Queen Mary
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3/1/2013

- MSc maths, financial maths
- PhD research programmes
- Locality for best Indian Food in London

I will talk on the topic of my last book, about:

True Nature of Space and Time

Is Time ...

- A river flowing past?
- Part of a spacetime continuum?
- Determined by increasing entropy?
- Ticking of a cosmic computer's clock?
- A sociological invention ...?

Edited by

Majid

On Space and Time
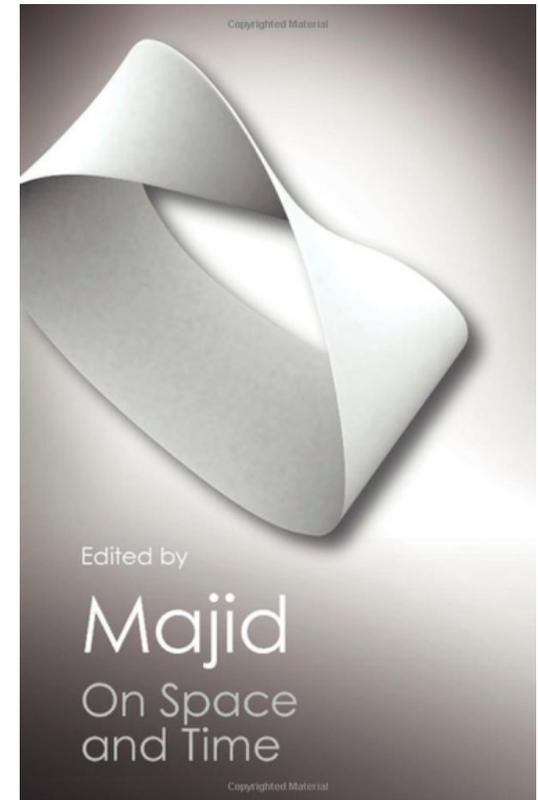
Proposition 1

Time is *not* a smoothly increasing quantity t independent of the observer (Newton was wrong)

Time dilation - time is experienced more slowly
- in a strong gravitational field ...
- for someone moving at speed relative to you ...

Eg infinite time watching someone fall into a black hole, but for the person falling, it happens in a finite time. Needed for SatNav

Einstein 1905, 1917 explained all this: time is part of a 4D spacetime continuum

Proposition 2

There probably *is no* spacetime continuum (Einstein was wrong) and no-one knows what there really is
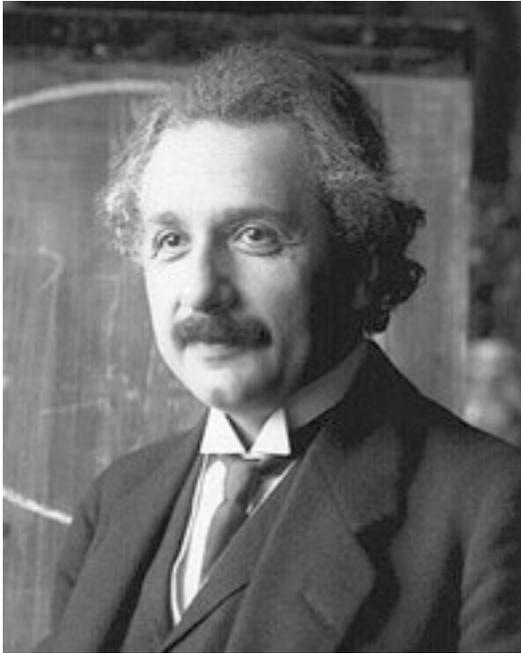
Einstein revolutionized both quantum theory and gravity but spent the later years of his life failing to unify them and never pretended otherwise

Failure to unify quantum theory and gravity even today (and string theory did not do it) has roots in a mistaken continuum assumption that space and time are infinitely divisible. Lets see why its mistaken...

The big picture

$10^{10} = 10,000,000,000$
$10^{-10} = 0.0000000001$

size (cm)

Universe

10^{20}

galaxy
quasar

Why are we
in the middle?

Sun
Earth

Cygnus X-1

10^0

•human

light

•virus

atom
electron
proton

forbidden by
quantum mechanics

forbidden by
gravity

10^{-40}

10^{-60} 10^0 mass (g) 10^{50}
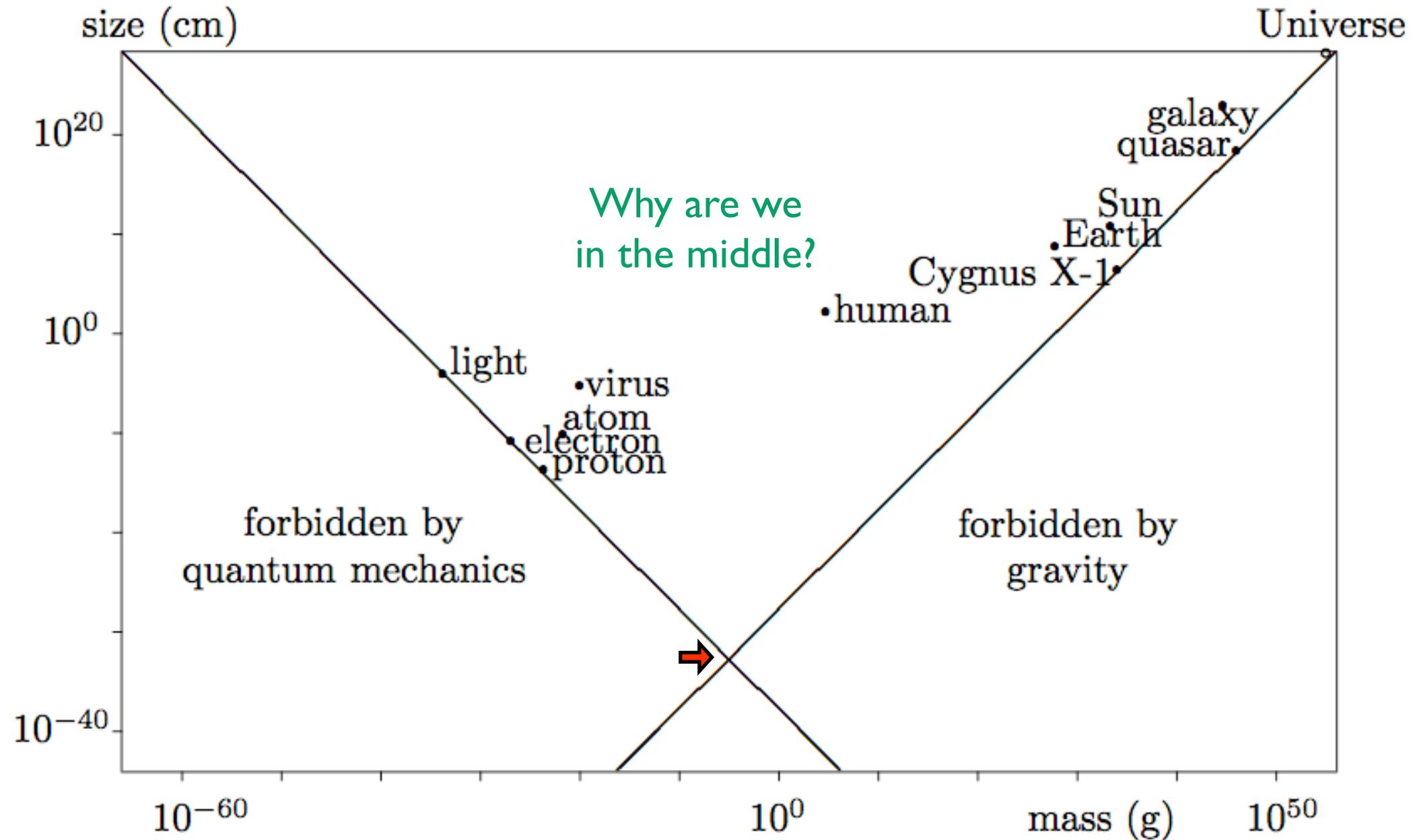
Planck scale = 2×10^{-5}g, 1.6×10^{-33}cm

Quantum theory

Light of wavelength λ has energy $E = \hbar \dfrac{c}{\lambda}$

(discovered by Planck, $\hbar = 6.6 \times 10^{-34}\,\mathrm{Js}$)

Energy and mass are interchangeable by $E = mc^2$

(discovered by Einstein, $c = 3 \times 10^{10}\,\mathrm{cm/s}$ speed of light)
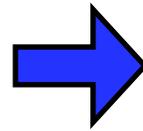
$$\lambda = \frac{\hbar}{mc}$$

This formula works for all kinds of particle - waves

The image on the left is an electron wave scattering off atomic defects in a copper crystal
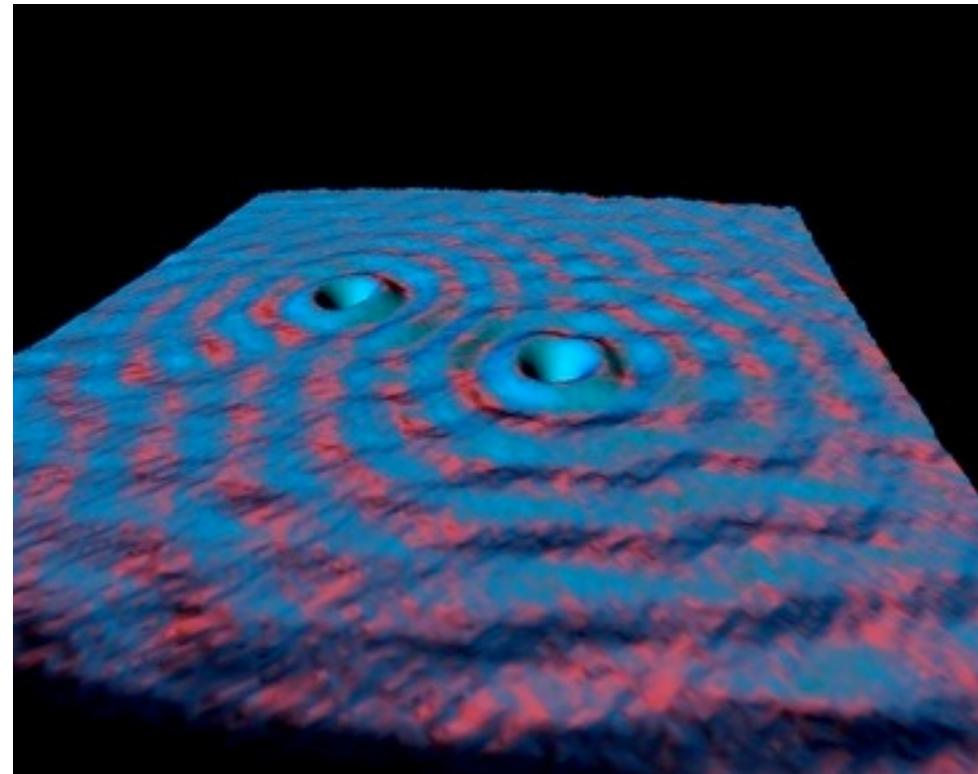
Gravity (curved spacetime)

Surface of constant negative curvature. Ants moving from *P* on what at each point is for them a straight line would be deflected *outwards*
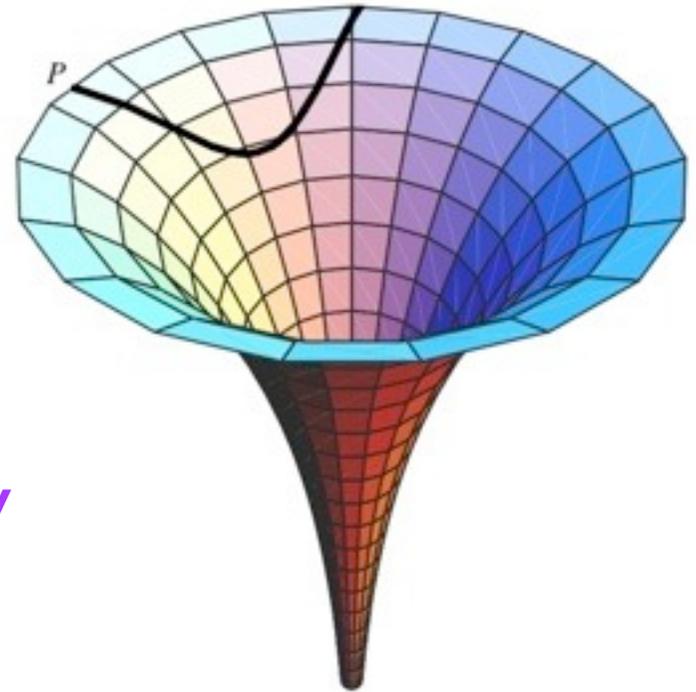
Discovered by Einstein: Curvature of 4-dimensional spacetime *is* gravity

➡ Black hole of mass M has size

$$r = \frac{GM}{c^2}$$

($G = 10^{-8}\mathrm{cm}^3/\mathrm{gs}^2$ Newton's constant)

Artists impression of a black hole. Our own galaxy has giant black hole in its centre

To resolve smaller scales need smaller wavelengths...

Radio
Telescope

Ships
Telescope

Hooke's
microscope

electron
microscope

LHC
"proton microscope"

decreasing wavelength, heavier quantum particles

To probe smaller and smaller distances by quantum wave-particles we need heavier and heavier particles as we move down the left slope of the graph

But ...

... as we approach the Planck scale 10^{-33}cm their mass-energy destroys the geometry we wanted to observe as they form black holes
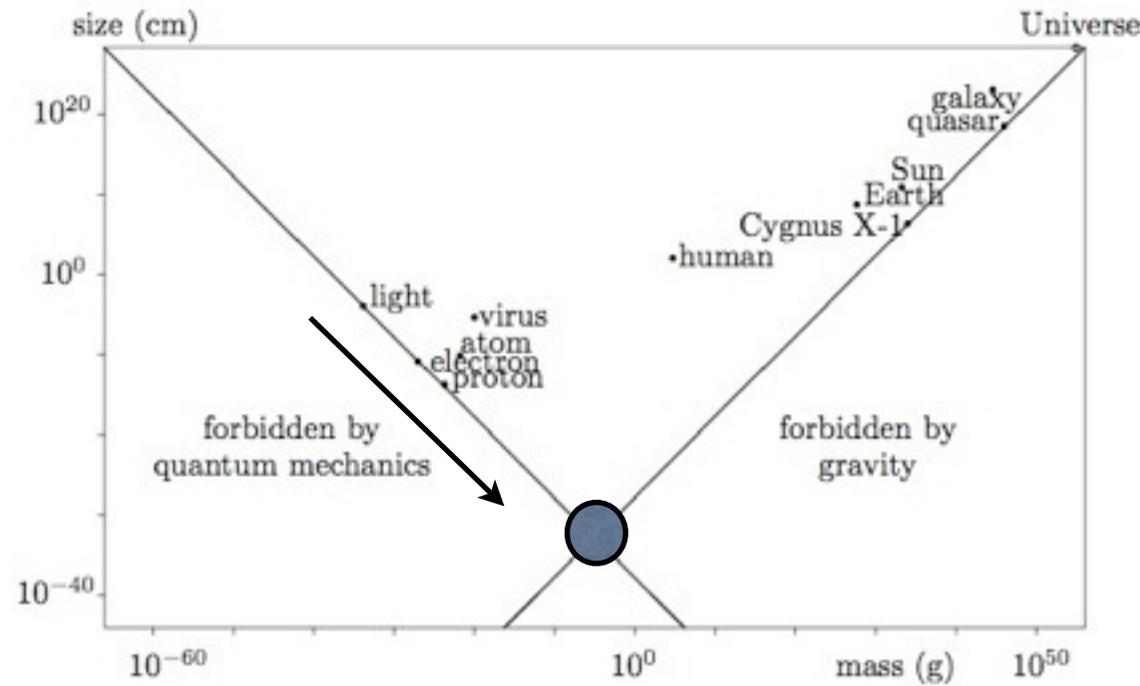
(We also don't know if black holes evaporate, going down right slope)

➡ Conceptual inconsisteny - we assume a continuum but distances less than 10^{-33}cm are INTRINSICALLY UNKNOWABLE

➡ It is an article of FAITH to believe in smaller distances and causes insurmountable infinities

Dark energy
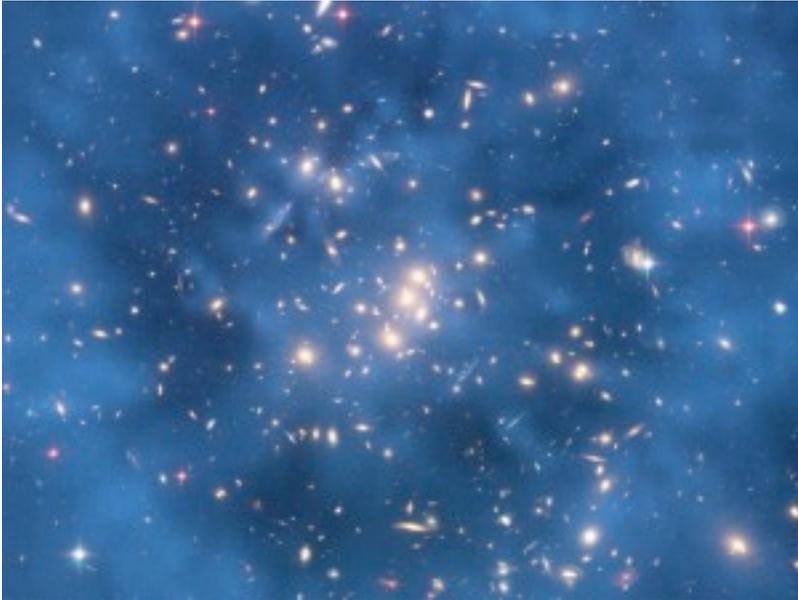
Dark matter and dark energy are *totally unexplained* features of our universe

70% energy in Universe mysterious uniform density $10^{-29} \mathrm{g/cm^3}$

Theoretical vacuum `zero point energy' is:

- 🔴 ∞ if you assume a continuum

- 🔴 $10^{94} \mathrm{g/cm^3}$ if you naively cut off at the Planck length

➡️ Need a reason why its *zero* plus *small* corrections

"zero point module" in *Stargate*
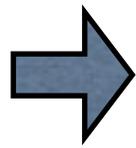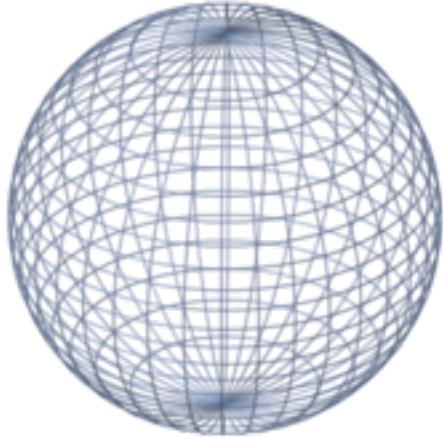
Geometry ➡️ Algebra
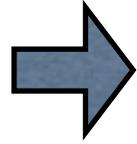
symbols x, y, z

rules like:

$$x(y + z) = xy + xz$$

$$xy = yx$$

$$x(yz) = (xy)z$$

numbers x, y, z

$$x^2 + y^2 + z^2 = 1$$

etc., *and*:
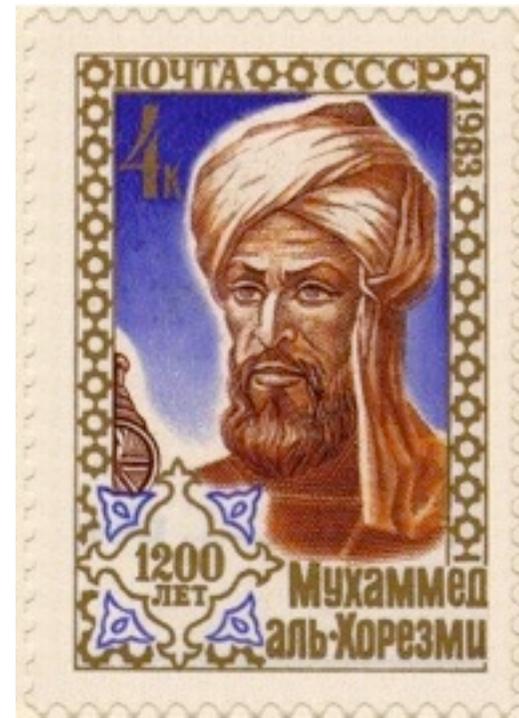
$$x^2 + y^2 + z^2 = 1$$

Muhammad al-Khwarizmi
c. 708- c. 850

**geometric structures
eg curved spacetime** ➡️ **algebraic operations**

$$\mathrm{d}(xy) = (\mathrm{d}x)y + x\mathrm{d}y$$
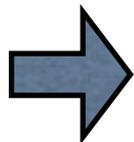
?quantum geometry? ➡️ **other algebras where** $xy \neq yx$

# Quantum spacetime

$$xt - tx = \imath\lambda x \qquad yt - ty = \imath\lambda y \qquad zt - tz = \imath\lambda z$$

$$\lambda = 5 \times 10^{-44} s$$

➡ measuring *where & when* $\neq$ measuring *when & where*

➡ blue light travels a *little* more slowly than red light

LISA gravitational interferometer *could* be retooled to test this!
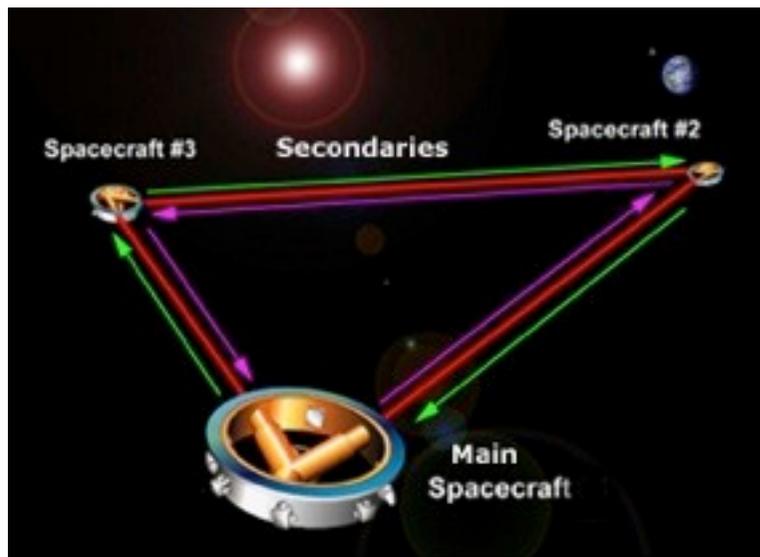
FERMI-GLAST launched May 2008 *is* testing this!

Host galaxy of gamma ray burst 12 billion light years away.
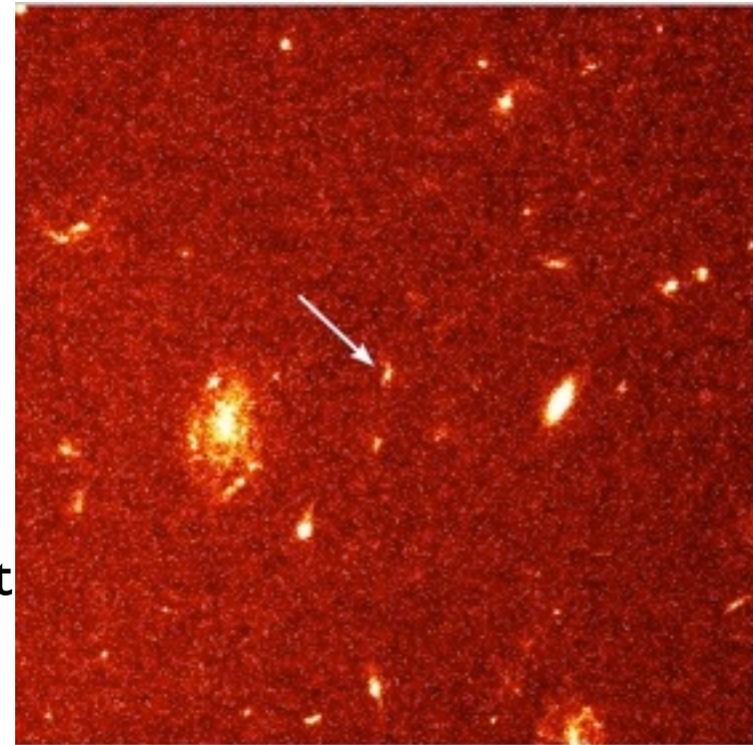
Quantum anomalies and origin of time

"Unstable spacetime vortex that starships fly through..."

It's when a quantum system does not behave analogously to a classical one

● String theory did not work in 4 spacetime dimensions, due to a quantum anomaly ⇒ fixed by unseen higher dimensions

● In quantum spaces, differential calculus typically has an anomaly ⇒ extra dimension `time' induced by the geometry of quantum space itself

Quantum high school calculus

Newton assumed dx was a number. But now ...
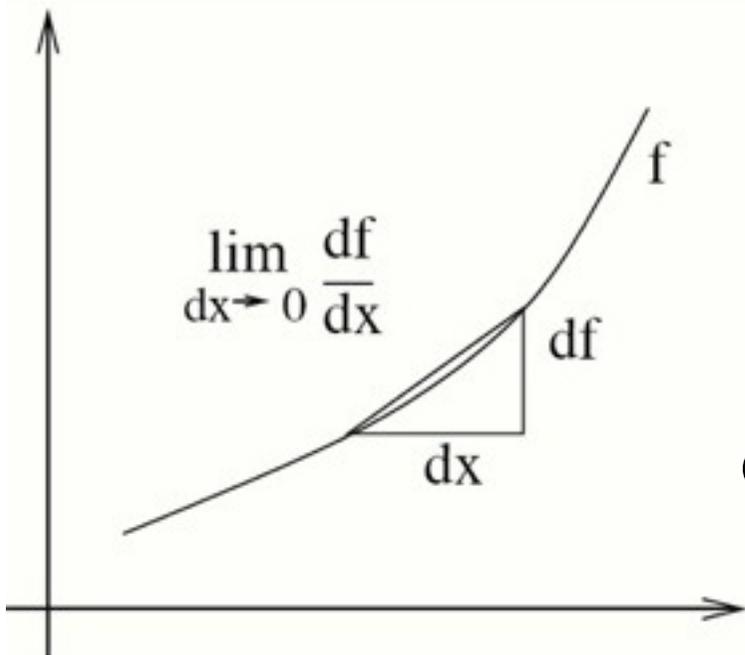
$$(\mathrm{d}x)y \neq y(\mathrm{d}x)$$

$$\lim_{\mathrm{d}x \to 0} \frac{\mathrm{d}f}{\mathrm{d}x}$$
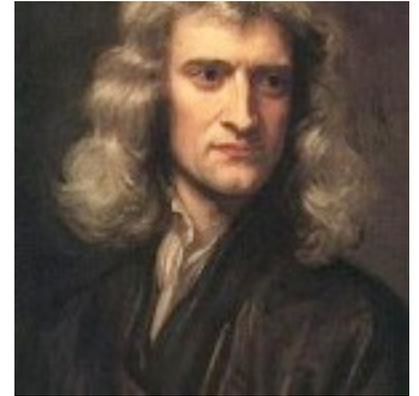
- Quantum geometries generally have a differential D with

$$\boxed{Df - fD = \lambda \mathrm{d}f}$$

- Equation invisible in continuum geometry

- D=dt defines an evolution of the quantum geometry

- As $\lambda \to 0$ we discover, eg, Schroedinger's equation

- The algebra of this D=dt is not unique. Its freedom can be viewed as the origin of gravity

- In qua spacetime model effective Schroedinger's eqn in the presence of a point source of mass M is

$$\imath\hbar\frac{\partial}{\partial t}\Psi = -\frac{\hbar^2}{2m_I}\bar{\Delta}^{flat}\Psi + (V_0 - \frac{GMm_G}{r})\Psi$$
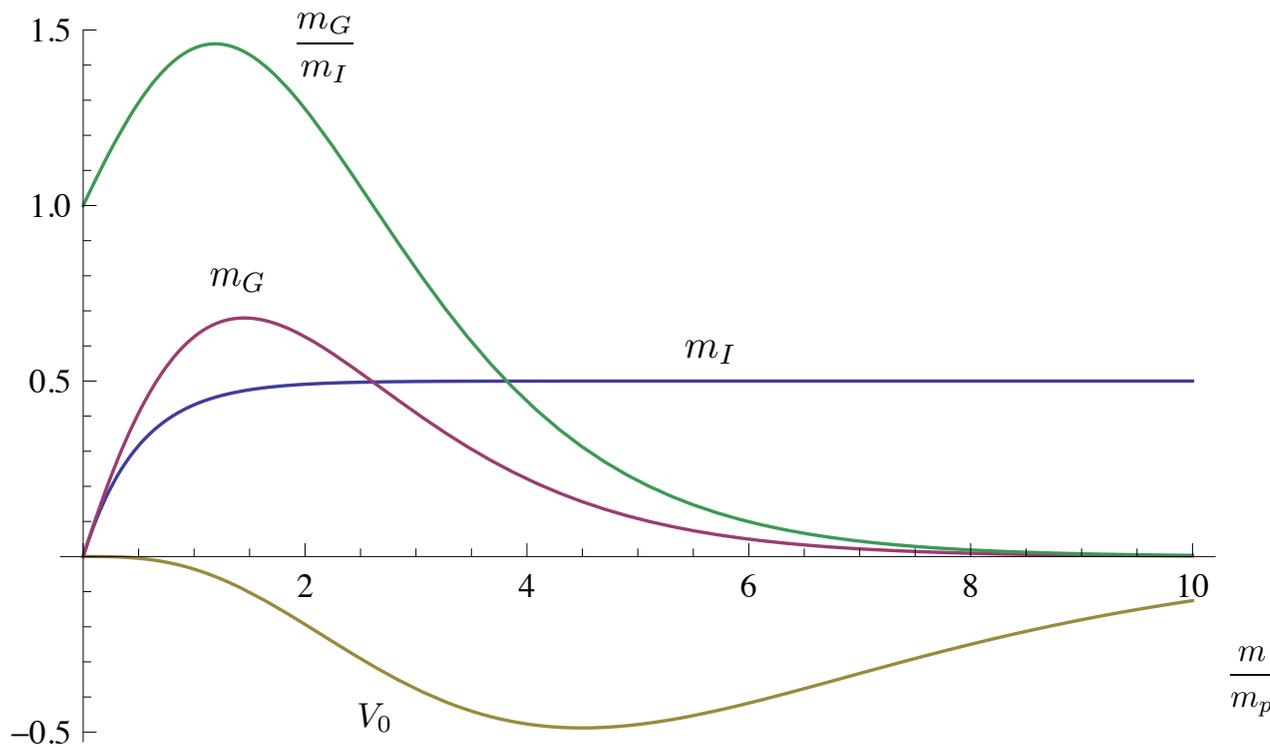
➤ macroscopic massive quantum states in lab may behave differently approaching and above planck mass!

Noncommutative spacetime and LHC

ELEMENTARY PARTICLES

Quarks: u c t | γ
d s b | g
ν_e ν_μ ν_τ | Z
e μ τ | W

Leptons | Force Carriers

I II III
Three Generations of Matter

Another great mystery about our world is why the *zoo* of elementary particles?

Alain Connes
has proposed that
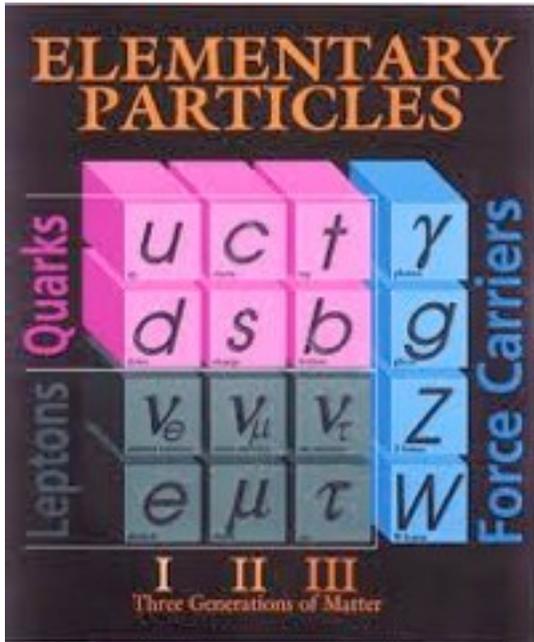
spacetime algebra = (x,y,z,t) X matrix algebra

zero-dimensional noncommutative extension of spacetime could explain this, eg two copies of quaternions:



$$i^2 = j^2 = k^2 = ijk = -1$$

(invented by Hamilton)

Before the big bang

Roger Penrose -
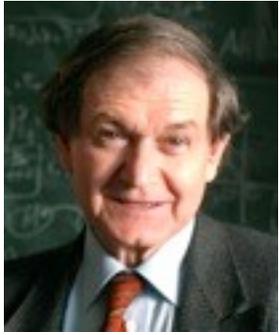
(from Penrose's chapter)

🔴 Photons and gravitational waves experience no time and can carry information to ∞ future and from origin of Universe
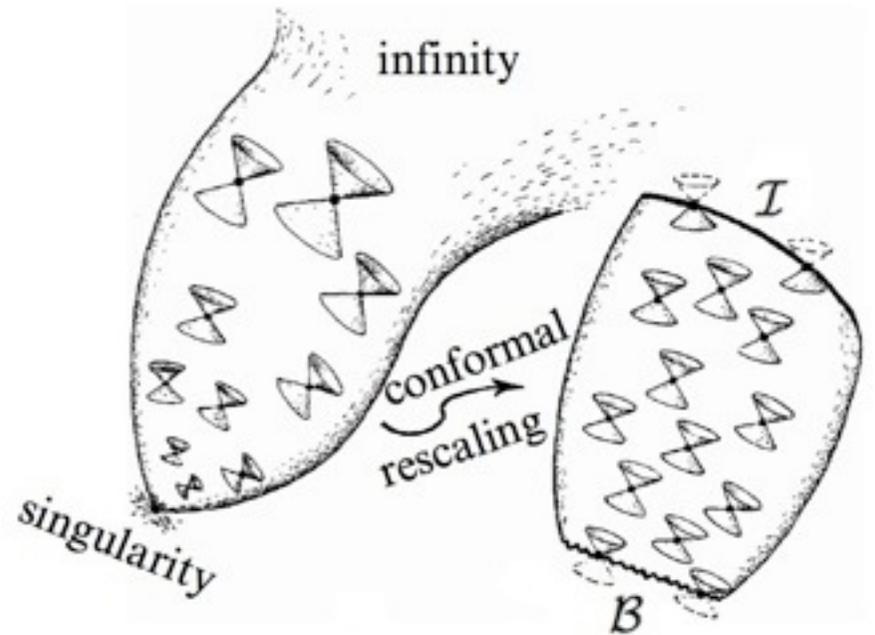
🔴 Such particles are blind to conformal rescalings that `stretch' spacetime but keep angles

🔴 Use such rescalings to identify origin of Universe with ∞ future of *a previous universe*

➡️ Remnants of previous universe may be visible in ours

Proposition 3

*Time's arrow is* a sociological construct same as which side of the road to drive on

Equations of physics invariant under t to -t
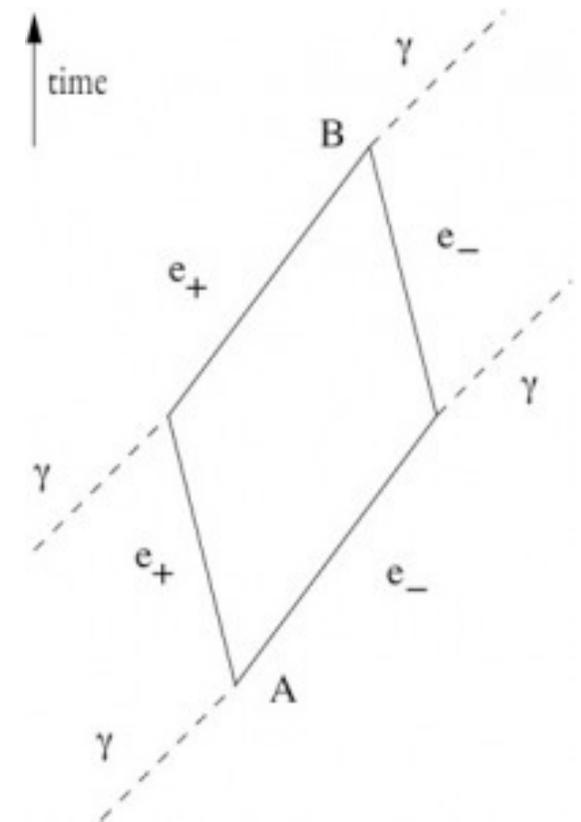
🔴 Entropy is a construct

🔴 Diagram shows electron-positron production at A, annihilation at B but could be read backwards

🔴 Could read e+ as e- travelling back in time from B to A

Quantum symmetry

An algebra takes two things and multiplies them

$$\begin{array}{cc} x & y \end{array}$$
product ·
xy
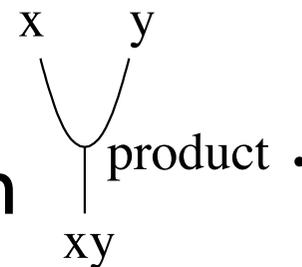
So we should also be able to `unmultiply'
coproduct Δ
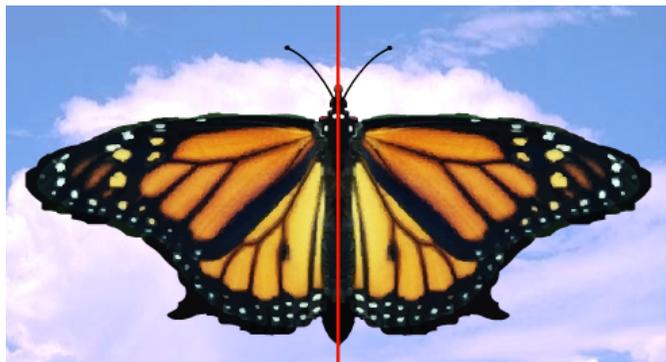
Already implicit in the ancient greek notion of symmetry in `xerox map'

flip(x R y)= flip(x) R flip(y)

→ New concept of quantum symmetry group as a `time reversible' object with both product and coproduct

● Quantum spacetime typically has a `Quantum group of motions' - underpins the x,y,z,t algebra