not all of the same type

- Different roles:

\hbar, c, k_B Structural

G, e, \dots Interaction strengths

m_e, m_μ, \dots Descriptive

- Dimensional vs. dimensionless

They are not all of the same type

- Different roles:

\hbar, c, k_B Structural

G, e, \dots Interaction strengths

m_e, m_μ, \dots Descriptive

- Dimensional vs. dimensionless

$$\alpha = \frac{e^2}{\hbar c} \approx \frac{1}{137}$$

“Varying constant” theories

e G

Brans-Dicke (1961)



Bekenstein (1982)

h

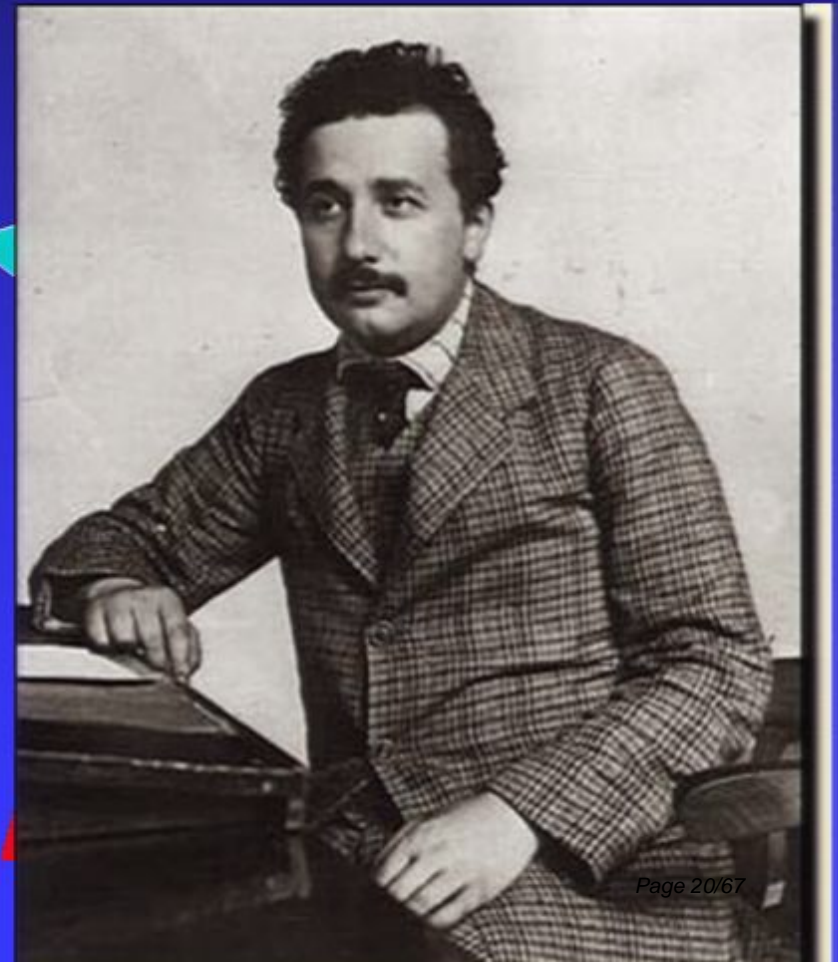


“Varying constant” theories

e G

Brans-Dicke (1961)

Bekenstein (1982)





How can the speed of light be the same for everyone?

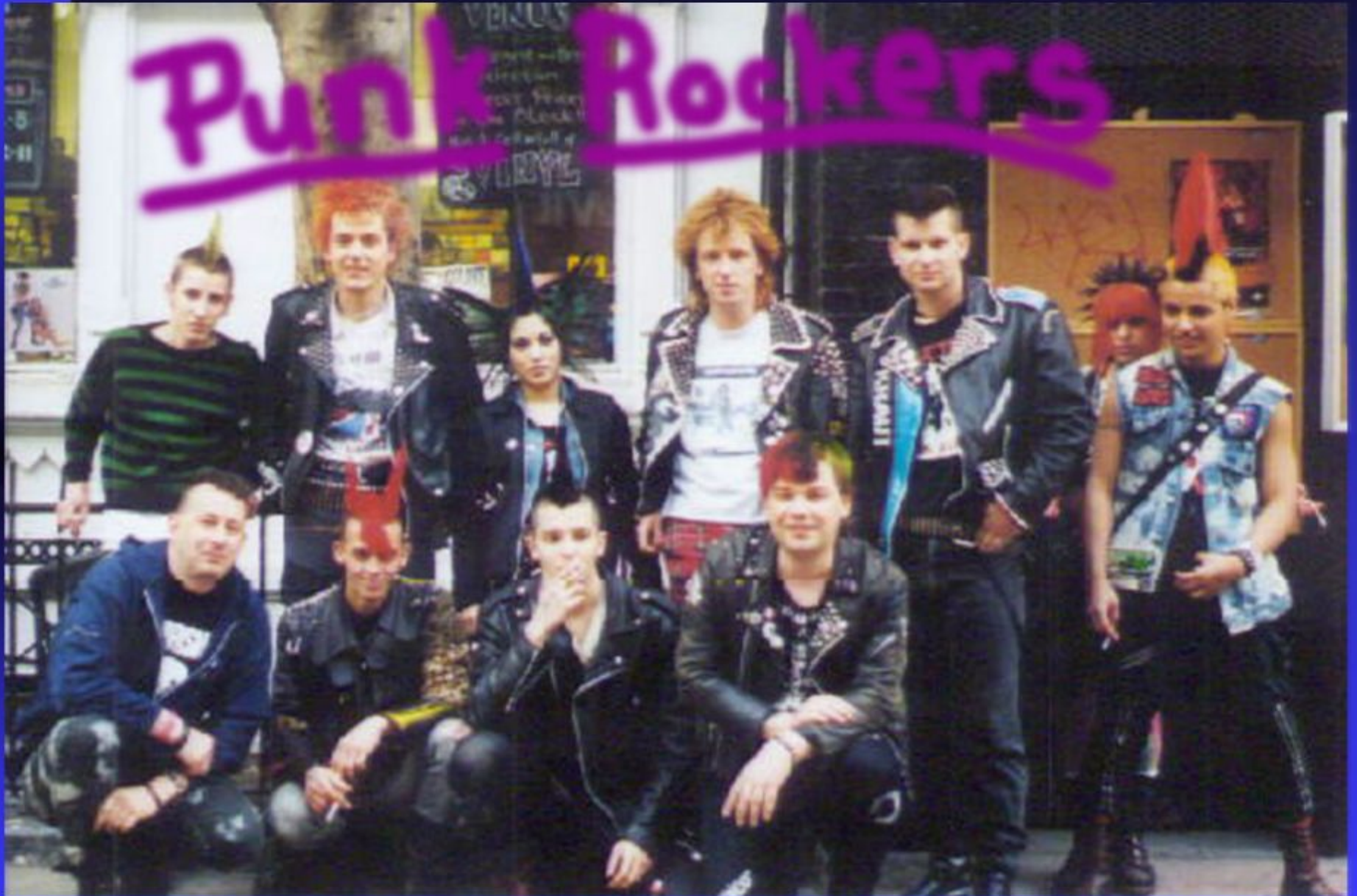
- Space and time cannot be the same for everyone
- Time dilates for moving observers
- Moving objects shrink

Time dilation

Length contraction

The speed of light is a
speed limit









Three reasons for a varying speed of light

- Cosmology is begging for it
- Maybe a necessary ingredient of grand unification
- It may be true!

Cosmology: the Universe as a natural phenomenon

Where did the Universe come from?

How big is the world?

How old is the world?

Will there be an end for the universe?



The Universe is expanding!!!!!!!!!!!!



The universe came out of
a **BIG BANG**

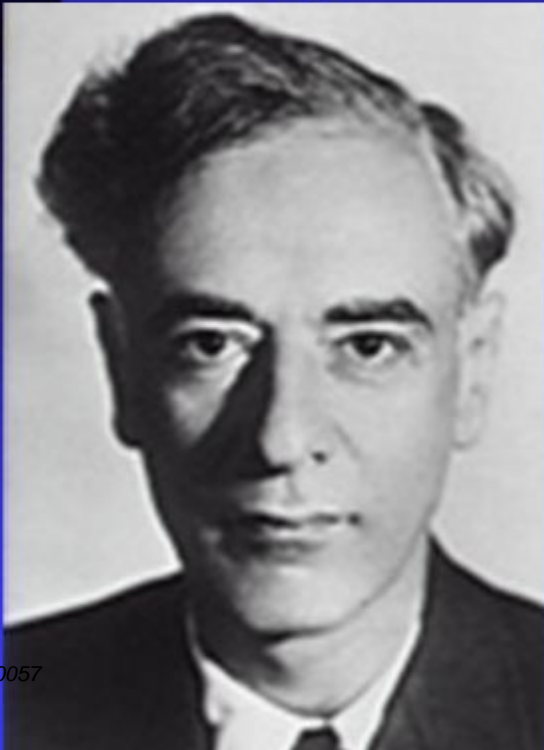
The universe is broken into disconnected “horizons”

- The speed of light is the speed limit
- The universe has a finite age
- Any form of contact has a limited range of action – there is a horizon
- The horizon gets smaller and smaller near the Big Bang

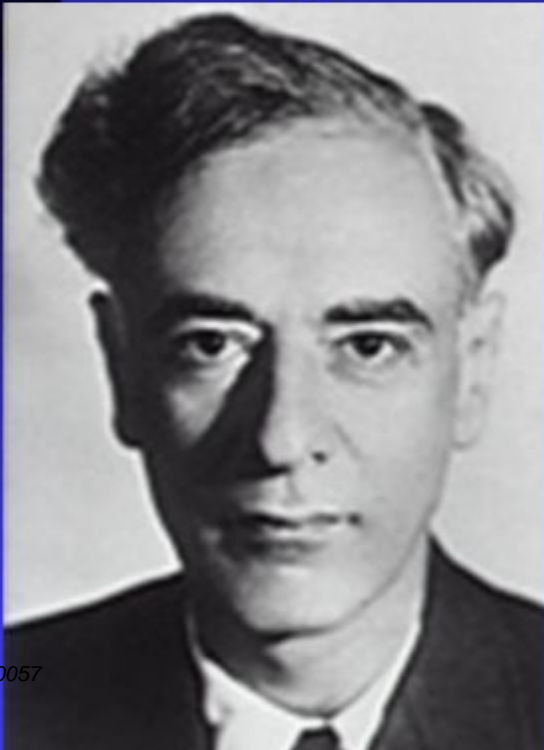
The horizon problem

- The universe displays a unity that it has no right to have
- No physical mechanism can explain why the universe looks the same everywhere

Cosmologists
are often wrong
but seldom in
doubt




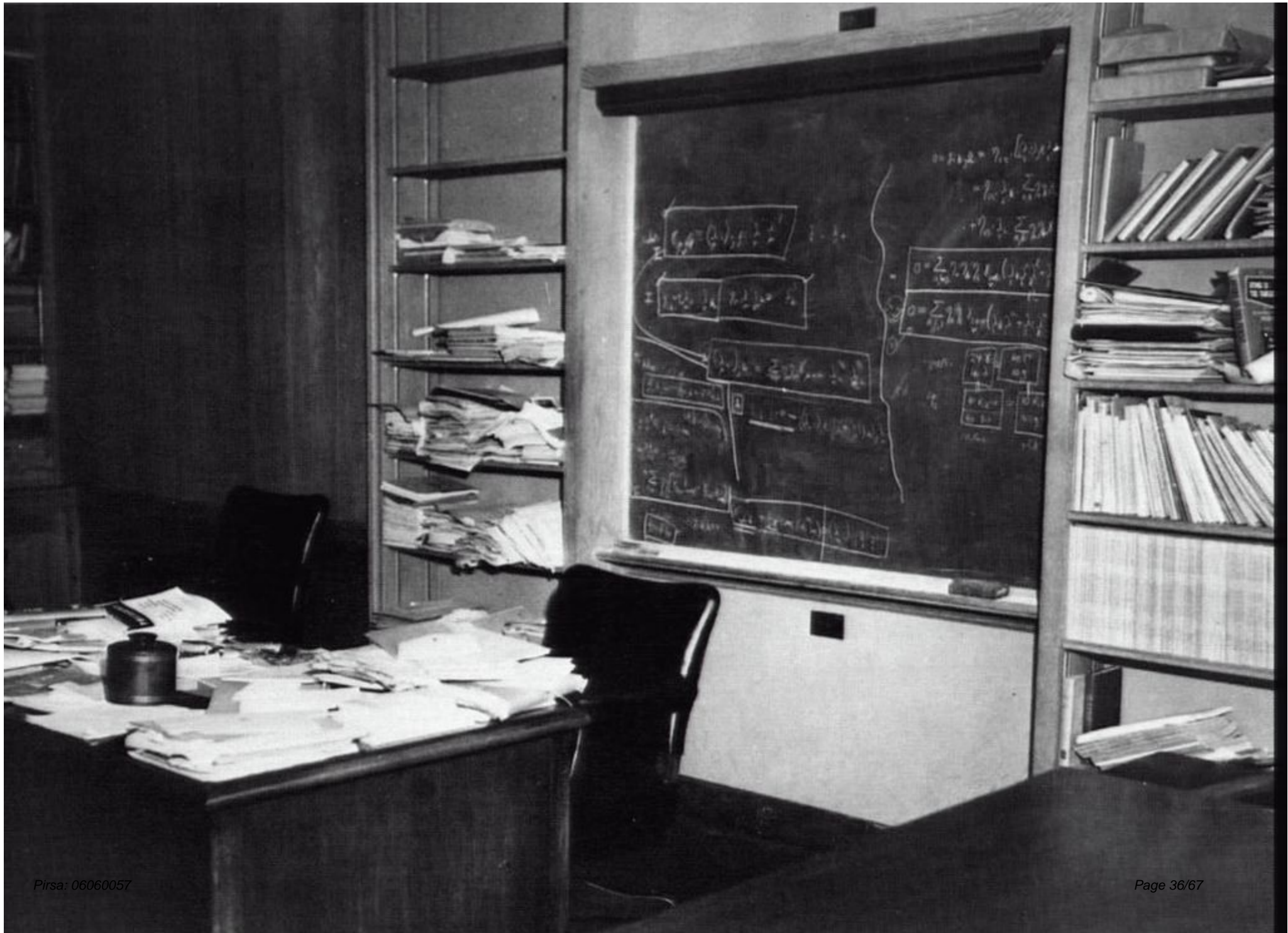
Cosmologists
are often wrong
but seldom in
doubt



Raise the
speed limit

Three reasons for a varying speed of light

- Cosmology is begging for it 
- Maybe a necessary ingredient of grand unification
- It may be true!





THE GRAND-UNIFIED THEORY



THE GRAND-UNIFIED
THEORY

Unification means to quantize space and time

- Gravity is a property of space and time
- Forces other than gravity are quantized – they come in “atoms” or smallest quantities that cannot be divided any further
- To quantize space and time means to introduced some type of `atoms` of space and time

The Planck Length

The Planck time

What kind of objects suffer from the effects of “Quantum gravity”?

Anything much larger than this is under the rule of classical gravity

$$L_P$$

Anything smaller than this should know that space has become full of pot holes

Length contraction!!!!!!

Need a theory where length contraction switches off
at small distances

Need a theory where length contraction switches off
at small distances

$$\lambda \longrightarrow L_p; c \longrightarrow \infty$$



Need a theory where length contraction switches off
at small distances

$$\lambda \longrightarrow L_p; c \longrightarrow \infty$$

A length (energy) dependent speed of light

$$E = \frac{mc^2}{1 + \frac{mc^2}{E_p^2}}$$

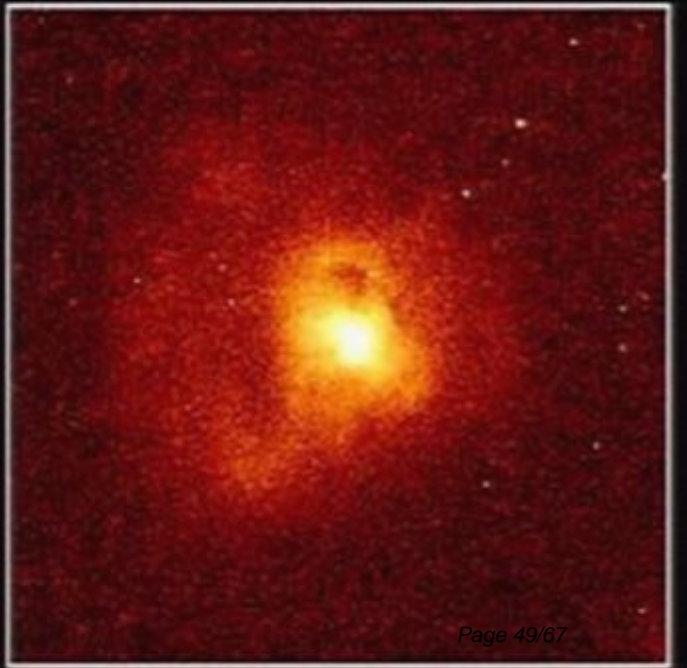
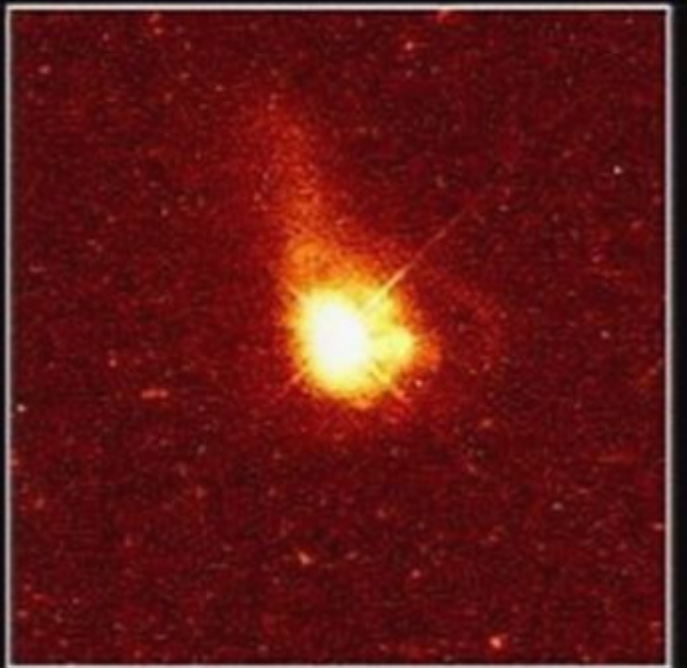
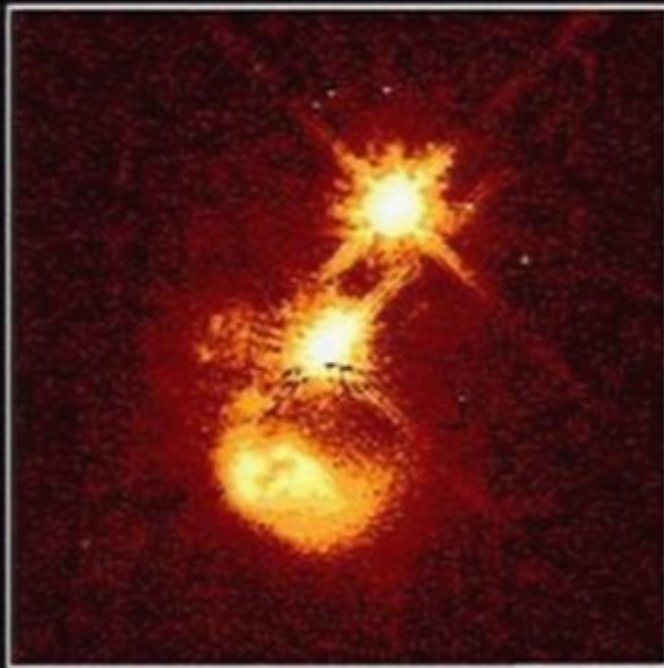
Three reasons for a varying speed of light

- Cosmology is begging for it 
- Maybe a necessary ingredient of grand unification 
- It may be true!

$$c = c(x, t, E, \text{etc})$$

$$c = c(x, t)$$





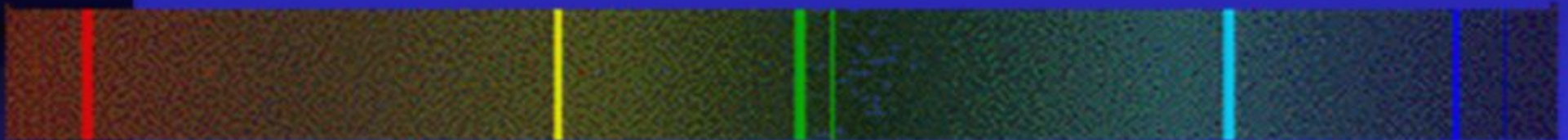
The mystery of alpha – the fine structure constant

$$\alpha = \frac{e^2}{\hbar c} \approx \frac{1}{137}$$

Continuous Spectrum



Emission Spectrum



Absorption Spectrum



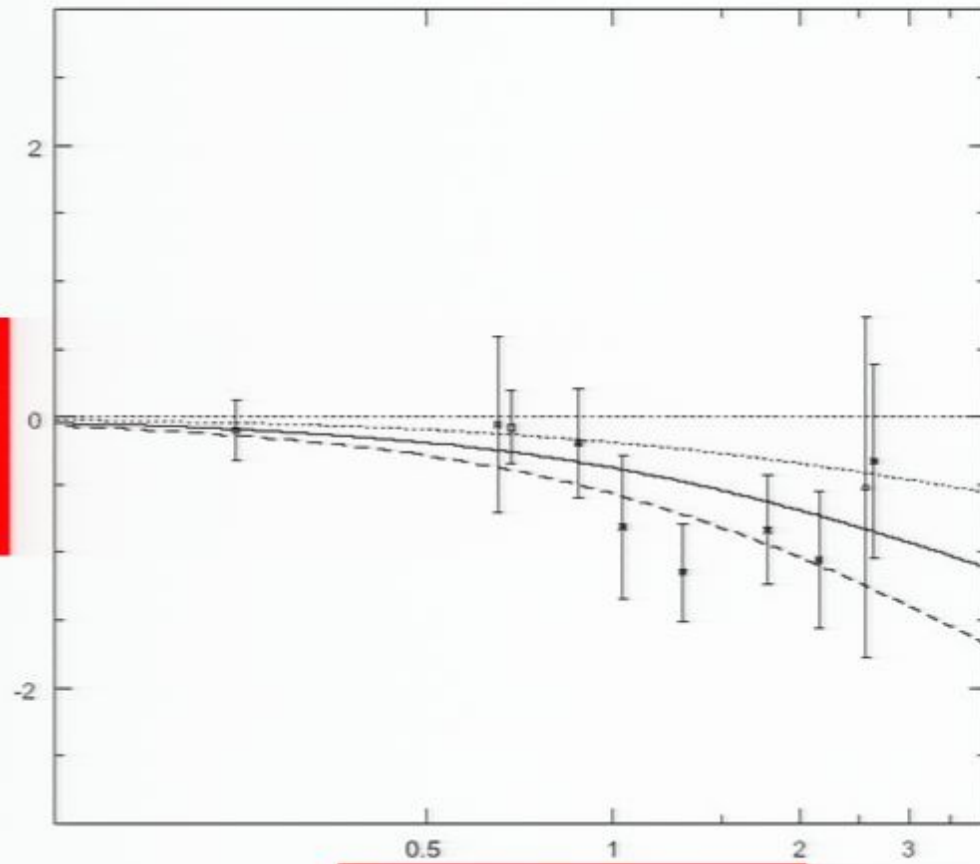
The mystery of alpha – the fine structure constant

$$\alpha = \frac{e^2}{\hbar c} \approx \frac{1}{137}$$

Evidence for a varying alpha

$$\alpha = \frac{e^2}{\hbar c}$$

$$\frac{\Delta\alpha}{\alpha} \times 10^5$$



Look back time

What is causing the varying alpha

- Varying e ?
- Varying c ?
-?

Constants of nature: where do they come from?

- They appear naturally in the formulation of physical laws

Constants of nature: where do they come from?

- They appear naturally in the formulation of physical laws

$$F = G \frac{Mm}{r^2}$$

Constants of nature: where do they come from?

- They appear naturally in the formulation of physical laws
- Their status as constants is historical

$$F = G \frac{Mm}{r^2}$$

Constants of nature: where do they come from?

- They appear naturally in the formulation of physical laws
- Their status as constants is historical

$$F = G \frac{Mm}{r^2}$$

g: gravity's acceleration

Constants of nature: where do they come from?

- They appear naturally in the formulation of physical laws
- Their status as constants is historical
- Related to metrology: the definition of units

$$F = G \frac{Mm}{r^2}$$

g: gravity's acceleration

Constants of nature: where do they come from?

- They appear naturally in the formulation of physical laws
- Their status as constants is historical
- Related to metrology: the definition of units

$$F = G \frac{Mm}{r^2}$$




g: gravity's acceleration



This is not metaphysics

- How much of physics is tautological?
- Are physical units “well” defined?

Three reasons for a varying speed of light

- Cosmology is begging for it 
- Maybe a necessary ingredient of grand unification 
- It may be true! 

Can physical laws change in time due to varying constants?

- It's possible, but you need a varying c and even then need to go to quite extreme measures
- It's viable experimentally, if done carefully

In 1874 Kelvin proposed a
varying speed of light

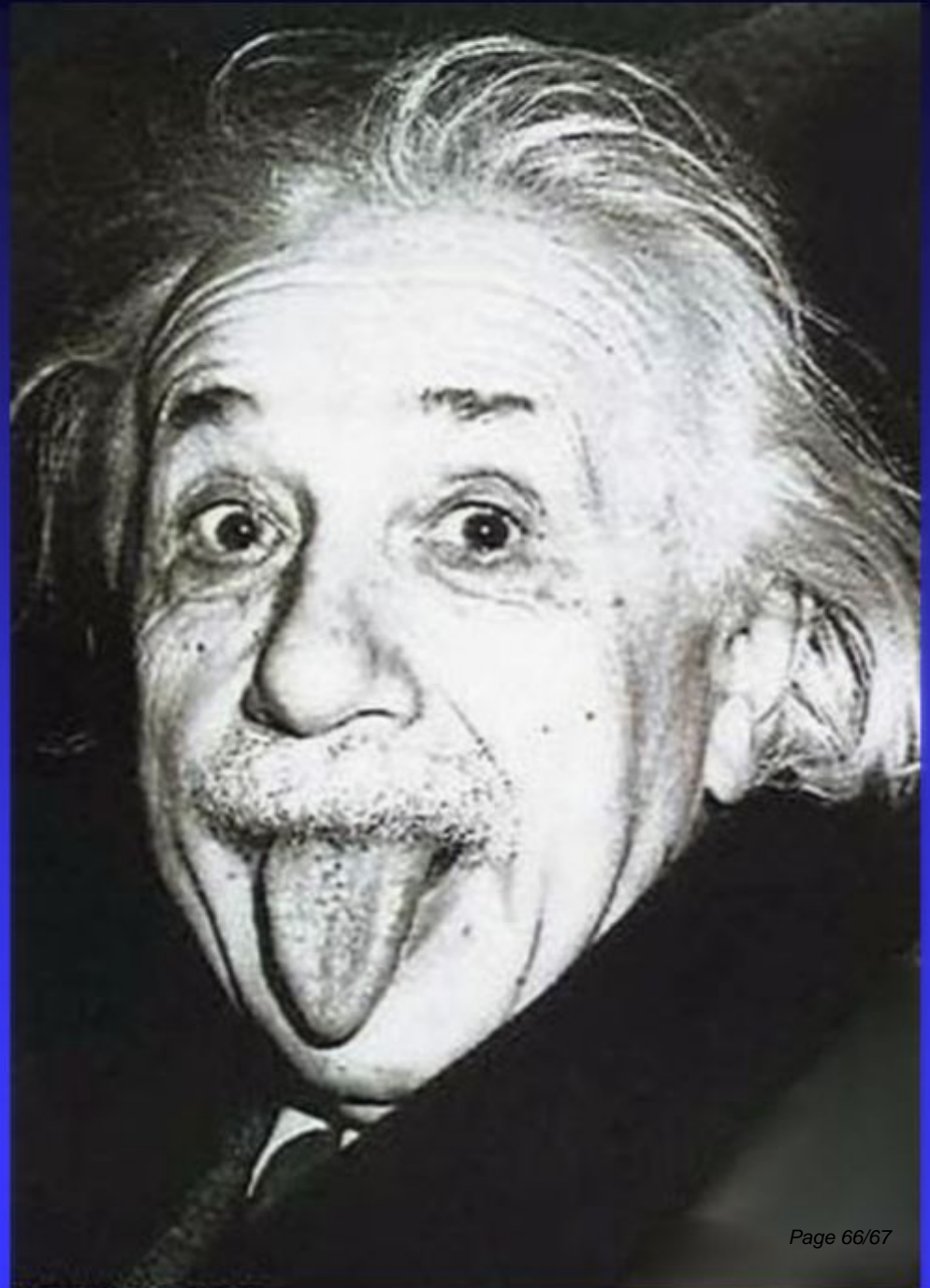
In 1874 Kelvin proposed a
varying speed of light

1905

“A variation in c is self-contradictory”

Eddington, 1930s

Since
mathematicians
invaded
relativity I don't
understand it
myself anymore



What is due to experiment may
always be rectified by experiment

(Hertz)