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New Frontiers in Science and Faith

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Determinism and Free Will

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- Peter Clarke
- English, now in Switzerland
- Faith in Christ as teenager
- Engineering
- Looked for subject with more philosophical and theological implications
- Doctorate in experimental psychology/neuroscience with Donald MacKay (Univ. of Keele)
- Neuronal death
- Protection against stroke

The fact that the laws of nature are (almost) deterministic raises many questions:

- Was the whole future of the universe determined at the moment of the Big Bang?

- Miracles

- Answers to prayer

- Free will

Different kinds of determinism 1

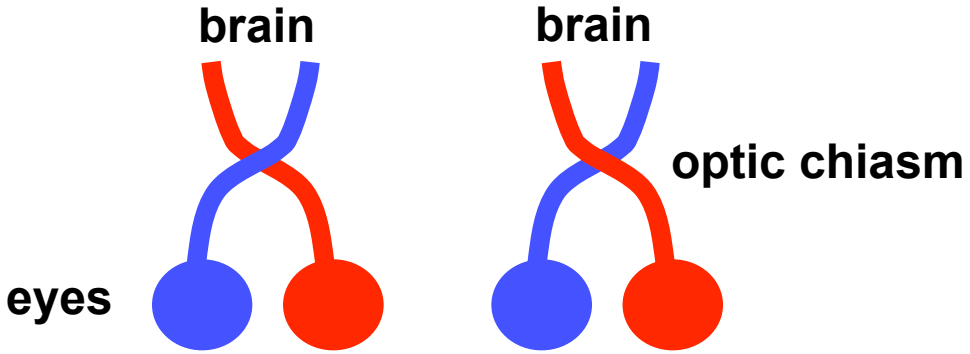
- **Social determinism** “I’m the slave of my social environment”

- **Psychoanalytic determinism** “I’m the slave of my unconscious”

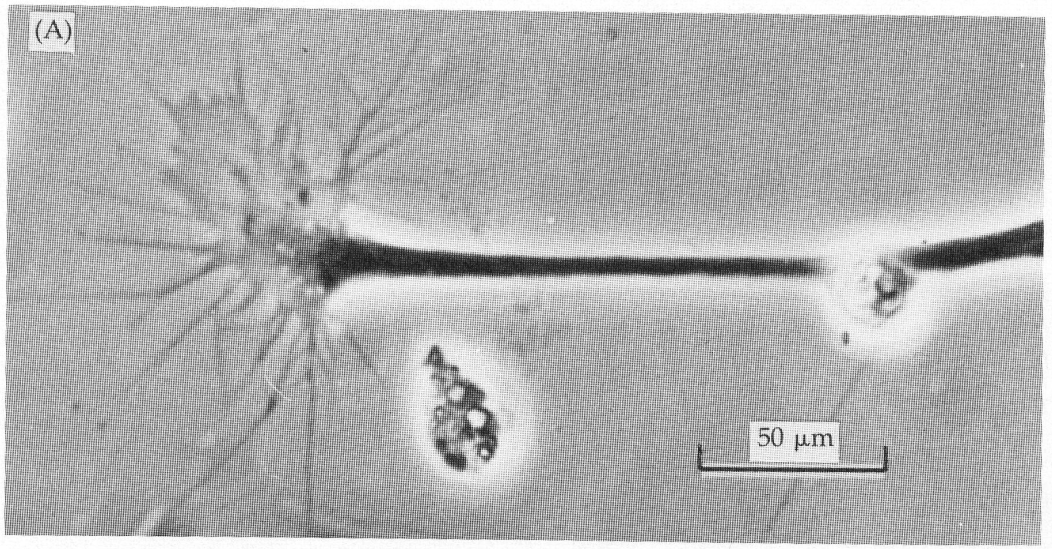
- **Genetic determinism** “I’m the slave of my genes” (but *environment*: identical twins, inbred strains)

Different kinds of determinism 2

Genes + environment determinism. But minor differences: e.g. crossing of optic nerves in isogenic offspring of *Poecilia formosa* (amazon molly).



Arbitrary decision at the optic chiasm



But suppose we could take account of every atom, every electron?

Physical (Laplacian) determinism applied to the brain (or the whole universe) “My brain is a slave to the laws of physics”

The problem of physical determinism and free will

If our brains work mechanistically, then our behaviour must be predetermined.

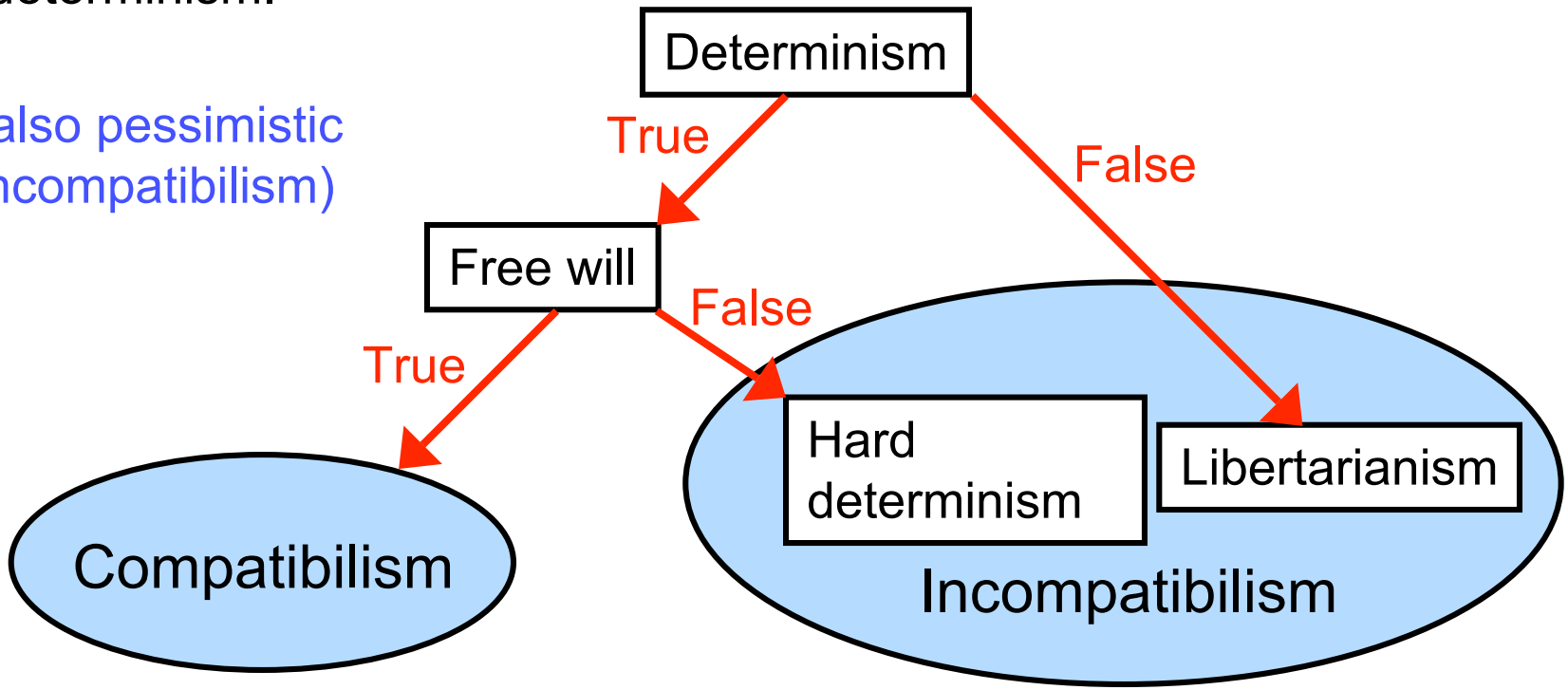
- How then can we be free?
- How can we be responsible for our choices if they were predetermined before we made them?
- How can we be responsible for our behaviour if it was determined not by ourselves, but by the impersonal laws of physics and chemistry?

Three main kinds of answer:

1. Hard determinism: The past completely determines the future, including the future of our own brains. Free will is therefore an illusion.

- **2. Compatibilism**: Determinism is compatible with free will and human responsibility ("soft determinism").
- **3. Libertarianism**: We do have free will, and this is incompatible with determinism.

(also pessimistic incompatibilism)



Problems in the definition of free will.

"I cannot understand what people mean by free will. … I feel that I will to light my pipe and I do it; but how can I connect this up with the idea of freedom? What is behind the act of willing to light the pipe? Another act of willing?" (Albert Einstein, 1933).

Still a subject of debate among philosophers. Let's at least include the notion of responsibility.

Two Very Different Definitions of Free Will

A compatibilist definition

"The power of making free choices unconstrained by external agencies."

(The Free Dictionary)

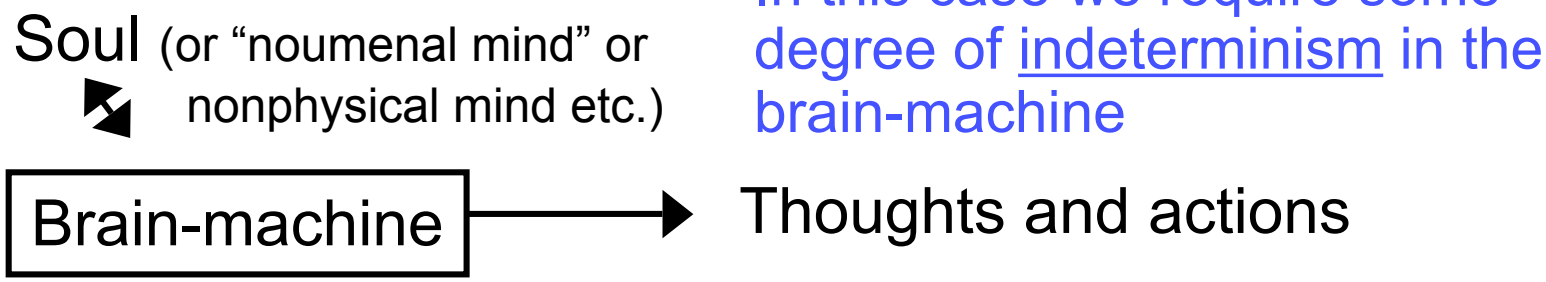
A libertarian definition

"The choices which are said to have no necessary determination from the nervous system or from any other physical cause."

(Handbook of Psychological Terms)

Our choice of a libertarian or a compatibilist approach may depend on our assumptions about the brain-mind relationship and the soul

Interactive dualism



In this case we require some degree of indeterminism in the brain-machine

Monism

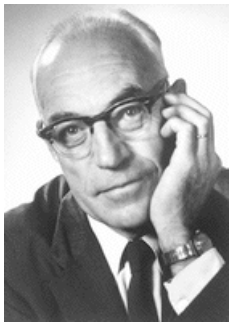
In this case we probably think in terms of a deterministic brain, a machine without loose screws

The soul and dualism

"Does not death mean that the body comes to exist by itself, separated from the soul, and that the soul exists by herself, separated from the body?" Socrates, in Plato's Phaedo.

Christians who adopted the neoplatonist concept of the soul

- Origen and Augustine
- Luther and Calvin
- Descartes
- Western folk philosophy
- Nobel prize-winning neurobiologist Sir John Eccles (1903-1997)



"We will have nothing to do with the fantastic suggestion, that what the supersensitive 'reactors' in the cortex react to, is the initiative of a virtually disembodied soul." (Austin Farrer, 1957, in reaction to a book by Eccles).

Monism v dualism in relation to Christianity

- Both have a strong tradition in Christian theology, especially dualism
- The biblical use of the word “soul” is essentially monistic
- Many modern Christian (and nonchristian) philosophers favour monism
- We have to take both views seriously

We shall therefore give further consideration to both

Compatibilism (associated with monism)

and

Libertarianism (associated with dualism)

Compatibilism (linked to monism)

External constraint: “I smashed the window because my sister made me do it. She pushed me.”

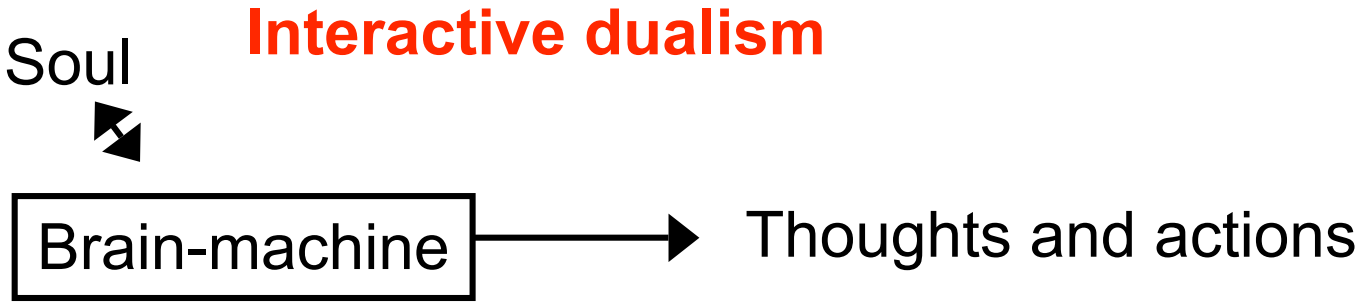
Internal constraint: “I smashed the window because my brain made me do it“

If my brain didn’t make me do it, then I wasn’t responsible.

Internal constraint is not compulsion.

But the debate amongst modern philosophers is much more subtle ….

Libertarianism (linked to dualism)



Requires **indeterminism** implying either

- the laws of conservation in physics must be continually broken (conservation of energy, momentum etc.)

or else

- brain-soul interaction within the limits of physical determinism

Quantum Libertarianism

The influence of the soul on the brain is claimed to load the quantum dice, acting within the limits of quantum (Heisenbergian) uncertainty, believed by most (not all !) physicists to be a fundamental limit to predictive precision

$$\Delta E.\Delta t \geq h/4\pi \quad \text{or} \quad \Delta p.\Delta x \geq h/4\pi$$

ΔE is uncertainty in energy
Δt is uncertainty in time
h is Planck's constant

Δp is uncertainty in momentum
Δx is uncertainty in position

$$h = 6.63 \times 10^{-34} \text{ J.s}$$

Quantum libertarians are not saying that free will depends on *random* fluctuations within the limits of quantum uncertainty.

They are saying that *non-random*, soul-directed changes are the basis for soul-brain interaction and hence for free will.

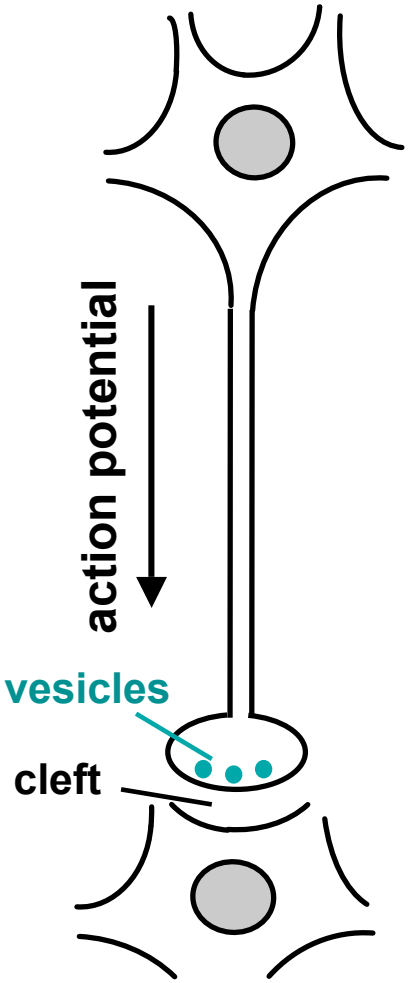
Where would this mysterious influence act?

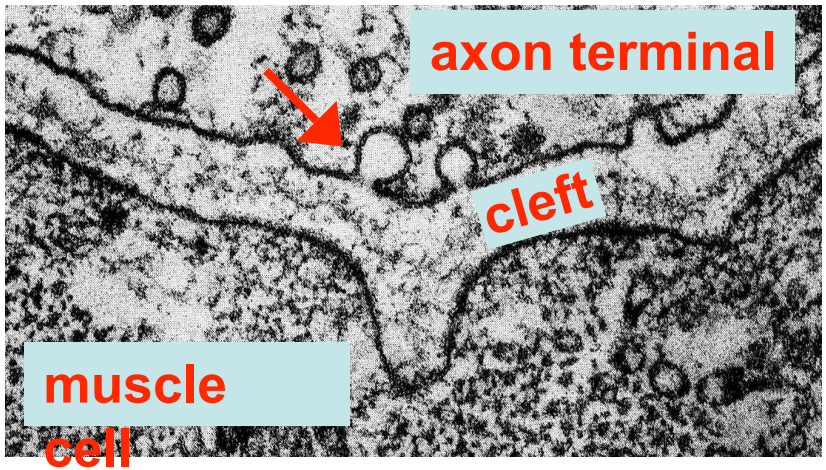
Quantum uncertainty would have to influence directly the electrical activity of the brain

- Many other brain events occur (metabolic reactions, transcription etc.) which influence brain activity indirectly (after minutes or hours)
- Conscious decisions can take place fairly rapidly (seconds or less).
- Therefore the quantum effects would need to affect electrical activity rather directly.

Where in the brain might quantum effects occur?

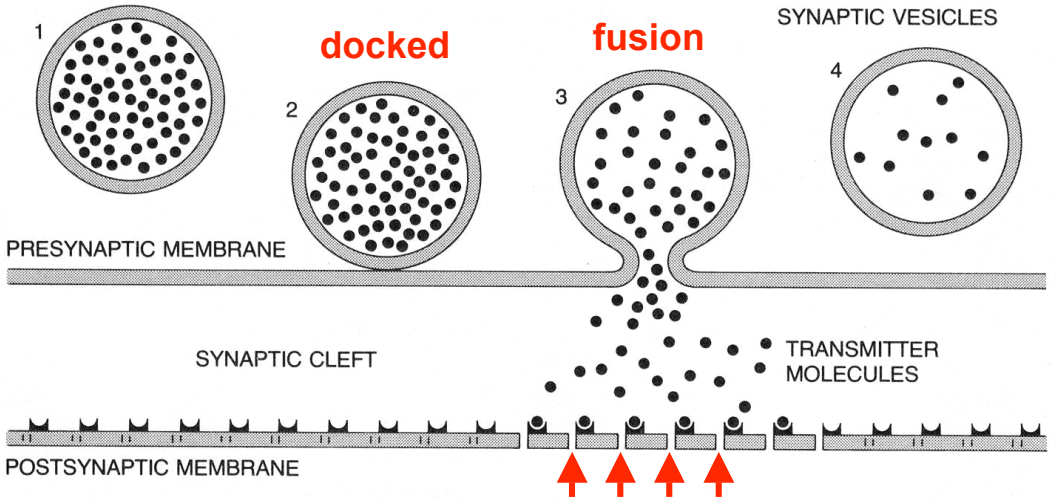
Quantum effects at synaptic clefts in the cerebral cortex (e.g. Beck & Eccles, 1992)



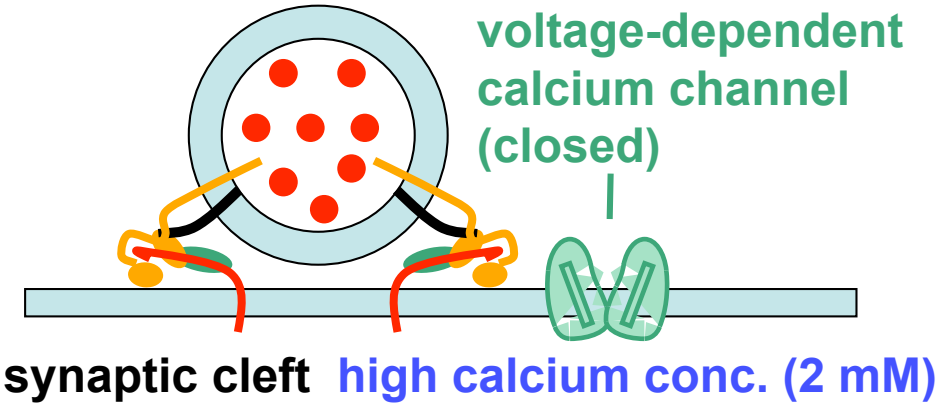


Neuromuscular junction (Heuser)

1 μm

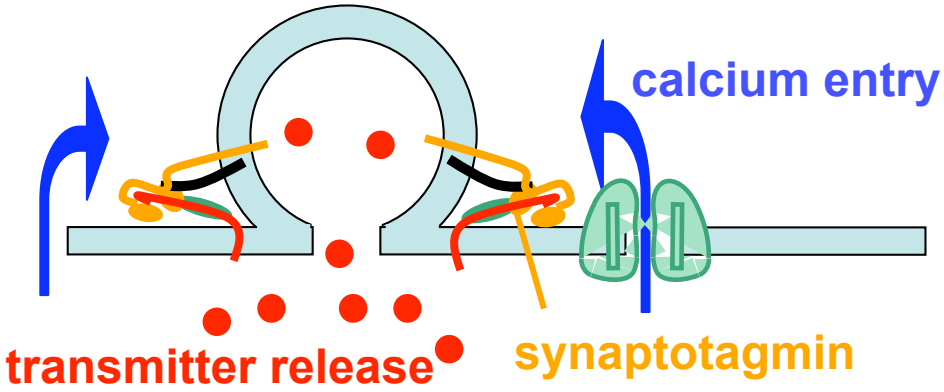


The vesicles that may release following an action potential are those that are already docked

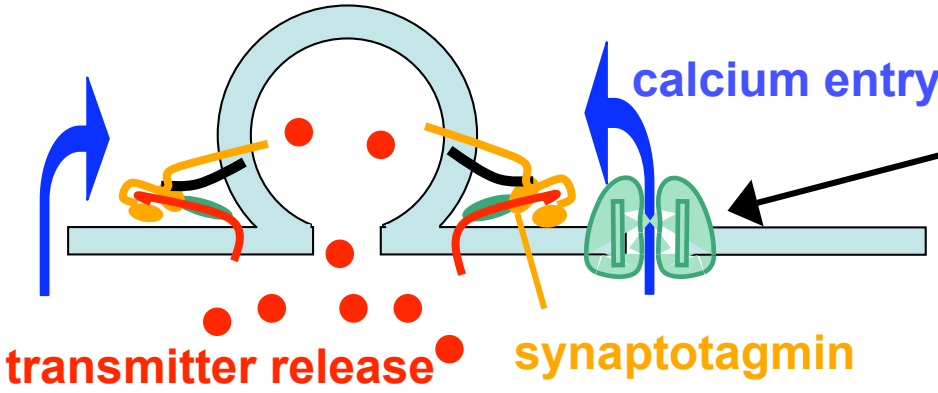


When an action potential arrives, the resulting voltage change:

- opens calcium channels
- calcium enters and acts on synaptotagmin
- this causes vesicle fusion



Problems with notion that the influence of the will "hides" in the cloud of quantum uncertainty



Let's focus on the possibility that the soul might modify a hydrogen bond in a calcium channel

$$\Delta E.\Delta t \geq h/4\pi$$

energy change available

time for which this change could be "hidden" (we would need about 10 microsec.)

<u>Problem 1:</u> quantum uncertainty is very small

$\Delta E.\Delta t \sim h/4\pi$ $\quad h = 6.63 \times 10^{-34}$ J.s

So if $\Delta t \sim 10$ microsec., $\Delta E \sim 5.2 \times 10^{-30}$ J

About 2×10^{5} times too small to affect functioning of an ion channel by disrupting a single Van der Waals interaction (1×10^{-24} J) for 10 microsec.

Even if we took $\Delta t \sim 10$ nanosec. (the permeation time for a single ion), ΔE is still 200 times too small.

You may object that the absorption of a very few photons can affect retinal function

Hecht, Schlaer and Pirenne (1942) showed that a human subject can see a light so dim that 6-14 quanta were absorbed over a 500 rod area; this implies that one rod can "see" a single quantum.

frequency of turquoise light

Energy of photon $E = h\nu \sim 6.63 \times 10^{-34} \times 6 \times 10^{16} = 4 \times 10^{-17}$ J

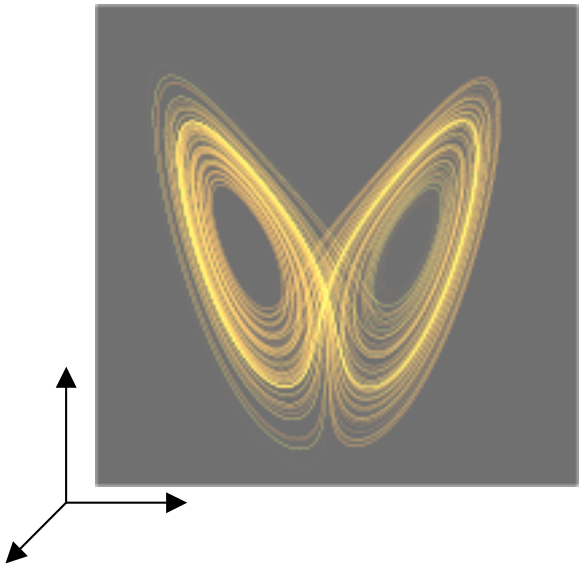
Important to realize that ΔE ($\sim 5.2 \times 10^{-30}$ J) is <u>much</u> smaller than the energy of a photon

Could Problem 1 (smallness of quantum uncertainty) be solved if the quantum fluctuations were amplified by chaos?

Chaos: extreme sensitivity to initial conditions or fluctuations

Despite many claims, chaos in brain events is difficult to prove

Problem of quantum chaos: mathematically predicted "quantum suppression of chaos"



Lorenz attractor

$dx/dt=-\sigma x+\sigma y$
$dy/dt=-xz+rz-y$
$dz/dt=xy-bz$

But, quantum suppression of chaos can itself be suppressed by another quantum effect, *decoherence*, in some circumstances

Problem 2. Cell function, brain function etc. have to be resistant to minor perturbations

Brain cells live in hot, wet surroundings of T ≈ 310°K

Molecules in a liquid continually make small random movements because of their thermal energy

Thermal energy per molecule $E_{th} = 0.5k_B.T.n$

n = degree of freedom = 3

Boltzmann constant $k_B = 1.38 \times 10^{-23}$ J/°K

So $E_{th} = 6.4 \times 10^{-21}$ J (compare with $\Delta E \sim 5.2 \times 10^{-30}$ J)

Instead of assuming Δt = 10 microsec. and calculating ΔE we could do the opposite, setting $\Delta E = E_{th}$ and calculating Δt.

Quantum libertarian F. Beck:

- calculates Δt for quantum events < 0.3 psec (10^{-12} sec)

- much shorter than the time-scale of cellular events (he thinks > 0.4 nsec.)

Time-scale of electron transitions etc.

More problems with notion that the influence of the will acts within the limits of quantum uncertainty

Problem 3: will-induced fluctuations amplified by chaos would not give free choice

Problem 4: not all physicists accept that Heisenbergian uncertainty is a fundamental limitation to knowledge (e.g. school of David Bohm)

Conclusions

The philosophical debate about determinism and free will is far from being resolved

Most Christian philosophers are compatibilist or libertarian (the only positions asserting free will and responsibility)

They are found in both camps

The almost-deterministic nature of physical interactions raises problems for libertarianism

Quantum uncertainty does not currently seem to provide a sound basis for defending a libertarian position