In Search of Space and Time

AN ALGEBRAIC APPROACH TO LIFE, THE UNIVERSE AND EVERYTHING

@ Shahn Majid

Douglas Adams (1952-2001)

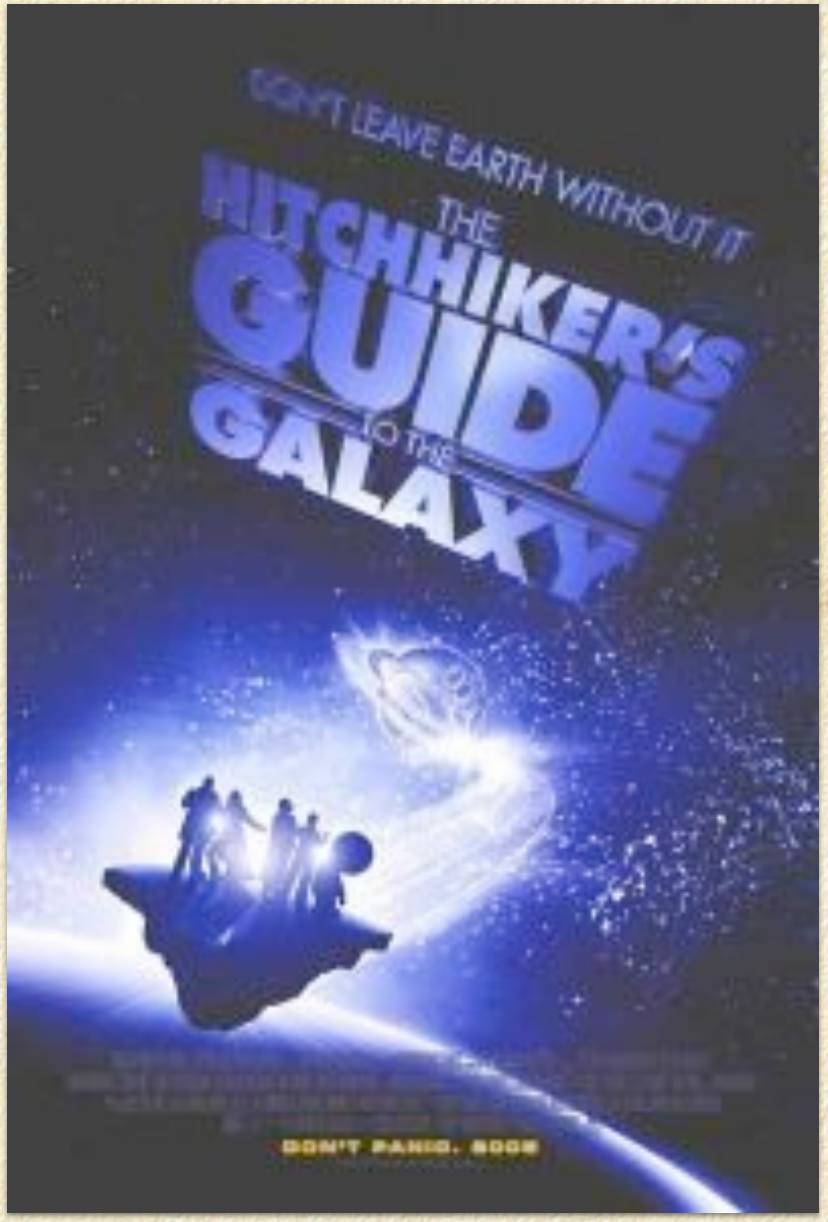
satirist and inventor of:

The infinite improbability drive $p \to 1 - p$

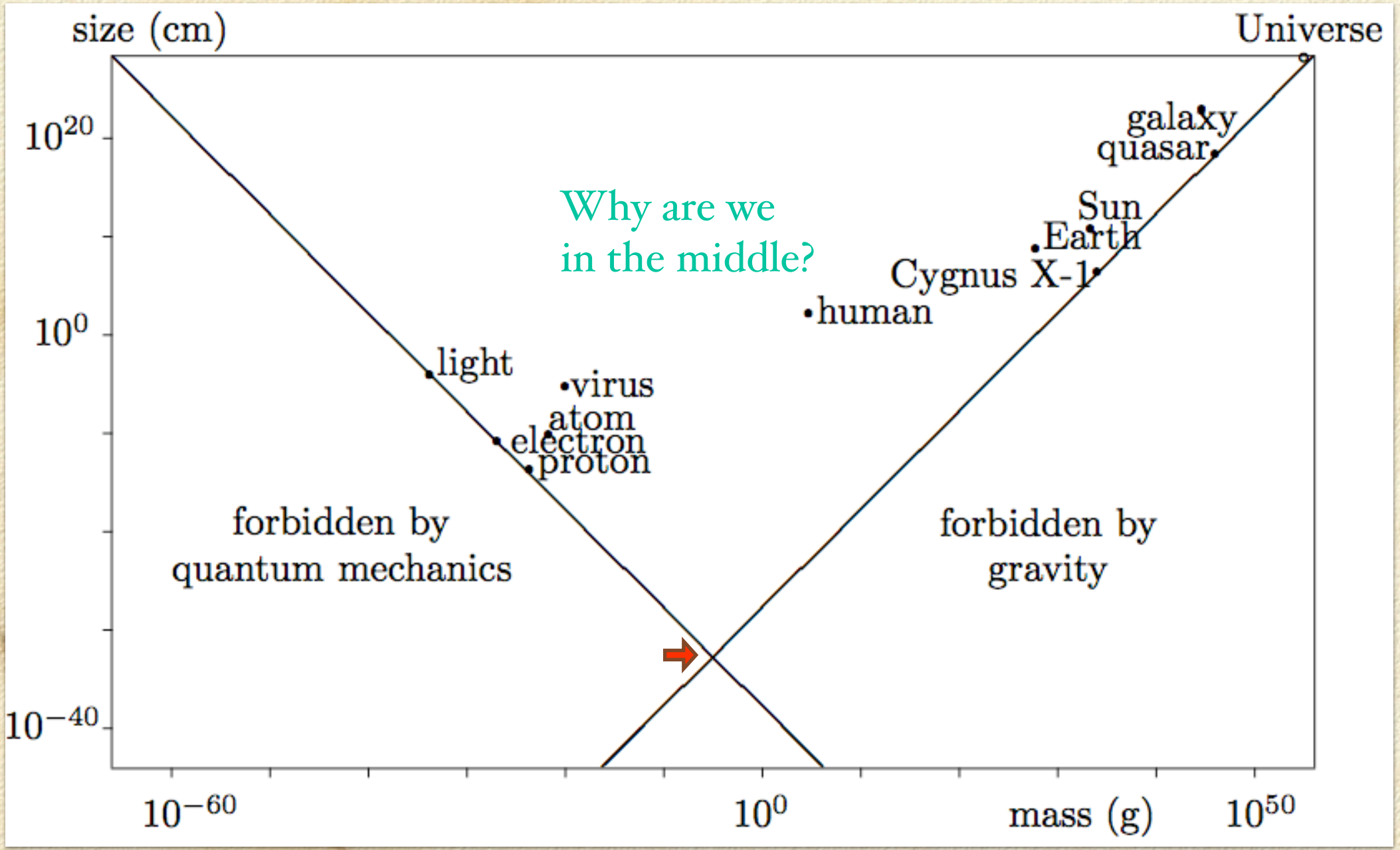
The answer to the ultimate question is 42

The total perspective vortex

And a lot else



Everything in the Universe



Planck scale = 2×10^{-5}g, 1.6×10^{-35}cm

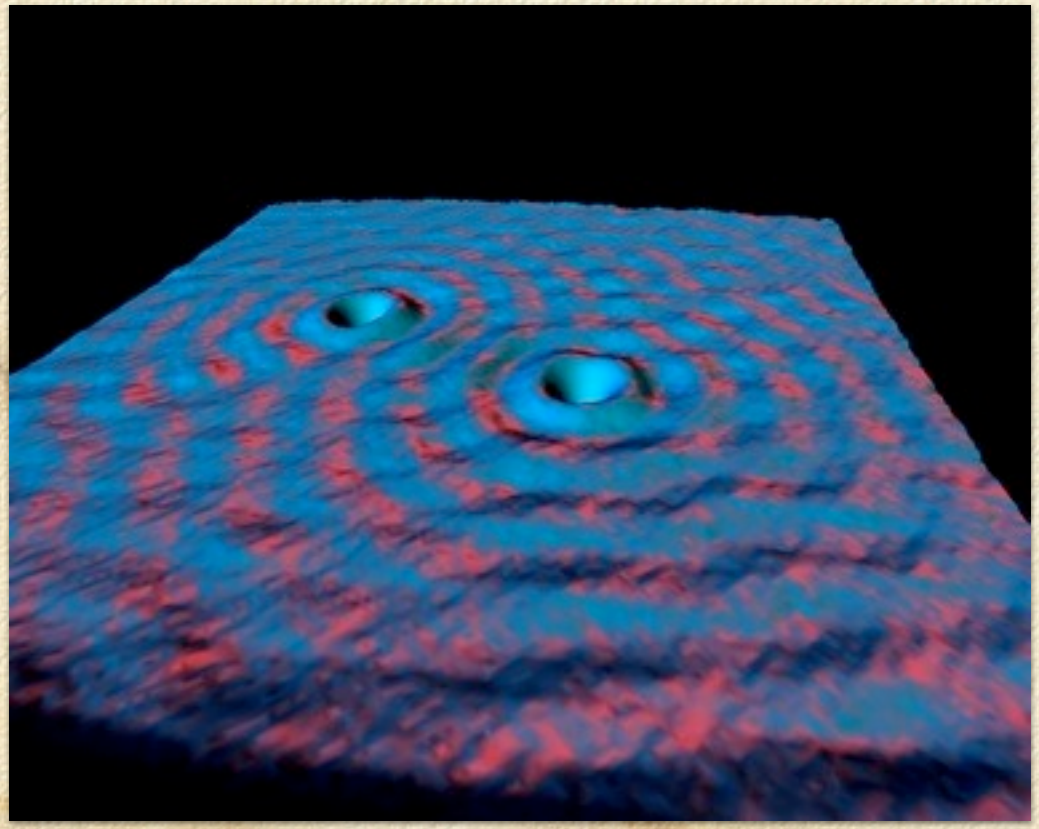
Quantum theory

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

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

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

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



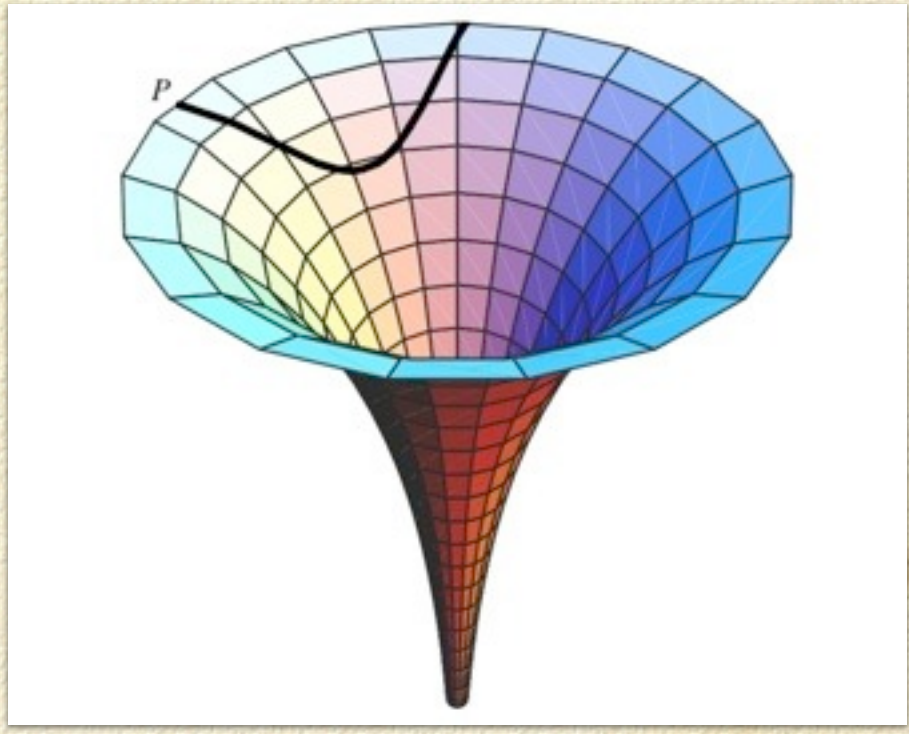
$\Rightarrow \quad \lambda = \frac{\hbar}{mc}$

This formula works for all kinds 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

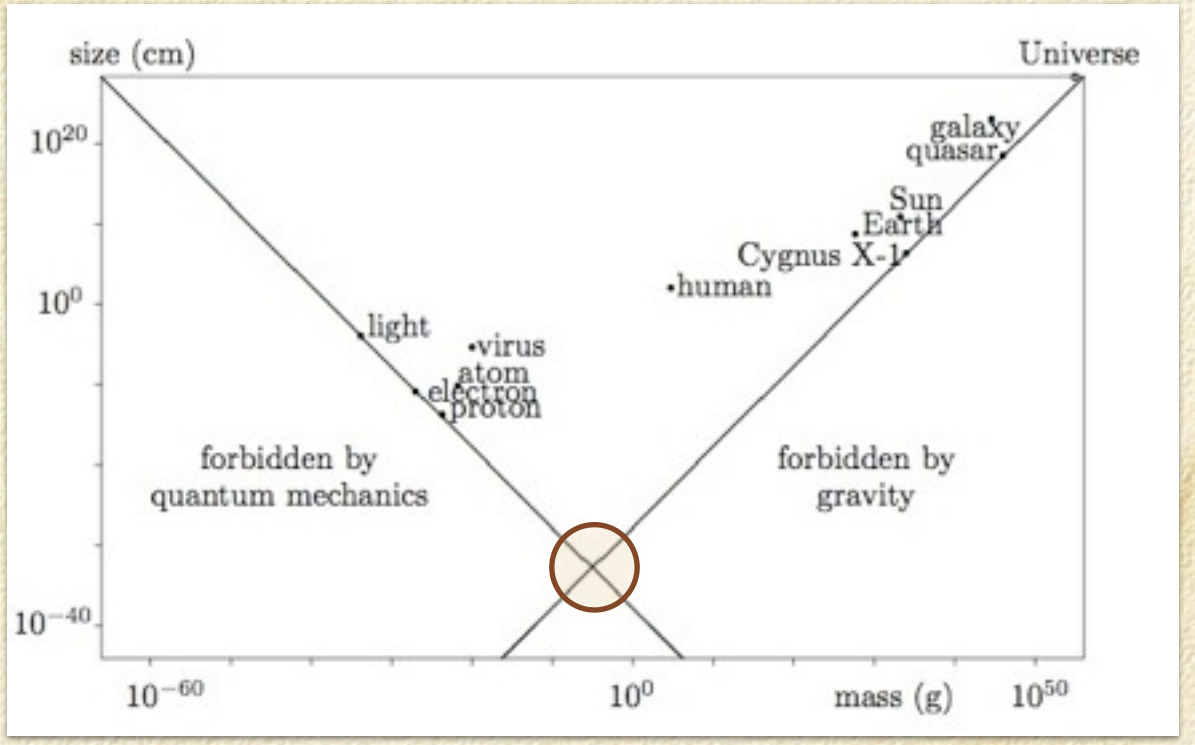
$$r = \frac{GM}{c^2}$$

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

Image on the right is galaxy NCG4696 with a giant black hole in its centre

Hole in the heart of science

To probe smaller and smaller distances by quantum particles we move down the left slope but at 10^{-35}cm they distort the geometry so much they form black holes

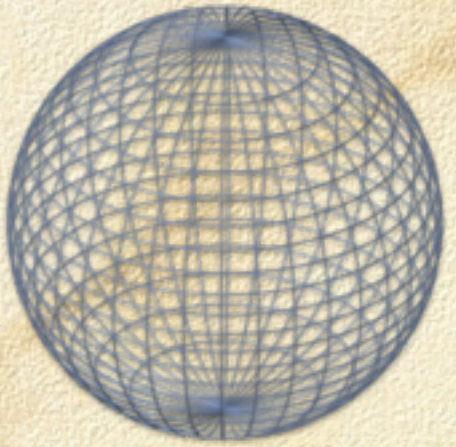


⇨ Conceptual inconsisteny: we assume a continuum but distances less than 10^{-35}cm are intrinsically unknowable

⇨ Continuum assumption causes infinities with result that we have *no theory of quantum gravity*. Two extrapolations from everyday scales failed to be consistent. What to do?

⇨ I think we are in the middle because we built the edifice of physics around ourselves (related to a left-right symmetry)

Geometry



numbers x, y, z

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

Algebra

symbols x, y, z

rules like:

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

$$\boxed{xy = yx}$$

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

etc., *and*:

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

Muhammad al-Khwarizmi

$$A = \mathbb{C}[S^2]$$

$$A \otimes A \dot{\rightarrow} A$$

geometric structures
eg curved spacetime

algebraic operations

$$\mathrm{d}(ab) = (\mathrm{d}a)b + a\mathrm{d}b$$

?quantum geometry?

other algebras where $xy \neq yx$

Quantum spacetime

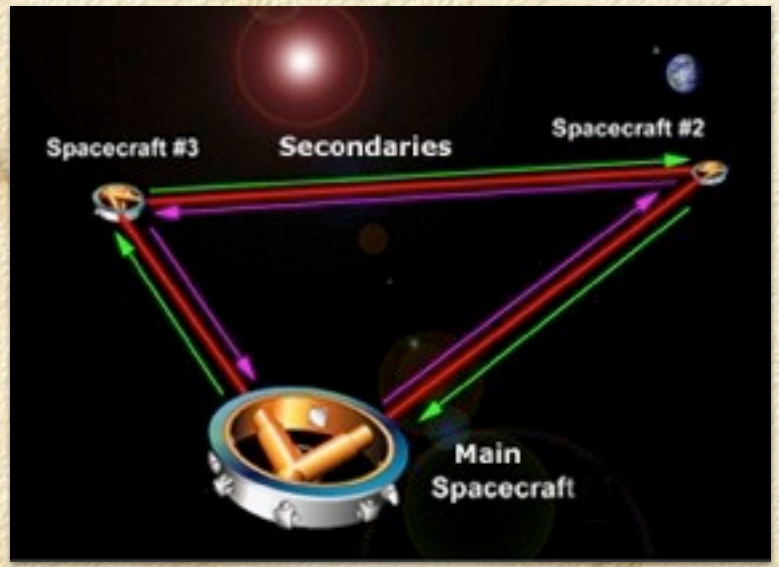
e.g. bicrossproduct model

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

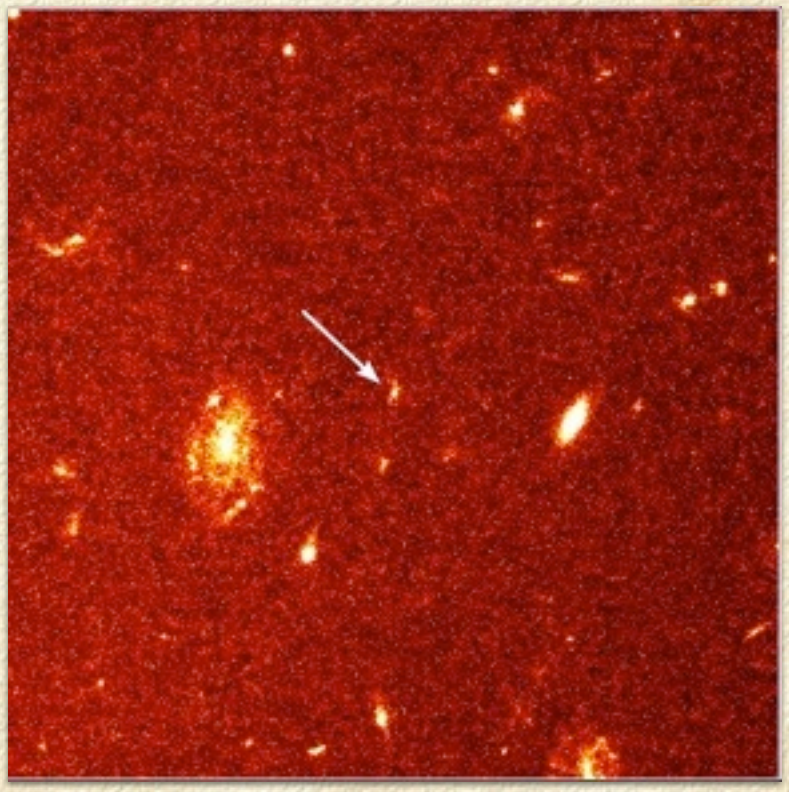
$$xt - tx = \imath\lambda x$$
$$yt - ty = \imath\lambda y$$
$$zt - tz = \imath\lambda z$$

- measuring *where* and *when* $\neq$ measuring *when* and *where*
- blue light travels a *little* more slowly than red light

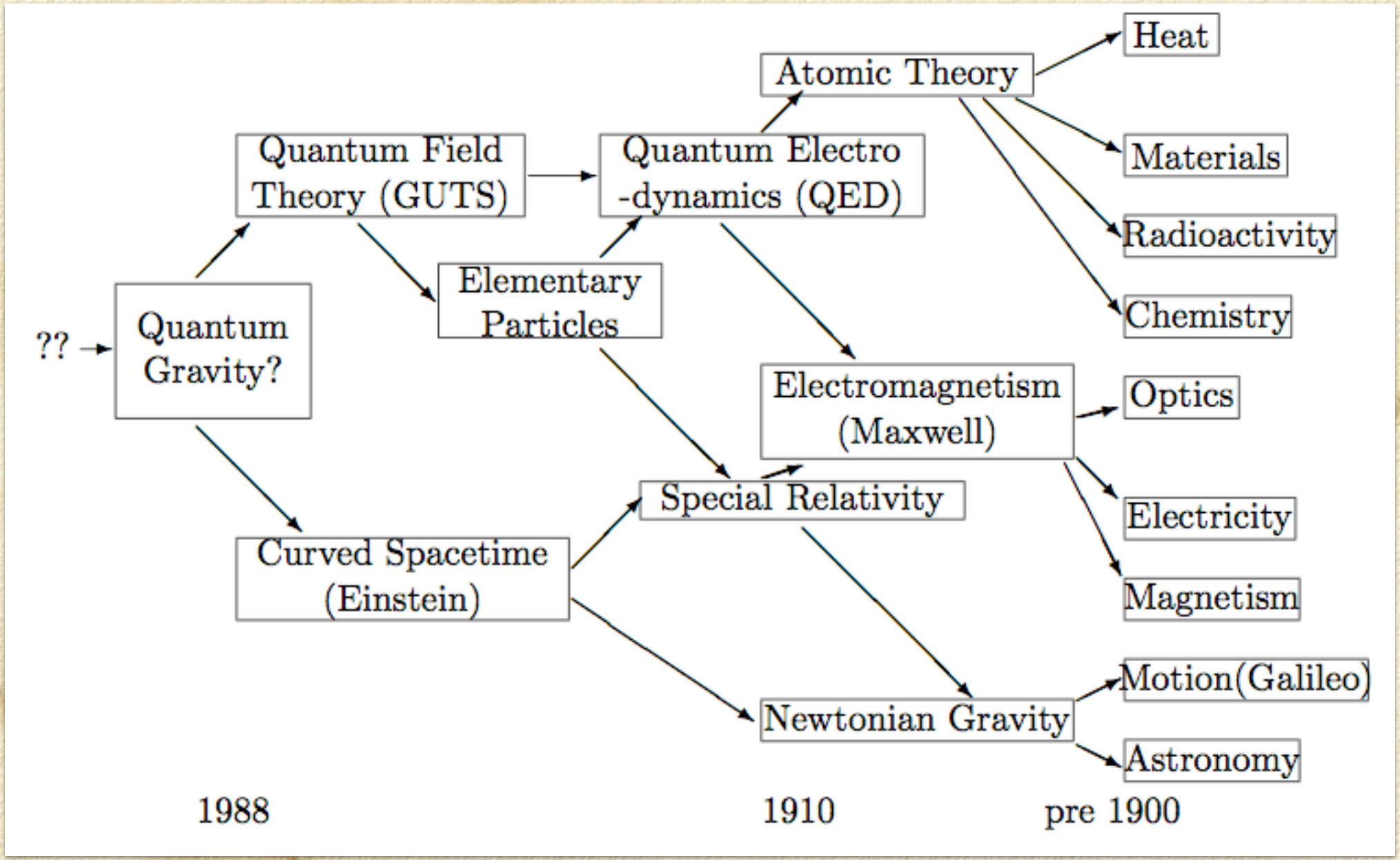
LISA gravitational interferometer *could* be retooled to test this



host galaxy of gamma ray burst 12 billion light years away. GLAST *could* test this

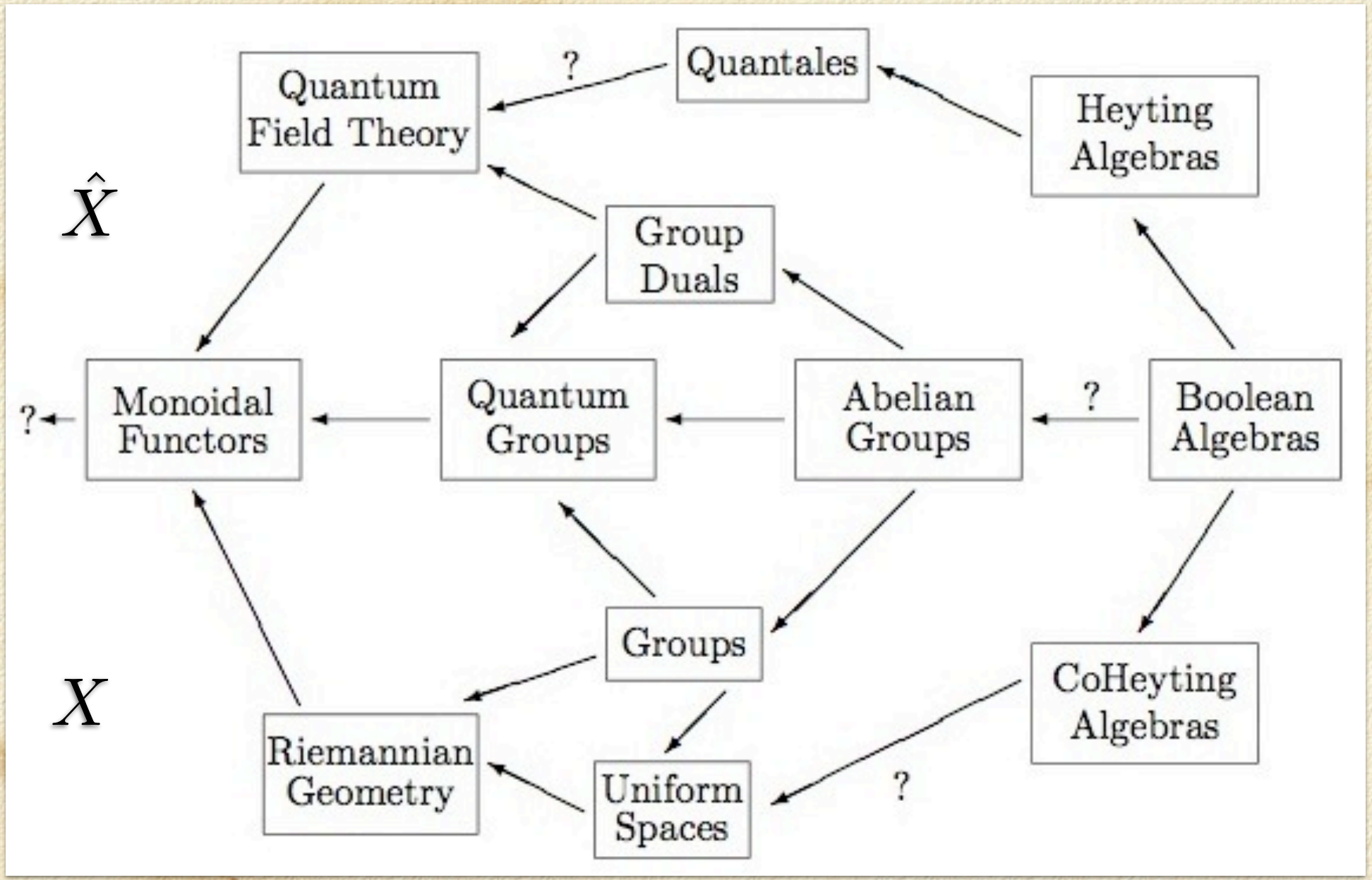


Are we in sight of the end of physics?



If so, what is the essential nature of physical reality?

Compare with mathematics of self-duality



Postulate: the search for the ultimate theory of physics *is* the search for a self-dual structure in a self-dual category

De Morgan duality in logic

$A \leftrightarrow \text{not}\, A \qquad \cap \leftrightarrow \cup \qquad (\text{i.e. and} \leftrightarrow \text{or}) \qquad \text{everything} \leftrightarrow \text{nothing}$

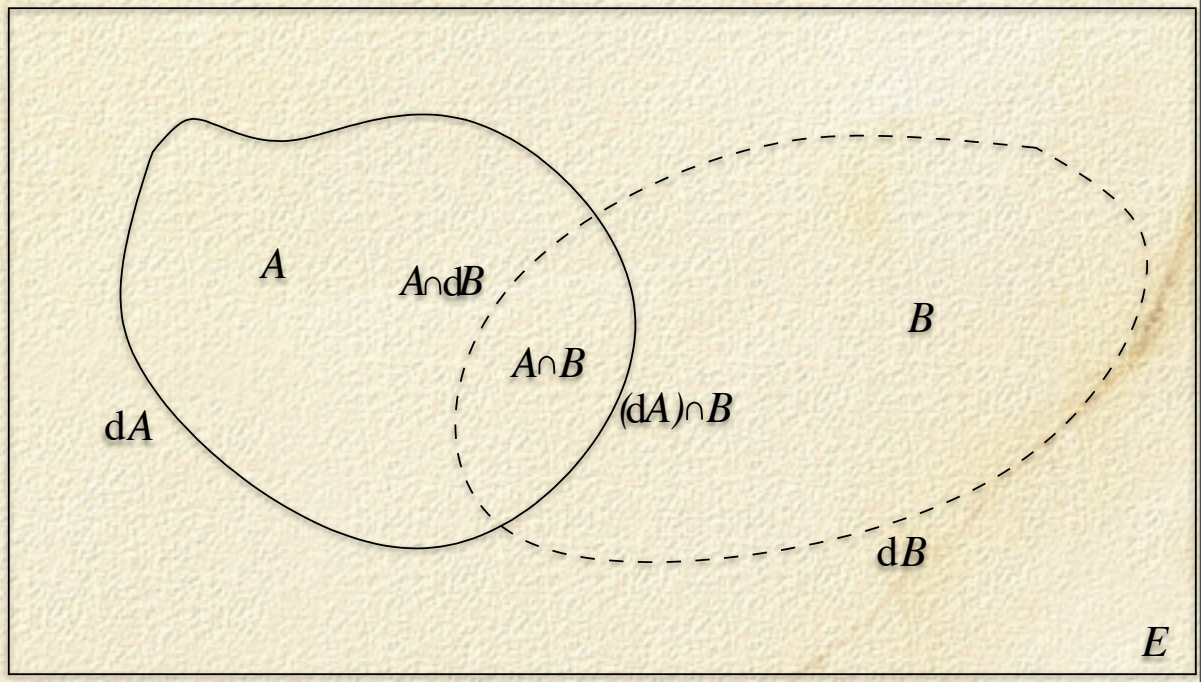
$A \cup \text{not}\, A \neq \text{everything}$ is the birth of quantum theory

$A \cap \text{not}\, A \neq \text{nothing}$

is the birth of geometry?

On the right is a proof that

$$\mathrm{d}(A \cap B) = (A \cap \mathrm{d}B) \cup ((\mathrm{d}A) \cap B)$$



But apples curve space, notapples do not. Should be restored in quantum gravity!

Black hole

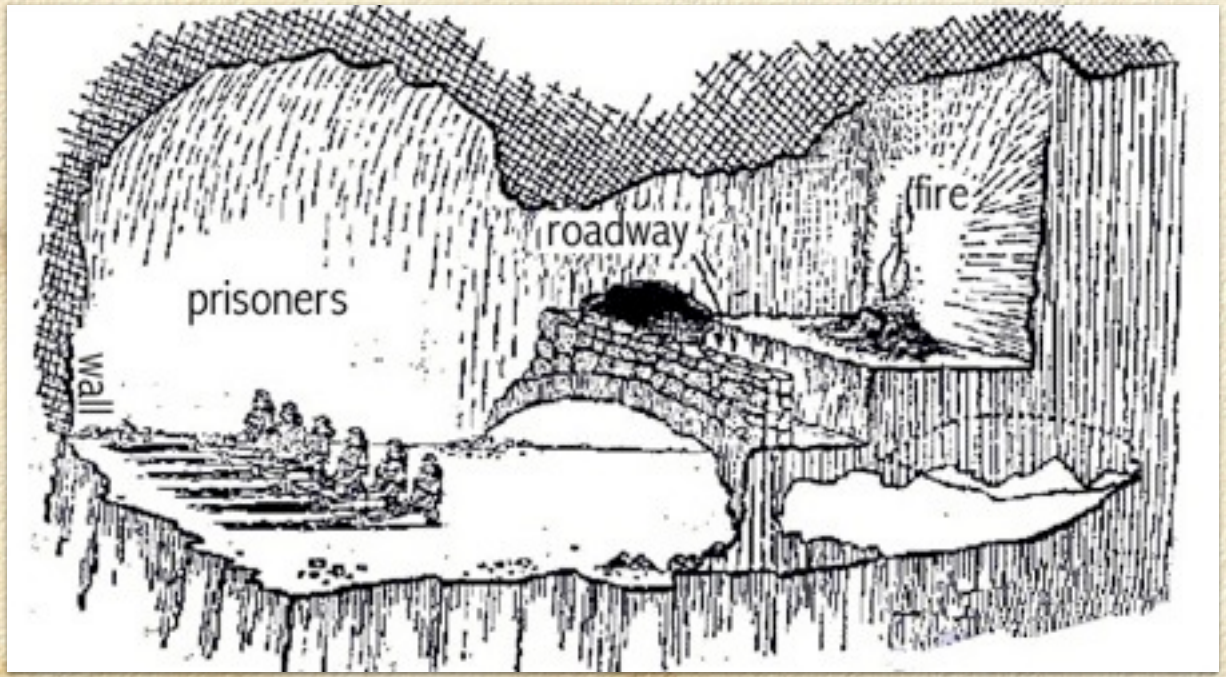
$\leftrightarrow$ vacuum energy $10^{96}\,\mathrm{g/cm}^3$ (dark energy? $10^{-29}\,\mathrm{g/cm}^3$)

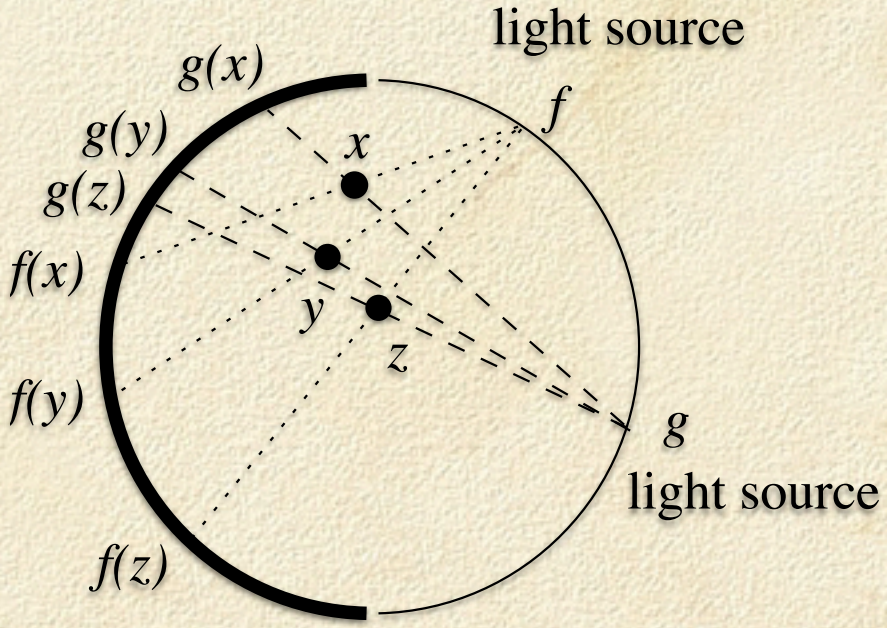
$f(x) = x(f)$ or my answer to Plato's cave

When you measure the value of f at point x in X, you could equally interpret it as measuring the value of x at the point f in $\hat{X}$

$$\hat{\hat{X}} \cong X$$

The set $\hat{X}$ of representations by different light positions f is as real as the arrangement X of objects x on the roadway



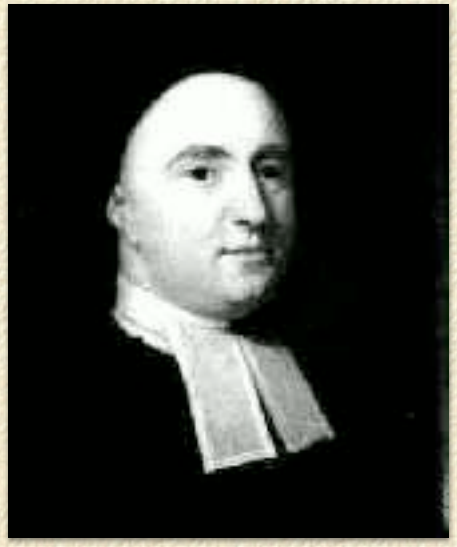


17th century Scientific Revolution

replaced God as source of reality by ideas going back to greek, latin and arabic thinkers: Scientific Method provided rules of engagement between 'Nature' and 'experiment'.

But if X is 'real' then equally is $\hat{X}$ and we should accept both or look for a self-dual object where $\hat{X} \cong X$

Robert Hooke's microscope



Bishop Berkeley (1686-1753)

"If there was no other matter in the Universe then the water in a rotating bucket would stay flat" - cf Mach, Einstein

It seems that the *structure* of physics (to which just add colourful names) is determined by the way of looking at the world called being a physicist. We are rediscovering our own assumptions

Relative Realism

As in pure mathematics or the game of chess, reality is *created by the choice* to work within certain rules

We *create* bits of reality when we make definitions, conventions, axioms and use them. The possible choices at any level are bits of reality created by more general choices.

Corealistic Rocker by Friedrich Kiesler
Is this a chair? It is to the extent that we agree it is a chair

- If this is enough for Physics, maybe this is all there is!
- We can still have the rigidity of science
- Unlike Buddhism the nexus of possible choices is not arbitrary, but we can 'navigate' within it