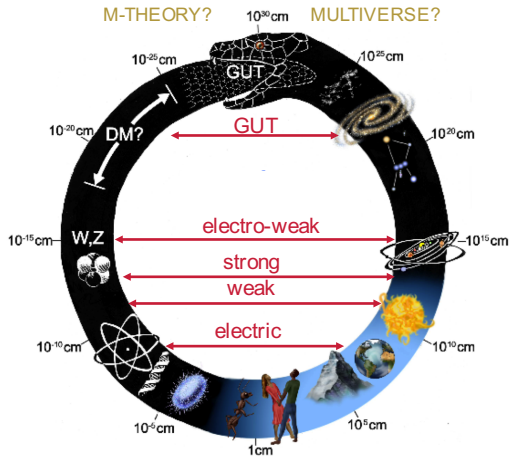
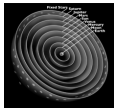


ANTHROPOCENTRIC VIEW

Humans are "central" to the Universe



MECHANISTIC VIEW

Universe exists independent of our awareness of it.
Humans are irrelevant

ANTHROPIC VIEW

Some features of the Universe are "explained" by requirement that observers should arise

EVOLVING COMPLEXITY VIEW

Big Bang should lead to increasing order and complexity, culminating in mind

Nature **278**, 605 - 612 (12 April 1979); doi:10.1038/278605a0

The anthropic principle and the structure of the physical world

B. J. CARR* & M. J. REES

Institute of Astronomy, Madingley Road, Cambridge, UK
*Present address: California Institute of Technology, Pasadena, California 91109.

The basic features of galaxies, stars, planets and the everyday world are essentially determined by a few microphysical constants and by the effects of gravitation. Many interrelations between different scales that at first sight seem surprising are straightforward consequences of simple physical arguments. But several aspects of our Universe—some of which seem to be prerequisites for the evolution of any form of life—depend rather delicately on apparent 'coincidences' among the physical constants.

DIFFERENT TYPES OF TUNING

Physics => natural coincidences between scales of structure
Eg. size of human is geometric mean of Planck and Universe

Mass and length scale of all objects depend on G and e

	Mass/m_p	Size/a_o
Universe	α_G^{-2}	$\alpha\,\alpha_G^{-1}$
Star	$\alpha_G^{-3/2}$	$\alpha_G^{-1/2}$
Humans	$\alpha^{3/4}\,\alpha_G^{-3/4}$	$\alpha^{1/4}\,\alpha_G^{-1/4}$
Proton	1	α^3
Planck	$\alpha_G^{-1/2}$	$\alpha^3\,\alpha_G^{1/2}$

m_p = proton mass

a_o = atom size

$\alpha = e^2/(hc) = 1/137$

$\alpha_G = Gm_p^2/(hc) = 5 \times 10^{-39}$

=> size of human ~ geometric mean of Planck and Universe

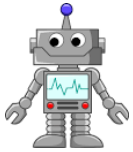
DIFFERENT TYPES OF TUNING

Physics => 'natural' coincidences between scales of structure
Eg. size of human is geometric mean of Planck and Universe

Selection effects for when and where observers exist
=> Weak Anthropic Principle Eg. Dicke coincidence.

WHY IS UNIVERSE AS BIG AS IT IS?

Mechanistic View



Time since big bang is $t_o \sim 10^{10}$ y
$\Rightarrow$ size of observable universe is $ct_0 \sim 10^{10}$ ly

No particular reason for this!

Anthropic View *Bob Dicke*

Life requires heavy elements made in stars
=> no life before lifetime of star $t_S \sim 10^{10}$ y

No stars left for $t >> 10^{10}$y
=> life exists when $t \sim 10^{10}$y => size $\sim 10^{10}$ ly

This explains coincidence $t_o \sim t_S \sim \alpha_G^{-1} t_p \sim 10^{10}$y

DIFFERENT TYPES OF TUNING

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Selection effect for when and where observers exist
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Fine-tunings between coupling constants needed for observers but not predicted by physics => Strong Anthropic Principle

FINE-TUNING OF COUPLING CONSTANTS

Strong force	$\alpha_S \sim 10$
Electric force	$\alpha_e \sim 10^{-2}$
Weak force	$\alpha_W \sim 10^{-10}$
Gravitational force	$\alpha_G \sim 10^{-40}$

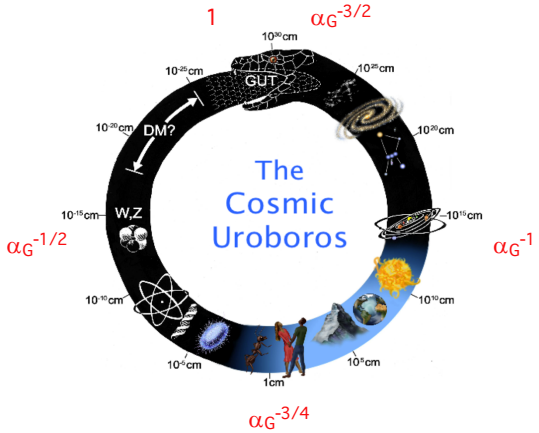
Will the Final Theory of Everything explain these values?

Planets => $\alpha_G \sim \alpha_e^{20}$

Supernovae => $\alpha_G \sim \alpha_W^4$

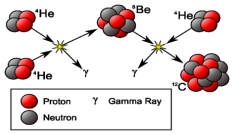
These relationships required for life but

Scales in terms of Planck length



$\alpha_G \sim 10^{-40}$ but this is unexplained by standard physics

TRIPLE-ALPHA COINCIDENCE



(Hoyle 1953)

Life requires carbon made in stars through 3α reaction

Beryllium would decay too soon but for finely-tuned resonance

Strong interaction tuned to 0.1%

This might be viewed as anthropic prediction

CONSTRAINTS FROM CHEMISTRY

α_S increased by 2% => all protons go into diprotons in early U
=> no H-burning stars => no time for life

α_S increased by 10% => all protons into nuclei of unlimited size
=> no interesting chemistry

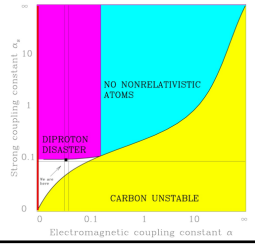
α_S decreased by 5% => deuterons unbound => only hydrogen
=> no interesting chemistry

Other constraints involve masses

$m_e/m_p \sim 10\alpha^2$

$m_n - m_p \sim 2m_e$

These relations are unexplained



DIFFERENT TYPES OF TUNING

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Some cosmological parameters need to be tuned for observers

Just Six Numbers (Martin Rees)

1. *N = electrical force/gravitational force ~10^{38}*
2. *E = strength of nuclear binding = 0.007*
3. *Ω = matter density in universe in critical units = 0.3*
4. *Λ = cosmological constant in critical units = 0.7*
5. *Q = seeds for cosmic structures = 1/100,000*
6. *D = number of spatial dimensions = 3*

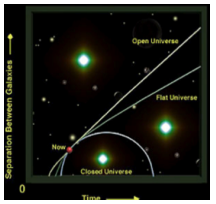
CONSTRAINTS ON MATTER DENSITY PARAMETER

$\Omega = \rho/\rho_{crit}$

$\Omega >> 1$ => Universe collapses before t_S

$\Omega << 1$ => fluct'ns freeze before gal's form

=> $0.1 < \Omega < 10$

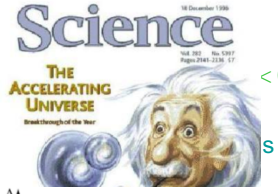


Nowadays inflation predicts $\Omega=1$ to great precision

But inflation itself requires fine-tuning!

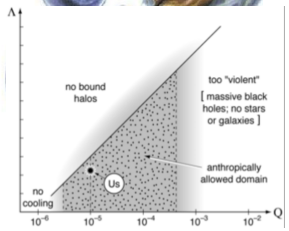
COSMOLOGICAL CONSTANT

120 orders of magnitude larger than expected

Galaxie 

< 0.6 (Weinberg 1987)

This als s of Λ and Q



PRO

ANTI

MIDDLE WAY

I do not feel like an alien in this Universe. The more I examine the Universe and examine the details of its architecture, the more evidence I find that the Universe in some sense must have known we were coming. (Freeman Dyson 1979)

The influence of the anthropic principle on contemporary cosmological models has been sterile. It has explained nothing and it has even had a negative influence. I would opt for rejecting the anthropic principle as needless clutter in the conceptual repertoire of science. (Heinz Pagels 1972)

The anthropic principle is a middle ground between the primitive anthropocentrism of the pre-Copernican age and the equally unjustifiable antithesis that no place or time in the Universe can be privileged in any way. (Brandon Carter 1974)

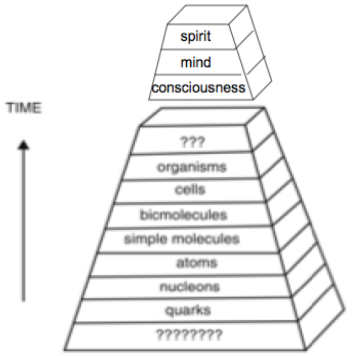
"Anthropos" = Man

Q: What counts as an observer?

- A human? 
- A mouse? 
- A robot? 
- A photon?

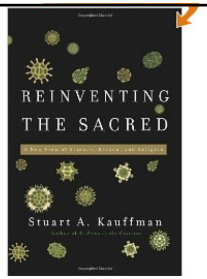
Consciousness? Life? Complexity? Tegmark

PYRAMID OF COMPLEXITY



Development of complexity during big bang requires many fine-tunings

Precise selection criterion may not be crucial because pyramid may inevitably culminate in mind once it starts to arise



Stuart Kauffman
Emergentism gives a creativity in nature which is unpredictable and cannot be reduced to physics. This creativity is sacred but not a personal God.

ASSESSING ANTHROPIC PRINCIPLE

- Just a coincidence (how many? how fine?)

  Stenger "The Fallacy of Fine-Tuning: Why Universe is not Designed for Life", Barnes "The Fine-Tuning of the Universe for Intelligent life"

- Tunings are mainly *post hoc*

  But triple-α and Λ were predictions

- Too anthropocentric (carbon-based?)

  Fine tunings relate to *complexity* rather than life

- Anthropic arguments don't explain *exact* values

  Multiverse accommodates this

- Final theory may predict constants uniqely and hence tunings

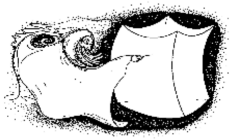
  But it would remain coincidence that these values allows life

- Too philosophical or theological

  Need some explanation, metacosmology evolves to cosmology

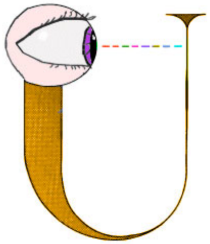
EXPLANATIONS OF FINE-TUNINGS

God created universe?



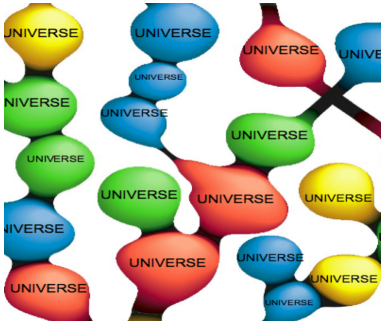
Most physicists don't favour this!

Consciousness creates the Universe?



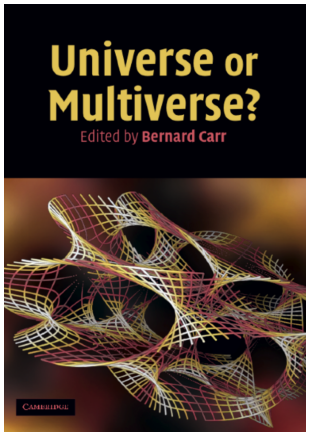
Depends on particular interpretation of quantum theory

Fine-tunings result from selection effect in multiverse?



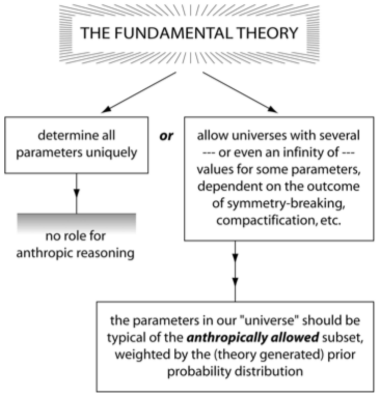
Some physicists like this because it removes need for God.

STRONG AP BECOMES WEAK AP IN A MULTIVERSE

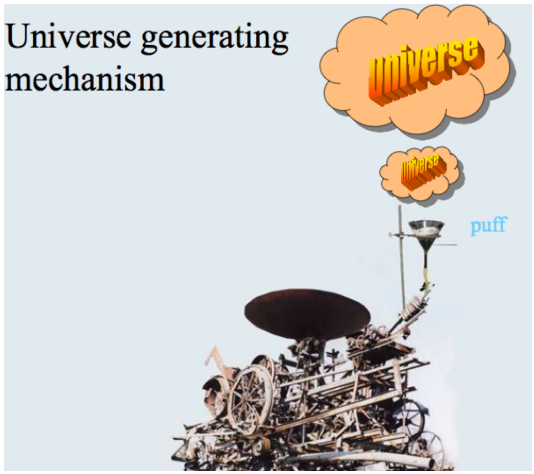


Recent developments in cosmology and particle physics suggest that our universe - rather than being unique - could be just one of many universes. Since the physical constants can be different in other universes, the fine-tunings which appear necessary for the emergence of life may be explained.

Status of anthropic principle depends on final theory of physics



The multiverse naturally explains fine-tunings



Albert Einstein

"What really interests me is whether God had any choice in the creation of the world"

MULTIVERSE SCENARIOS

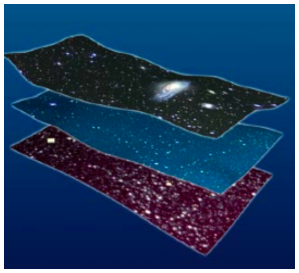
COSMOLOGY — PARTICLE PHYSICS

Cyclic model
Eternal Inflation --- ? --- Quantum many worlds
Colliding branes — String landscape
Quantum cosmology

Eternal inflation

…where art meets science!

Branes

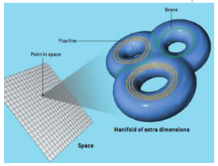


Many worlds in 5th dimension

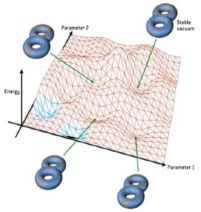
Bousso and Polchinski

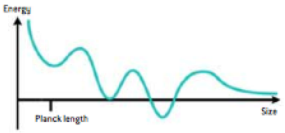
THE STRING THEORY LANDSCAPE

The theory of strings predicts that the universe might occupy one random "valley" out of a virtually infinite selection of valleys in a vast landscape of possibilities

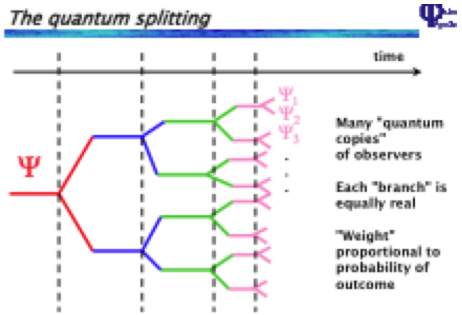


10^{500} vacuum states

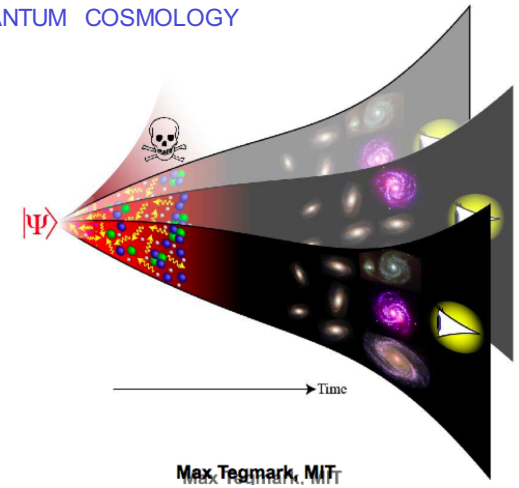




"Many worlds" interpretation of quantum mechanics



QUANTUM COSMOLOGY

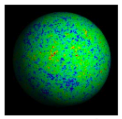


Max Tegmark, MIT

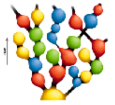
Tegmark

Which are the 4 multiverse levels?

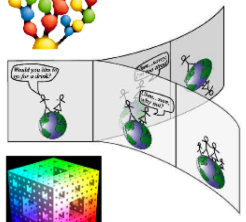
1) Different Hubble volumes



2) Different post-inflationary regions



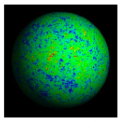
3) Different decohered branches of the quantum wavefunction



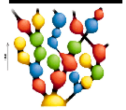
4) Different mathematical structures

Where are the parallel universes?

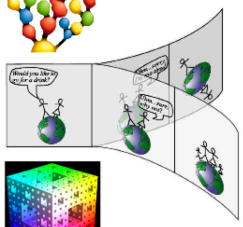
1) Far away in space



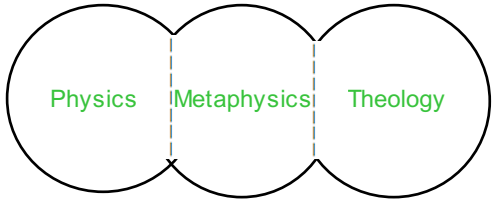
2) Infinitely far away in space

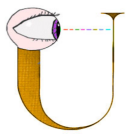


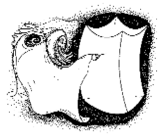
3) Elsewhere in Hilbert space



4) Elsewhere in "math space"

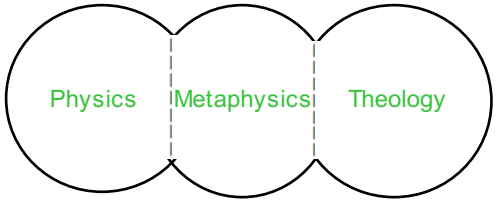


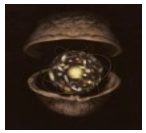


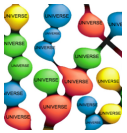


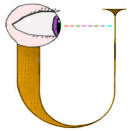
Multiverse Consciousness God

But opinions of boundary differ - boggle threshold!

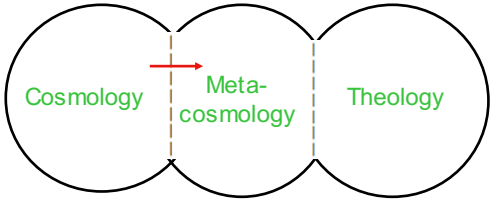








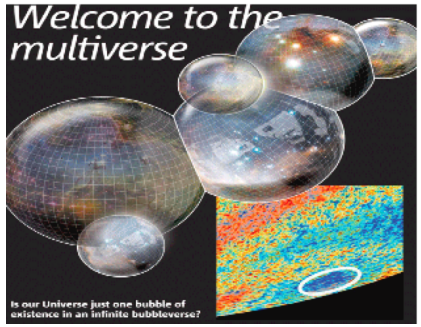
Self-creation



But cosmology/metacosmology boundary is fuzzy and evolves

Efstathiou "Such ideas may sound wacky now, just like the Big Bang theory did three generations ago. But then we got evidence and it changed the whole way we think about the universe"

METRO 24 June 2013



Don't believe everything you read in the press!

CHANGE IN ATTITUDE TO FINE-TUNING

Frank Wilczek

"The previous gathering [2001] had a defensive air. It prominently featured a number of physicists who subsisted on the fringes, voices in the wilderness who had for many years promoted strange arguments about conspiracies among fundamental constants and alternative universes. Their concerns and approaches seemed totally alien to the consensus vanguard of theoretical physics, which was busy successfully constructing a unique and mathematically perfect Universe. Now [2005] the vanguard has marched off to join the prophets in the wilderness."

Taboo words ANTHROPIC CONSCIOUSNESS GOD

Steven Weinberg

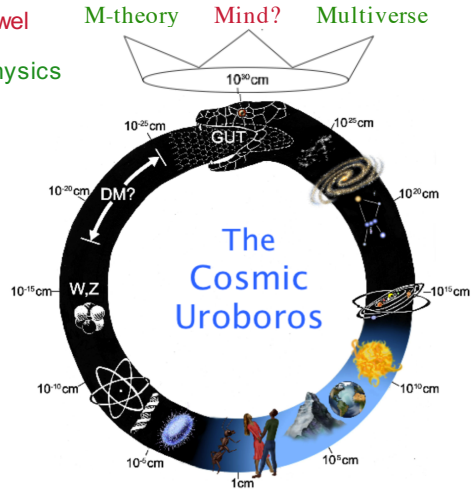
We usually mark advances in the history of science by what we learn about nature, but at certain critical moments the most important thing is what we discover about science itself. These discoveries lead to changes in how we score our work, in what we consider to be an acceptable theory.

I found a report of a discussion at a conference at Stanford, at which Martin Rees said that he was sufficiently confident about the multiverse to bet his dog's life on it, while Andrei Linde said he would bet his own life. As for me, I have just enough confidence about the multiverse to bet the lives of both Andrei Linde *and* Martin Rees's dog.

Missing Jewel

Crown of Physics

M-theory Mind? Multiverse



BRAIN IS CULMINATION OF COMPLEXITY

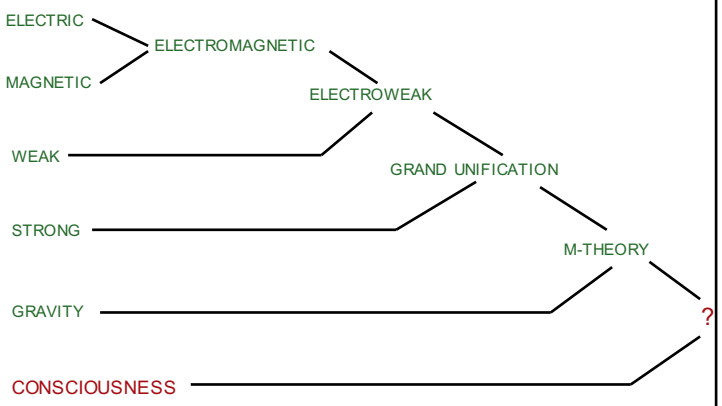
BUT MAINSTREAM SCIENCE SUGGESTS

- Consciousness is just an excretion of neurons
- Mind plays a purely passive role in the universe
- Religion, spirituality and mystical insights are illusions

Stephen Hawking finds Theory of Everything.... enjoyable!

THEORY OF EVERYTHING

Unification of forces
but half world missing!



ARGUMENTS FOR SIGNIFICANCE OF MIND

- Comprehensibility of Universe

  "The Universe is more like a great thought than a great machine" (Jeans)

  "The structure of the material Universe has something in common with the laws that govern the workings of the human mind" (de Broglie)

- Beauty of Universe

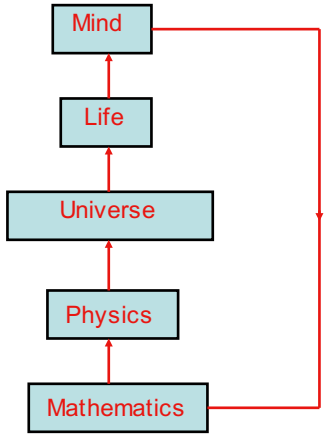
  "Beauty in equations is more important than fitting experiments" (Dirac)

  "One day a door will surely open and expose the glittering central mechanism of the world in all its beauty and simplicity." (Wheeler)

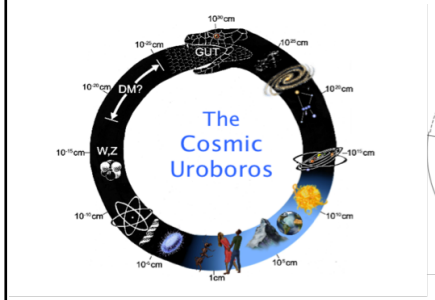
- Physics progressively demolishes our common-sense notions of reality

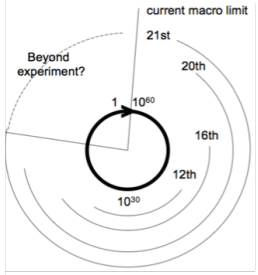
ATOMIC THEORY	=>	OBJECTS NOT SOLID
SPECIAL RELATIVITY	=>	SPACE AND TIME MODIFIED
GENERAL RELATIVITY	=>	SPACETIME CURVED
QUANTUM THEORY	=>	REALITY IS FUZZY
KALUZA-KLEIN	=>	HIGHER DIMENSIONS
QUANTUM GRAVITY	=>	BEYOND SPACE AND TIME

- Physical paradigms area sequence of mental models
- Ultimate reality can only be appreciated intellectually



UROBORUS AS BLOSSOMING OF CONSCIOUSNESS

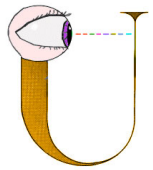




Expansion of micro and macro frontiers with time (century)

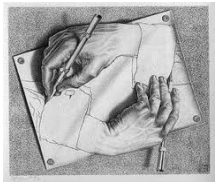
QUANTUM THEORY AND MIND

Eugene Wigner
Consciousness collapses wave function



Henry Stapp
Observer selects quantum possibility

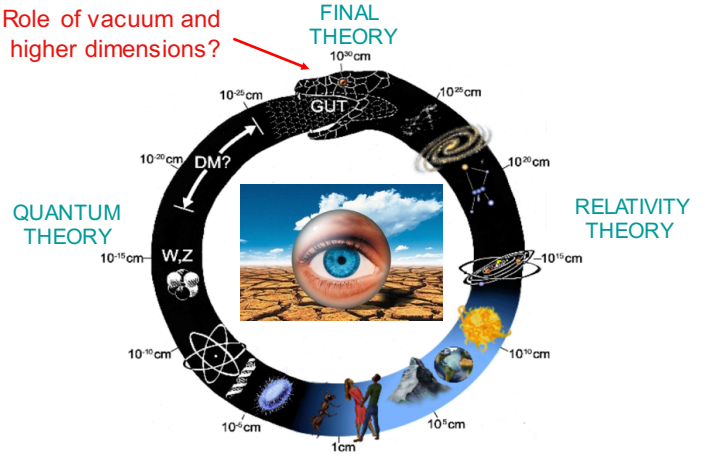
David Bohm
Implicate order underlies explicit order of physical world



Roger Penrose & Stuart Hameroff
Orchestrated Objective Reductionism via microtubules in brain

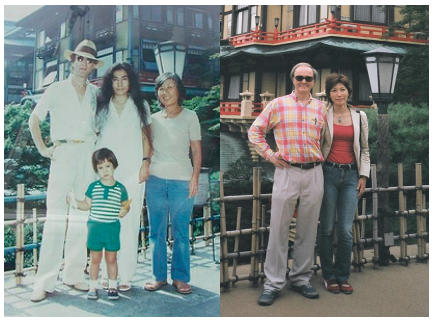
Mind is fundamental not incidental to universe!

• quantum theory • anthropic principle • psi



Will marriage of quantum and relativity theory accommodate mind?

FUJIYA HOTEL, MIYANOSHITA, HAKONE



1977 2011

DRAKE EQUATION

$$N = R^* \times f_p \times n_e \times f_\ell \times f_i \times f_c \times L$$

where

N = the number of civilizations in our galaxy with which communication might be possit
R^* = the average rate of star formation per year in our galaxy
f_p = the fraction of those stars that have planets
n_e = the average number of planets that can potentially support life per star that has pl
f_ℓ = the fraction of the above that actually go on to develop life at some point
fi = the fraction of the above that actually go on to develop intelligent life
f_c = the fraction of civilizations that develop a technology that signals their existence
L = the length of time such civilizations release detectable signals into space

Pessimistic: R^* = 10/y, f_p = 0.5, n_e = 0.01, f_l = 0.13, f_i = 0.001, f_c = 0.01, L = 1000 y
N = 10 x 0.5 x 0.01 x 0.13 x 0.001 x 0.01 x 1000 = 0.000065 (we are alone).

Optimistic: R^* = 20/y, f_p = 0.5, n_e = 2, f_l = 1, f_i = 0.1, f_c = 0.1, L = 100,000 y
N = 20 x 0.5 x 2 x 1 x 0.1 x 0.1 x 100,000 = 20,000 (closest one is1500 ly away).

Current: R^* = 7/y, f_p = 0.5, n_e = 2, f_l = 0.33, f_i = 0.01, f_c = 0.01, L = 10,000 y
N = 7 x 0.5 x 2 x 0.33 x 0.01 x 0.01 x 10,000 = 2.1