Complex Organisation and Fundamental Physics

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video of lecture available at https://sms.cam.ac.uk/media/2777683

Main Theme

Theoretical Physics is primarily *mathematical*, whereas biology is concerned primarily with *mechanisms*.

Mathematical and biological aspects of nature need to be integrated (cf. Simeonov’s *Integral Biomathics*).

Expectation: this will expose hidden mechanisms underlying observed phenomena (cf. atoms underlying sound waves, viscosity, etc.).

Mathematical aspect of physics

In physics mathematics is primary, laws expressed as equations

e.g. Newtonian mechanics, Maxwell's electromagnetic theory:

1. $\nabla \cdot \mathbf{D} = \rho_V$
2. $\nabla \cdot \mathbf{B} = 0$
3. $\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$
4. $\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J}$

and the Standard Model of elementary particles.

Limitations

So far so good. But …

What about gravity, dark matter, etc.?

And biology, and the ‘collapse of the state vector’…

Issues with biology

The difficulty in treating biology in the same way as physics lies in the *variability* of biosystems (no two organisms are the same).

In physics we can usually model variability in terms of presumed *independent probability distributions*.

But in biology, *relationships* and sophisticated *mechanisms* are important: the *independent fluctuation* assumption is not a good one.

Comment: we can't make an furniture from a kit just by putting the parts together in any way that comes to mind, and the same applies to organisms; the situation in biology is much more subtle than is typical in physics.

Observation and Collapse in Quantum Mechanics

The Schrödinger paradox: an imaginary experiment involving radioactive decay, which the equations say leaves a cat apparently both alive and dead at the same time.

Graphic: Christian Schirm

One interpretation is the *many-worlds hypothesis*: the universe splits into two, one with a live cat and the other a dead one. We are in just one of these universes, and see only the situation in that universe.

Collapse alternative

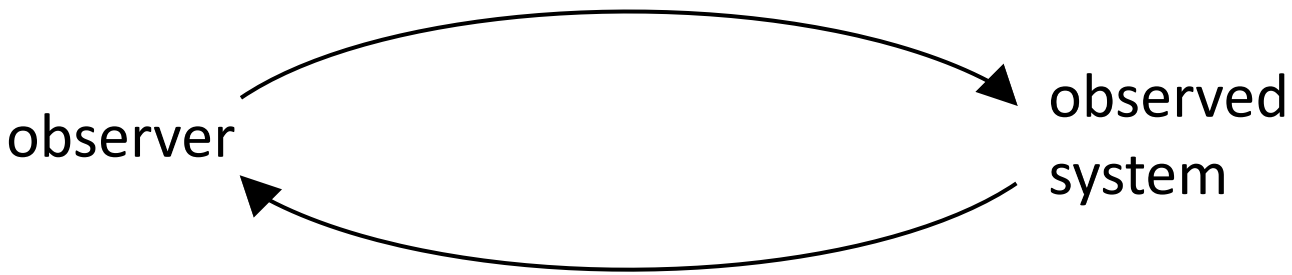
The problem: how is that ‘I’ end up in a particular universe? The difficulty is normally ignored.

An alternative to many-worlds is the ‘collapse’ hypothesis: only one of the universes is real.

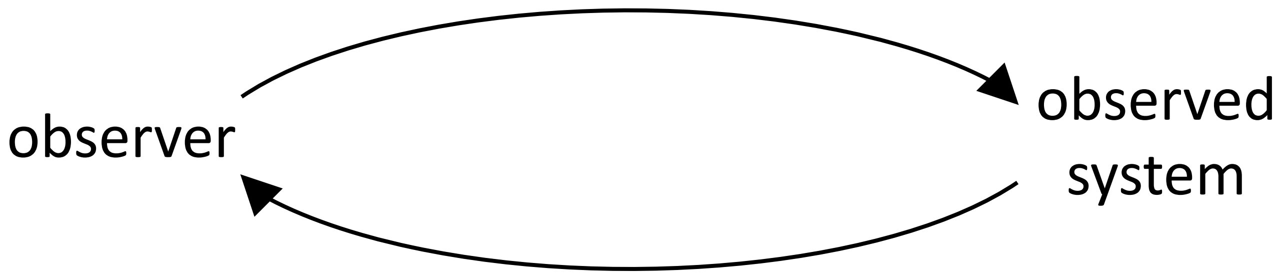
Wheeler's mechanism

A separate law for observation (the collapse equation) has been widely dismissed, as inelegant and ill-defined.

However, Wheeler has postulated a special mechanism for this process, *reflexive circuitry associated with an instability*, resulting in a value being registered in an *irreversible process*:



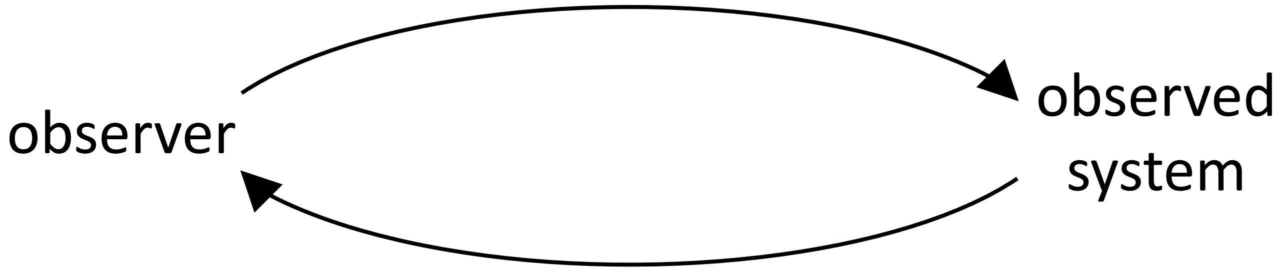
Fabricating Form



Wheeler suggests that in the same way that a sculptor fabricates a sculpture through a large collection of basic actions, a multitude of ‘observer-participancy’ processes can lead to the ‘fabrication of form’.

We now turn to the *relationship between physics and biology* to clarify the detail.

Observer-participancy in biology



Biology has very similar observer-participation, with a process involving reflexive circuitry leading to refinement of the process concerned, on the basis of feedback. Such refinement, and sometimes also high precision, arises naturally in biology. Perhaps physical systems work in a similar way?

How does life work?

If one asks the question ‘how do computers work’, the answer will typically involve accounts of the various *ideas* underlying the design, at various levels.

Design tends to work *from idea to implementation*, an idea being a mental picture of some kind, to which the designer attempts to make the implementation conform. An accumulation of design components leads over time to a ‘grand design’.

Biological research tends to work in the opposite direction, from discovery of details to insight into the corresponding concept. But it is fruitful to view an organism as a similar ‘grand design’, built up from *structures with power*.

Power structures, systematic activity

In a computer, random code can't achieve much, highly specific structures are needed. In the same way, very specific 'power structures' are needed for life (note contrast with physics).

Structures are also needed that *build structures in a systematic way*.

Sign systems also facilitate this structure building process.

Mathematical formalism is possible: e.g. the 'hyperstructures' of Baas, modelled in a computer simulation by Osborne.

Osborne’s hyperstructure simulation

https://philarchive.org/archive/OSBTLS-2

5.3 A Mathematical Formalisation of the ’Emergence Relative to a Model’ Model

A mathematical formalism has been proposed by Nils Baas[32, 33] in an attempt to define emergence from the ’emergence relative to a model’ approach. This may be summarised as follows:

Consider a set of primitive objects - ’first-order structures’ - denoted $\{S_i^1\}$, and an observational mechanism, Obs^1, to ’evaluate, observe and describe the structures $\{S_i^1\}$’.

A general procedure is then required to construct a new set of structures - second-order structures - $\{S_j^2\}$ from $\{S_i^1\}$. To this end, the observation mechanism is applied to the members of $\{S_i^1\}$.

Using the properties derived from the observations, $Obs^1(\{S_i^1\})$, a set of interactions Int^1 may be defined. By subjecting members of $\{S_i^1\}$ to Int^1, a new structure is obtained:

$$S^2 = R(S_i^1, Obs^1(\{S_i^1\}), Int^1) \tag{5.1}$$

where R is the construction process resulting from the interaction Int^1 and S^2 is a second order structure. Second order structures may be observed by a new observational mechanism Obs^2 (it may be equal to, overlap, or disjoint from Obs^1). According to Baas, emergence may now be defined thus:

P is an emergent property of S^2 iff

$$P \in Obs^2(\{S_i^2\}) and P \notin Obs^2(\{S_j^1\}) \tag{5.2}$$

Program structure

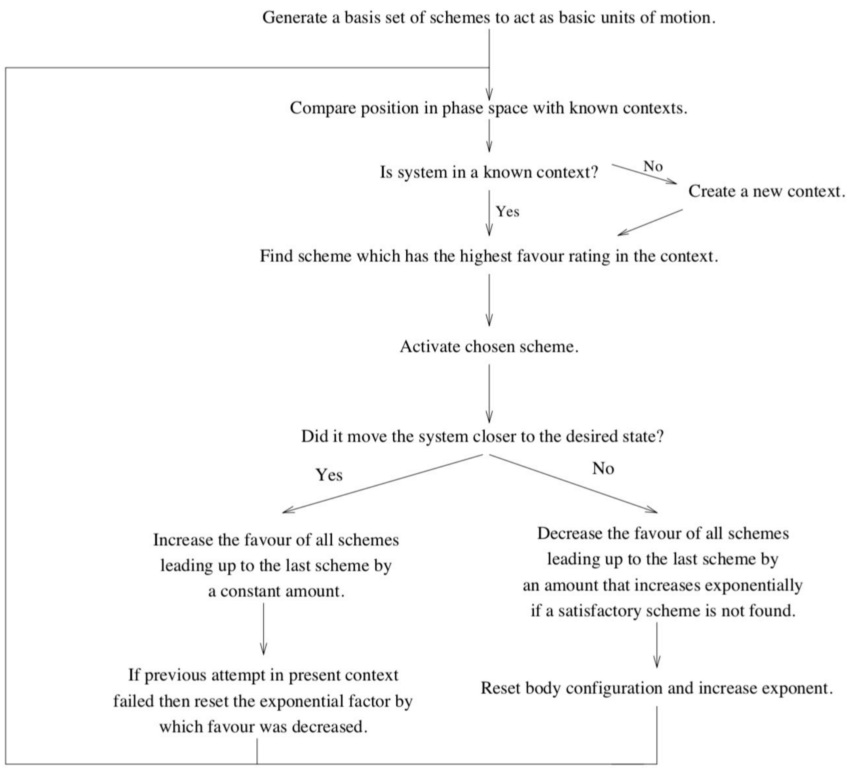
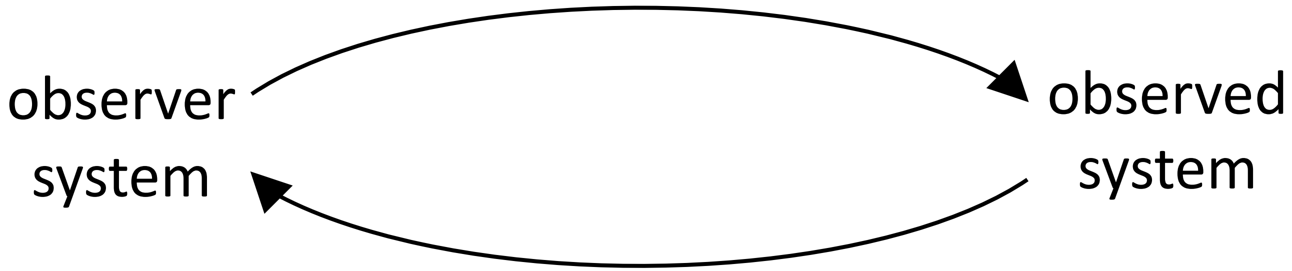


Figure 10.1: Flowchart Representation of the Second Program

Flexibility and power

Some structures are observed to be very *flexible* as well as powerful.

For example language: particular strategies (e.g. naming objects) work in a wide range of circumstances, and the brain's language mechanism makes use of such flexibility using appropriate observer-participant systems.



The same applies to sign systems in general, once the appropriate structures have come into existence.

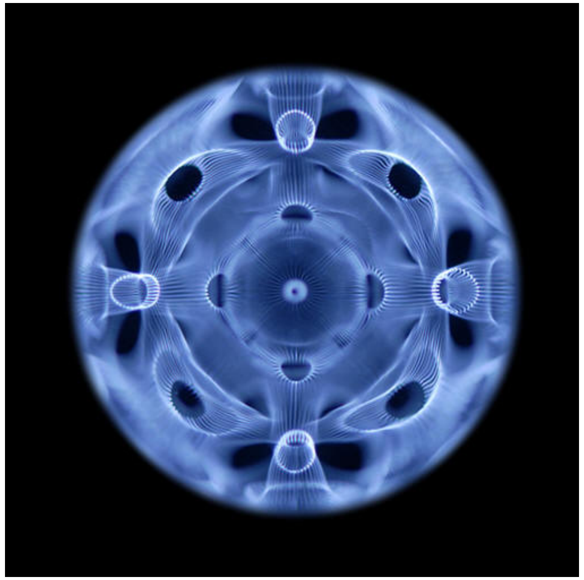
Starting from Simplicity: Yardley's Circular Theory

Yardley has a theory whereby the 'circle' is viewed as the most fundamental form of life. Expressing her Circular Theory along the lines of the ideas developed here:

- cycles occur naturally in complex systems (cf. weather)
- their persistence will be a function of associated structures (again cf. weather)
- natural selection can function in such a situation, leading to effective support
- increased activity promotes exploration and development, reduced activity stability
- acoustic information can be effective in creating structures, and can in principle function as codes for building well-defined structures

Acoustic Codes and Cymatics

Cymascope image showing response of water to the *Phantasy Quintet* of Vaughan Williams



(phenomenon attributed to Faraday)

Triads and contexts

Observer and observed are like phases in equilibrium, a third entity acting as background; structure emerges spontaneously

idea (mind/observer)	unfolding of idea (matter/or object)

context of activity
(semiosphere)

Three entities in quasi-equilibrium, different and yet compatible with each other.

From simple to complex

We start with cycles, with increasing structural complexity as the amplitude increases. Stabilising structures are linked cymatically to acoustic codes.

Powerful structure-building capacities lead to effective designs of increasing complexity and capacity (cf. what happens with language).

An aspect of power is the enforcement on their *environment* of effective laws, making use of codes to define behaviour.

Ultimately life processes evolve to be able to define universes, necessarily favourable to the life processes themselves, a kind of perfectly functioning society, a global system maintained by its effective supporting mechanisms.

Such evolved mechanisms underlie life, the universe and everything.

Conclusions

We should look to biology to understand physics better: it has been wrongly assumed to be irrelevant to physics.

I have exposed a collection of ideas that fit well together into a comprehensive scheme, with components amenable to scientific analysis (cf. Artificial Life). Filling in the details is a task for the future.

Overall scheme is so complex that it is hard to formulate in terms of words, but one can still make *models* of such schemes to test ideas, still do science.

Sources of concepts used in this lecture

Barad: *Meeting the Universe Halfway: the Entanglement of Mind and Matter*

Hoffmeyer: *Biosemiotics*

Yardley: *Circular Theory*

Hankey: discussions of complexity biology

THE END