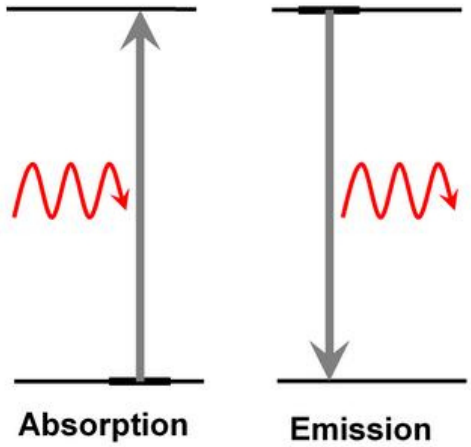
Music of the week (Spanish):

A 'Brief History of Time' Revisited

As the **cosmic horizon** increases monotonically (according to the **second law of black hole thermodynamics** and in concordance with observations), this suggests that it defines a perfect classical "cosmic clock", that is whenever an experimenter does a measurement, be it of a **quantum mechanical** or a classical system, he/she can always (in principle) "label" it with the size of the cosmic horizon corresponding with "cosmic time". This defines an ordering of events associated with the experiments.

Let's do a gedanken experiment: We are an observer who happens to detect an emission and an absorption in the following order:



One could label them with the related size of the universe. In other words, instead of just regarding the atomic subsystem, one considers the largest possible physical system at a given moment including the quantum system in regards, the boundaries given by the cosmic event horizon. If one would randomly shuffle the two processes and hand them to some other person, he/she could not tell in which order they have taken place (without the labels). This is due to time reversal invariance of quantum mechanics. (Another way to see this is by inverting the arrows of the processes which corresponds to an inversion of quantum mechanical time).
Thus if one considers a quantum mechanical system in the context of the whole cosmos one breaks *unitary invariance*. Is this the way the **second law of thermodynamics** creeps in ? It seems, that if the cosmos would be monotonically contracting instead, this would equally well define a perfect classical clock (all we need is an ordering of events). **Hawking** raised the question if time would run backwards in this case. I would claim NO, running backwards makes only sense

for quantum mechanical time and not for cosmic classical time. (Addendum: I just learned that later on Hawking regarded this as the biggest blunder of his life [1]). But if the cosmos were static, the conjecture is that classical time would stand still and there would merely be quantum evolution in quantum mechanical time. It would then make no difference if the universe ran forwards or backwards in this time coordinate due to time reversal invariance of quantum mechanics.

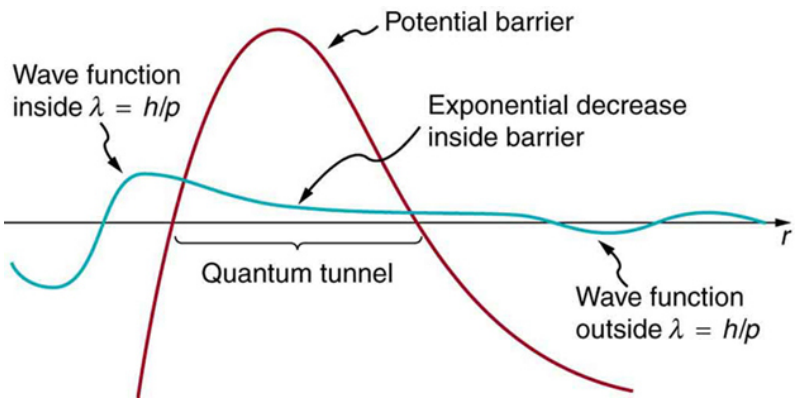
But there is more to the process of labeling an event than might seem at first sight. In fact it means that the "cosmic entropy reservoir" (which by the **holographic principle** is related to the area of the cosmic horizon) is coupled through the observer with the quantum system, this way breaking time reversal invariance. This defines the interface quantum/classical which goes under many names, like **measurement process**, **"collapse of the wavefunction"**, quantum to classical transition, **decoherence**, just to name a few of them. (Notice that all these notions are surrounded by a veil of mystery, suggesting that they are all referring to the same thing and that there is something that needs to be better understood).
In the example given **consciousness** was included (through the observer), but it seems not to be necessary. Nevertheless if we want to have a breaking of time reversal invariance in the same spirit, we have to require that the quantum system couples to the cosmic entropy (which is dominated by the entropy of **dark energy**). Then measurements (and "reductions of wavefunctions", etc.) can take place without involving a conscious observer which is very satisfactory as the latter is quite problematic anyway due to the lack of a proper physical definition.

Let's look at another example, the decay of a radioactive element. (I am well aware that the following arguments are not fully watertight and may require some amendments. At least the example may serve as an analogy or a toy model. Maybe a scattering experiment would be a better example).
The decay process is a quantum process, nevertheless time-reversal invariance is broken. How can this be ? We can argue by including an observer, but this makes things only more involved, so let's assume that a decay takes place independent of a (conscious) observer being around or not (at least archeologists doing radiocarbon dating will probably have no problems with this assertion). Then, we have to define what "spontaneous emission" means. We say that a spontaneous emission has taken place when a state initially confined

to the nucleus (i.e. it is inside its potential barrier), one *Planck time* interval Δt_P later is outside the potential, i.e. it has **tunneled** through the potential barrier. We cannot use a smaller time interval because we are talking about a classical clock here and for smaller time intervals the *uncertainty relations* imply that there is no more classical time. (This is where relativity and quantum mechanics meet and actually we don't know what happens there, not having a **theory of quantum gravity** - at least this is common lore).
We can estimate the increase of the cosmic entropy reservoir during Δt_P using **Hubble's law**. The increase of the area of the cosmic horizon ΔA during Δt_P is given by

$$\Delta A \approx H_0 \Delta t_P A \approx 10^{-61} A$$

Assuming that the *Bekenstein bound* is saturated, the current entropy of the universe corresponds with 10^{122} Planck areas on the cosmic horizon. We therefore get an increase of about 10^{61} Planck cells per Δt_P. (Note that these calculations involve the **"large numbers"**).
This can explain why we never see a decay process running backwards in time, as each decay event goes along with an immense increase of the cosmic phase space and the cosmos as a whole doesn't find its way back to the prior situation with the decayed element inside the potential barrier.
It is crucial that this conclusion is based on the coupling of our quantum system to the cosmic reservoir. After one Planck time the quantum system could be additionally coupled to any combination of the new cosmic phase space elements, but we are completely lacking information what these and their couplings are. At least this is the current state of the arts. Though even if it were in principle possible to find out something about the new degrees of freedom of the cosmos it seems practically hopeless to track down all of them. Therefore we have to live with uncertainty, entropy increase and the second law.
Another objection could be that if we knew the state of the universe at a given time we could calculate all its future states. But this would imply that we have determinism on a fundamental level AND no **chaoticity**. (Although this appears highly unlikely, we have to leave this as a possibility).



Can we model this ? Let's try. A decay process is described by an

evolving **Gamow state** according to

$$e^{-\mathrm{i}\hat{\mathbf{H}}\mathrm{t}/\hbar}|\mathbf{\Phi}\rangle = e^{-\mathrm{i}E_0 t/\hbar}e^{-\Gamma t/(2\hbar)}|\mathbf{\Phi}\rangle$$

One may wonder what the time variable means that enters this expression. We have distinguished between a quantum mechanical and a cosmic time so far. If we set $\Gamma = 0$ we have no decays and unitary evolution reigns, thus quantum mechanical time is the correct time in this case. But if the particle is at rest, i.e. $E_0 = 0$ (actually we are ignorant of **zero point energy**), we still have decays but no unitarity. Thus we have to use the time of our "cosmic clock" instead. Can we identify these two times? It seems that this is not so as the cosmic clock "knows" **a time direction** (that is its essence) whereas the quantum mechanical clock is "blind" when it comes to the direction of time.
The conclusion is, that we better use both times (not excluding the possibility that they are not completely independent, rather saying that they cannot be **bijectively mapped** to one another). We therefore define a *complex time*

$$t_{\mathbb{C}} \equiv t_{class.} + it_{q.m.}$$

where $t_{class.}$ is the classical time and $t_{q.m.}$ the quantum mechanical time, the times alluded to respectively.
With this complex time the evolution of our Gamow state reads

$$|\Phi'(t_{\mathbb{C}})\rangle = e^{-\hat{\mathbf{H}}'\mathrm{t}_{\mathbb{C}}/\hbar}|\mathbf{\Phi}\rangle$$

where $\hat{\mathbf{H}}'$ defines an appropriately redefined Hamiltonian. This (new) **Hamiltonian may also be complex** but this is not so clear at this point. As we take into account the breaking of unitarity, our state $|\mathbf{\Phi}\rangle$ cannot "live" in a **Hilbert space**, rather, the right home for it seems to be a **Hardy space**. One can think of having a "stack" of **unitarily inequivalent vacua** in this case.
As the evolution in the imaginary time coordinate is periodic, this means that the system naturally is **quantized** in this time direction, whereas in the real time direction it is not, i.e. it is classical. This time evolution rather looks like a frictional process of the system.
Note also that here quantum mechanics and relativity come together and these considerations may be interesting in respect to potential theory of quantum gravity.

What if we nevertheless include the conscious observer in our considerations? As consciousness is intimately related to classical time and a time direction (conscious events are ordered and they are typically separated by about $1/50\mathrm{s}$), the observer directly or indirectly must be coupled to the cosmic entropy reservoir, or simply, he/she must be classical. This seems obvious, we are not a purely quantum mechanical system. In other words if classical time stood still (not quantum time !) we would have no consciousness (similar arguments

have been given by Schrödinger). But now a difficult question arises, is this background fully stochastic or not ? This touches upon the question of the existence of **free will**. In the first case the "classical" cosmos just "does what is wants". Our consciousness propagates along with it like a *Brownian particle* through time - one may call this free will if one likes. In the latter case we are "running some program" which is "written" in the language of the cosmic state space. (In the extreme case, if the cosmos were fully deterministic, there would be no free will, rather we had to consider us being a **"simulation"**).

See also:

- **Large numbers and wavefunction collapse**
- *Coupling dark energy with the brain*

Videos:

- [1] The Nature of Time in Inflation and Quantum Cosmology (2011) - A. Linde

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

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About Spacetime and the Moon

"Is the moon there if nobody looks at it?". This is a famous question when it comes to the **interpretation of quantum mechanics**.

Picture taken 1982 by the author with a Celestron 8
(a classical "orange tube") and chemically processed in own photo-lab.

A long-standing quest is to find a theory of **quantum gravity**, that is to say to describe spacetime in terms of **quantum mechanics**. Suppose this can be done with quantum mechanics as we know it. Wouldn't it then be consequent to ask: "Is space and time there if nobody looks at it?". Or put it more drastically, would the universe be gone if there were no observers? **Einstein** probably would have said that spacetime is there, whereas **Bohr** would have insisted on the absence of an objective reality.
The reason why one could be worried is that one is tempted to assign properties to spacetime and regard them as being objective. One such property is **discreteness**. If we take instead a more conventional quantum mechanical system, say an atom, would it make sense to ask the question if it is discrete or not? If one thinks of the energy levels (eigenvalues) it is, but if one thinks of the orbitals (eigenfunctions) it is not.
The point to be made here is that, given the fact that there is growing experimental evidence that spacetime is not discrete (the latest results of the Integral- and **FGST** satellites point in this direction), it may be better to regard concreteness (and any other property) as intimately related to the measurement being done, the concrete experimental setup. In other words, it is a property dependent on the specific interaction of the observer with spacetime.

A good compromise therefore could be to regard spacetime as a **spectral manifold**. This way one establishes a close analogy with the situation of the atom described above, where whatever the ontological interpretation of an atom is, experimentally it is just a matter of fact.

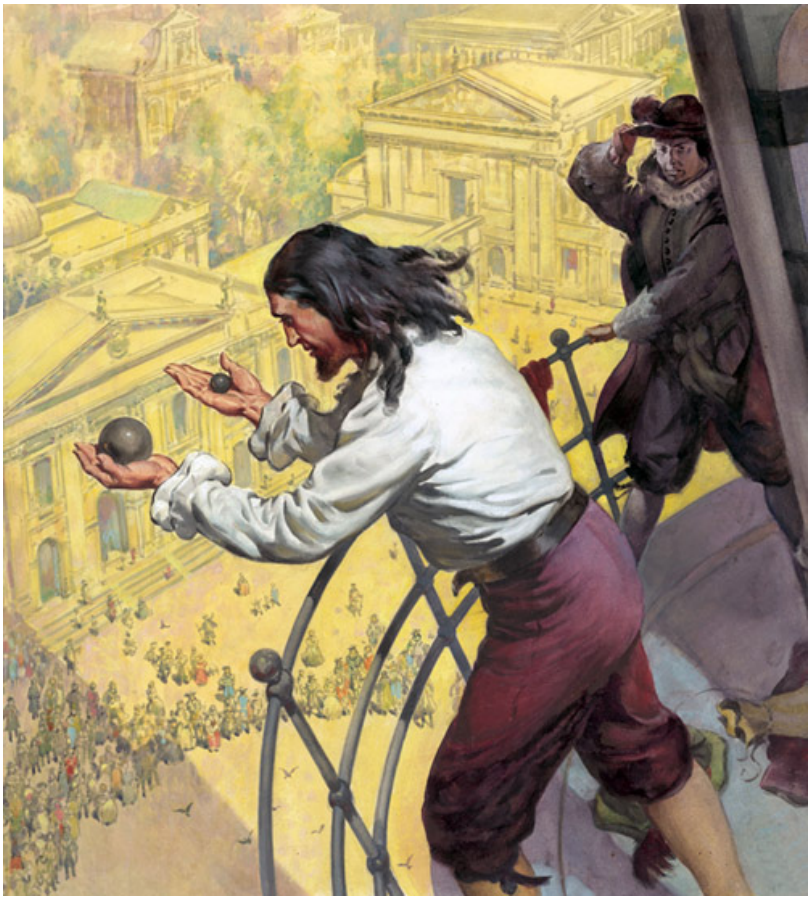
So the conclusion could be this: A property of spacetime only makes

sense together with an instruction how to measure it.

What remains is the problem of "the role of the observer" which is inherent in any (standard) quantum mechanical description. In other words, is spacetime a **"friend" of Wigner**? But one can see the problem as being even worse in this situation, as instead of an infinite regression of friends, one runs into a tautology: If one considers spacetime (and all the matter it contains) within an observer's *apparent horizon* as "all there is" (at least in respect to the observer), then this apparent universe is Wigner's friend, but isn't the observer (Wigner) part of it ? Moreover, instead of the universe having yet another friend this should not be so, given our assumption that there is nothing beyond (at least nothing that is causally connected). So in a way here one should get a "closure" of the problem - something one may want to better understand.

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

About the Scientific Method



The classical scientific method is based on reproducibility of an experiment. It is the method introduced by Galileo, an example being his famous experiments, dropping masses. It allows for "detecting" laws of nature. (E.g. all objects experience the same acceleration in the earth's gravitational field).

So far, so good, applying this method consequently has lead to an enormous success of the natural sciences and progress of mankind during the last centuries. This has caused many to blindly believe in the sciences and to reject anything beyond. But doing this really means to fully trust the principle(s) underlying it without questioning it(them). Is this justified ?

I say no, and at least I think it is worth thinking about an extension to the principles on which the (classical) scientific scientific method is based upon.
The point is this. Suppose one drops a mass over and over again and each time one would measure a different acceleration. What would be the conclusion ? One could conjecture that there is no law. But how could one be sure ? In fact one cannot. Because this implies that the accelerations had to be completely uncorrelated. So practically what one had to do is a correlation analysis, but this is sensitive to a nasty parameter, namely the number of experiments. To be "exact" one had to do an infinite number of experiments - impossible. Of course if one "detects" a law one encounters the same problem here.
Reproducibility is based on what one has seen so far in the experiments, but who guarantees that this applies forever - that a law is immutable, in other words embedded in cascade of super laws.

Actually the original scientific method à la Galileo has already undergone a modification long time ago, maybe unnoticed by some, namely through **quantum mechanics**, and beyond any doubt this was another incredible boost for the progress of mankind.
It lead to a weakening of the principle of reproducibility. Now it matters how the sequence of measurement looks like. If I take instead of the mass a quantum object and measure its position to a certain accuracy and next its momentum, this value is fuzzy, the fuzziness being encoded in the famous **Heisenberg uncertainty relation**: $\Delta x \Delta p \approx \hbar$. To give an example of a measurement sequence: $x_0 + \Delta x$, p_0, $x_0 + \Delta x$, $p_0 + 5\frac{\mathrm{kg\,m}}{\mathrm{s}}$, ... Quantum mechanics allows for this weirdness and it is within the laws, whereas Newtonian mechanics doesn't. This new behaviour essentially comes into play through the noncommutativity of quantum operators corresponding with any experiment in quantum mechanics.

What can we learn from this ? In fact on general grounds it is better to speak of correlations instead of laws. A law is just an extreme of a correlation, meaning that if I make two measurements, I can be

absolutely sure that I will get the same results. That works well for classical physics be it that one is dealing with a law in the strict sense or that it is just an incredibly good approximation. (This distinction in fact being a subtle issue).
In the example above the correlation is coded in $\hbar$. If one could tune $\hbar$ and make it very large, quantum mechanics would take over classical physics in our everyday realm and presumably Galileo's experiments would look apparently different.
But again there is a fraction of those who blindly believe in the state of the arts of the scientific method represented by the principles of quantum mechanics and that there is no room for new principles beyond. (I can assure this because I had discussions with such "fundmentalists" in the blogsphere, and it was frustrating ...).
Maybe this is so. Also, it seems not easy to conceive a reasonable extension to these principles. But before doing a radical step in this direction, one may ask if those principles have already been exploited exhaustively. I think that this is not so.
Here are some suggestions where one could look for the new within quantum mechanics ...

- Maybe the correlations are not hard coded via $\hbar$ and there are realms (e.g. the **Big Bang**) where $\hbar$ is different or where another constant determining correlations plays a role.

- There is a practical limit to the detectability of correlations. That is for all practical purposes a measurement sequence could be classified as completely random, although it may still exhibit subtle correlations which may be relevant in another situation. Here I particularly think of the human mind. Of course there are strong correlations imposed by the biological body as we know it (electrophysiological, biochemical, etc.) and we pretty well understand these things already. But what about things like free will ? The idea is that the brain could be kind of a unique amplifier for correlations of an otherwise unseen level of reality. (Yet really part of the physical world - no metaphysics here). A nice example of a theory in this respect, I find the **Orch-OR model**.

- To do a (quantum) measurement, one needs an operator. Do we know all operators that are possible and allowed ? Are we sure that no experiment is conceivable, requiring an operator of yet unseen weirdness ? E.g., I think of **nonassociative quantum operators**, instead of "only" noncommutative ones. Thus instead of an uncertainty relation involving two observables, one had to consider an analogue with three or more ones. In the most extreme case there would be no way to disentangle anything at all completely (commutativity of two observables not being enough, because it ignores relics of higher orders of nonassociativity of more than two observables involved).

- There are successful "prior realities" or "templates" of a world like

ours, call them parallel universes which we are correlated with. To stress it, no causal connections, "just" correlations. But these could imply that the evolution of the universe is not completely random, yet "follows" a given concept. In other words the today and the tomorrow are correlated yet causally fully independent. See also **organic universe** and **cosmic creation and God** in this respect. An example of an interesting such concept in my opinion are the morphogenetic fields by Rupert Sheldrake.

- If one bans things like **telepathy**, **synchronicity**, **archetypes**, etc. to the realm of very weak correlations they might well fit into the framework of quantum mechanics. Then a classical Galilean experiment requiring reproducibility is doomed to fail. Actually there should be a vast sea of directly unseen weak correlations, and who knows what their true relevance to our complex everyday life is. Hence there seems to be much room for subtleties. (Something only true materialists can deny :-)). To quantify this in terms of *entanglement entropy*, the bulk of the contributions may well stem from a realm beyond that of conventional everyday laboratory physics. (See also **"dark information problem"**).

- To put up something more concrete: I suggest considering a *coupling of the brain with the dark energy field*, allowing to "read out" the presumably very feeble correlations of the dark energy quanta which even could turn out to represent be the substrate of **consciousness**. (And could be identified with what is circumscribed so tellingly by the German "Feinstofflichkeit").

A last word: Things like "quantum entanglement/correlations", "everything is connected with everything", etc. have become buzz words/phrases theses days and extend far into the esoteric scene - selling well. So to stay within physics one really has to make concrete what one means in the particular case, otherwise related statements remain empty. In the words Mermin -: "Shut up and calculate!" ... (Admittedly my suggestions are still quite at this level and I yet have to do my homework).

See also:

- *The mind mapping problem*

Papers:

- Limits to the Universality of Quantum Mechanics (2011) - B. D. Josephson local pct. 18
- Niels Bohr's Argument for the Irreducibility of Biology to Physics (1994) - P. Hoyningen-Huene local pct. 6

- Quantum Entanglement in the Multiverse (2011) - S. Robles-Pérez, P. F. González-Díaz local pct. 0

Links:

- Rupert Sheldrake
- WIKIPEDIA - Feinstofflichkeit
- Brian Josephson's Home Page

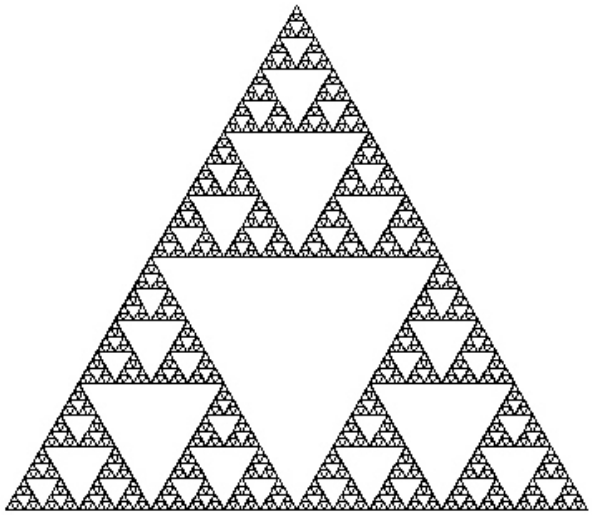
Google books:

- Niels Bohr: Collected Works, Volume 10: Complementarity Beyond Physics (1928-1962) (1999) - D. Favrholdt bct. 4

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Algebraic Reachability and Reality

An Essay ...



Let's start with the real numbers or any set that is bijectively equivalent. We'll call this meta-reality. We can speak of it in a non-constructive way, but we cannot "write down" all real numbers explicitly.

We define physical reality as all those numbers that can explicitly be named. These will we called "algorithmically reachable" (or AR numbers)*. E.g. 1, 0.5, 0.25, 0.125 are easily "reachable" such numbers. (However each one in the sequence is harder to reach and

requires more time and algorithmic brain power = energy.) Roughly speaking, algorithmic reachability is closely related to the number of after comma digits. Notice that saying 1.12 with 12 periodic implies that this is not a AR number, as one really had to write it down digit by digit.

The limit of algorithmical reachability is where it would require more than all the possible resources of the universe to construct a machine (a computer) that generates an explicit output of an AR-number. All non-AR numbers will be called non-constructive numbers (NC-numbers). An example is π with $10^{100000000}$ digits. We can name this number but we cannot explicitly write it down. Therefore non-constructive mathematical truths can be regarded as metaphysics, as they are not part of our physical reality.

In a different universe different mathematics might prevail and the AR numbers might be different. Due to the speciality of our universe and its evolution, the set of AR numbers must be quite special with a high degree of symmetry which finds its counterparts in the "beautiful" mathematical structures that govern our mathematics.
This could also help to resolve Wigner's paradox of the "unreasonable effectiveness of mathematics in the natural sciences".
As the universe ages, it might well be that the number of AR numbers changes.
Notice, that the section of AR numbers in the continuum is completely disconnected. I.e. we cannot write down two adjacent AR numbers, or put it differently, every AR number is surrounded by infinitesimally many NC numbers. (E.g. the number $0.99999\ldots$ is a NC number and is therefore not adjacent to 1). The measure of the AC numbers is 0. Maybe this explains why building reality starting with 1 is so successful. (Decomposition of 1 or equivalently decomposition of probabilities).

In respect to the continuum hypothesis, I claim that it will always remain a hypothesis, as we can only talk about the AR number world with $\aleph_0$ in terms of logic defined by means of NC numbers (which we can code in a computer). The real numbers are the union of the AR and the NC numbers and there is therefore a natural split of meta-reality into those two number systems with different cardinality.

Interestingly, the number of AR numbers might grow. This could be related to a growth of the forward light cone which makes causally connected spacetime grow and hence the available resources to build a computing machine. However there is no algorithmic means within a subset of AR numbers to determine how they will grow, the only way to find out is to let the whole set of AR numbers grow, i.e. let our universe grow. Therefore only the algorithm representing the whole of the universe "knows what comes next". Every subset (i.e. any human brain) is limited in its ability to predict the exact growth of any subset of AR numbers. Furthermore the change of any such subset depends

on the change of the whole algorithm, i.e. in a way is determined (I hesitate to use the word deterministic) by the whole algorithm representing "our" reality.

Certain very big symmetries within the continuum just don't exist in mathematics because they are not algorithmically reachable. I.e. there is a limit on the size of mathematical structures. But within the AR numbers we can hope for a classification of structures to a certain degree. And those are the ones that matter anyway, because they are part of reality and might practically serve to "describe it". Therefore the claim is, that no NC number will ever be useful in a physical theory. Or put it differently, the theory can equally well be defined without referring to them. They are part of the realm of metaphysics.

AR numbers are physically realizable numbers, be it in the brain or in a machine/computer. So they really exist, can be autentically represented by a physical system. But how could a physical system represent a line or a circle, which are mathematical idealisations. Any physical system can at best "approximate" them (and give us a pseudo smooth representation of these abstract objects).

To sum up: Reality is a non-dense subset of the continuum.

* After having written this essay I found the notion of "feasible number" in literature, which I regard as equivalent.

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Are Planck Units Fundamental ?

Common lore is that **Planck Units** are fundamental in the sense that the expectations are that around these values new physics "kicks in". For instance it is expected that around the **Planck length general relativity** and/or **quantum mechanics** breaks down and some more fundamental theory (**quantum gravity**) takes over.

But there is a catch to this argument - the **Planck mass**, which is about $10^{-8}\mathrm{kg}$. Nothing unusual seems to happen for objects of this mass. Rather, it's way smaller masses like the quark masses or the electron mass that appear to be fundamental.
Maybe we have overlooked something, but if Planck unit-related effects are generally subtle and difficult to observe, what are the

chances that we will ever see such an effect at the Planck scale, the Planck temperature, etc. ?

Contrary to Planck units, **large numbers** seem to be regarded as more esoteric, maybe just an accident. But aren't they in the same manner the result of some ad hoc algebraic manipulation ? Yet, contrary to Planck units, these are at least within experimental reach and therefore may deserve more attention.

There is no doubt that the Planck units are universal numbers that one can form by combining (supposedly) fundamental constants of nature, but does this really imply that they are fundamental ? I have begun daring to doubt.

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Cosmic Creation and God

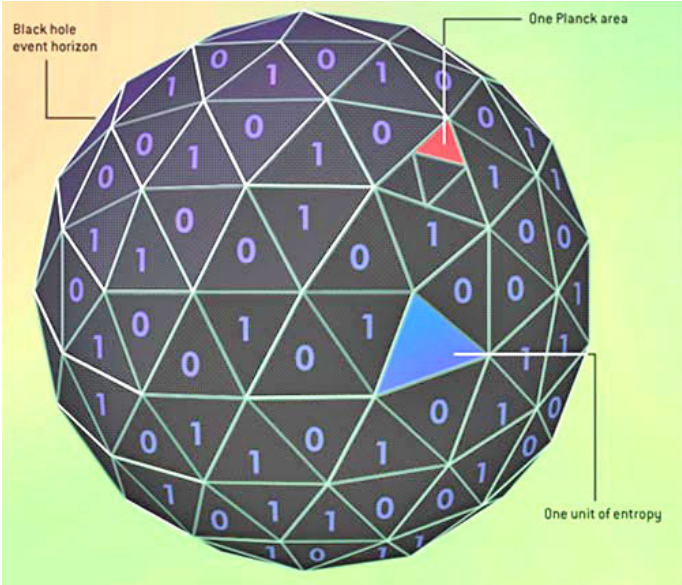
> Mind and intelligence are woven into the fabric of our universe in a way that altogether surpasses our understanding.
>
> God is what mind becomes when it has passed beyond the scale of our comprehension. God may be either a world-soul or a collection of world-souls. So I am thinking that atoms and humans and God may have minds that differ in degree but not in kind. We stand, in a manner of speaking, midway between the unpredictability of atoms and the unpredictability of God. Atoms are small pieces of our mental apparatus, and we are small pieces of God's mental apparatus. Our minds may receive inputs equally from atoms and from God. This view of our place in the cosmos may not be true, but it is compatible with the active nature of atoms as revealed in the experiments of modern physics. I don't say that this personal theology is supported or proved by scientific evidence. I only say that

> it is consistent with scientific evidence.
> - **Freeman Dyson** -

A preliminary remark: A pretty save way to discredit oneself in the physics community is to use the words **"consciousness"** and "God". But wait - I have included the word "philosophy" in the title of this WIKI-Blog and introduced the tag "philosophy" for this reason.

The following is a sketch of probably one of the most crazy ideas I ever had ...

Physical assumptions (preliminary and apt to be modified)



- Two levels of reality (**dualism**):
  Level 1 - **Planck scale** structure (coded in space). "Planckian atoms, molecules", etc.
  Level 2 - Classical and quantum matter (currently represented by the **standard model of elementary physics**).

- The fundamental concept and entity is assumed to be (quantum) information, on level 1 as well as on level 2. (The estimated **information of the universe** within our **causal horizon** is about 10^{122} bits, whereas the actually observed information (on level 2) is only of the order of 10^{89} bits. I.e., potentially "there is incredibly much room down there" (at level 1). Thus the information coded on level 2, seen from a quantitative point of view, is totally negligible. What could this information be on level 1, is it totally random ? We'll make the case that it is not. (It appears quite unnatural that the universe is totally structured and organized on level 2 whereas it is totally random and chaotic on level 1).

An update: It appears more and more convincing to me to assume that the bulk of information is coded in "global modes" which is motivated by the properties of **dark energy**. (Such modes have also been considered by Hameroff, Nanopoulos and others in the context of **(quantum) consciousness**). Consequently the Planck scale would be pretty void of information (see also **big desert hypothesis**). This need not be all that bad as it could be helpful in rendering gravity **UV-finite** (see also **asymptotically safe gravity**). Be it as it is, the arguments put forward should also "go through" in this case.

- Consciousness is coded on level 1. "Templates" of consciousness, which are "timeless". (Maybe related to **Jung's** concept of a **collective unconscious**). Helps to solve the **"hard problem" of consciousness**.

- Level 1 and level 2 allow for interactions. Manifestation: *Life*. Idea: The **collapse of the wavefunction** of a critical (biological) mass on level 2 leads to transitions between energy levels of Planckian structures which are of the order of the Planck energy. "Planckian chemistry" gets triggered. (Analogy: Transitions between energy levels of atoms due to Heisenberg's time-/energy uncertainty).
  I.e. lively/conscious matter is a totally different quality than is dead matter, as it requires a simultaneous chemistry on level 1 and on level 2. The concrete process underlying the reduction of the wavefunction is unknown at this stage. (There are many different collapse mechanisms described in literature but probably the correct one is yet to be found - **"Theory of Quantum Gravity** WANTED").

The scenario

- Different biological systems, being conscious, correspond with different structures on level 1, called "consciousness structures" henceforward. These are spacially separated from one another.

- We assume that every life form (in particular every **biological cell**) is related to a consciousness structure and therefore conscious. Higher consciousness is recruited by assembling (merging) and interlinking lower consciousness structures via level 2. (Multicellular organisms, **brains**).

- Our universe is part of a larger evolutionary process (it is part of a family tree of universes). We'll refer to it as **Supracosmic Evolution**. See also, **creating a universe** .

- The universe can be seen as an organism. The consciousness structures are the **"genes"** of the universe. (Carrier of the

relevant information).

- Every consciousness structure consists of a functional part and a message part. Analogy: genes.

- A consciousness structure should be as robust as possible, to be a relevant part of a "successful" evolution of the universe. Therefore the functional part should contain optimal *error correcting mechanisms*. (Hint: look for manifestations of the **Golay code** and the **leech lattice** in the context of a **fundamental description of spacetime**). See also, **organic universe**.

- The evolution of the universe is directional, towards more complex structures on level 2. See also: **omega point/"the singularity"**.

- A structure being complex enough, will technologically be able to read out the message part of the consciousness structures. (Compare this to gene sequencing).

- The message part contains an instruction how to create a new universe. (If not so, our universe probably represents a dead end of the supracosmic evolution - pretty unlikely). The message was "engraved" by the conscious beings that created our universe. That is, it essentially tells us "how to reproduce" on the cosmic scale. (Compare this to genetics where the genes code for a sperm and an egg and the polymerases are those who can read and "understand" that message).

- The reason to create a new universe is to escape the entropy increase and finally the heat death of the universe and to rescue the relevant structures into a newly designed spacetime and hence to become kind of **immortal**. (This is supported by latest findings that the universe is "flat").

- *"Reincarnation"* is possible, i.e. any structure on level 1 can give rise to a coherent structure on level 2.

- A coherent state associated with a specific consciousness structure is only possible during a certain period of time of a universe.

- There is a necessary hierarchy of coherent structures ("piled up over time"). This is kind of a consistency constraint. I.e. for larger consciousness structures to be realized, more complex biological structures on level 2 first have to build up step by step. I.e. **biological evolution** on level 2 is indispensable.

- Biological evolution is not "blind" and stochastic, it only appears to

us so, because our current physical and biological description only takes into account level 2.

- The space snippets a future intelligence can pack into a **black hole**, giving rise to a new universe (genetic engineering on the cosmological scale), will be limited in extend and information. I.e. they will be forced to include relevant structures only. Certainly, it will be their own consciousness structures. But for them to reincarnate they also have to include all lower level consciousness structures required for a successful evolution toward their reincarnation. This can explain the variety of creatures seen in our universe and the hierarchy of complexity they constitute. (So in principle we, i.e. our consciousness structures, too have a chance to be considered one day, meaning that we can reincarnate and get immortal ...). Thus, an advanced civilisation will not be allowed to be altruistic and will try to save their own consciousness structures in the first place.

- A resolution to the **fine tuning** problem is offered: Our universe is the result of inheritance and is not due to an extraordinarily unlikely **quantum fluctuation** "in the beginning". Hence fine tuning is not a problem at all any more, rather a virtue: An extremely fine tuned initial condition is required such that the algorithm representing the universe "generates" the relevant intermediate consciousness states, finally leading to the "instantiation" of the super consciousness/intelligence guaranteeing a further replication of the universe, keeping it in the supracosmic evolutionary race. (Compare this to the importance of the initialization of a **cellular automaton**).
  Maybe once a new universe is triggered, there is no more possibility to take influence. Thus a careful choice of the initial conditions is crucial. Another aspect: "Launching" as many universes as possible increases the chance that the correct consciousness structures will arise again. Yet every daughter universe created consumes resources (energy) in the universe of the creators. Therefore in such a scenario, universes created will be held as small and minimalistic as possible. Overhead will be avoided as far as is possible. (One could look for signs of such a lack of redundancy in our universe). This increases the pressure to select only most relevant consciousness structures.
  Supposedly there is an optimal number of daughter universes to be created, maximizing the probability of the superconsciousness structures to reappear in one of the universes.

- Another way to say it: A future generation creates a black hole, endows it with an algorithm and initializes it. (In physical terms this means setting the boundary conditions of a future universe and maybe the **constants of nature** therein, i.e. the free parameters of a fundamental physical theory).

- This offers an explanation of the incredibly low entropy of the **Big Bang singularity** and the high entropy of final singularities without conscious intervention (conventional black holes). (By the way, I suggest the name "Designer Black Hole" for a black hole/universe created by intelligence).

- The algorithm running our universe is the best algorithm known so far. (Once again, compare this to our genes). Preserving it therefore is imperative. This algorithm produces growing complexity up to a certain point but then drifts into chaos. Therefore a better algorithm is wishful. Yet a better algorithm - at least from our perspective - requires a blind search. There is no way of knowing if a cosmic algorithm is better without running it. Therefore initiating several daughter universes with slightly "mutated" initial conditions is tempting.

- A superconsciousness structure will be recruited from many lower level consciousness structures. I.e. a future super-intelligence should rather be seen as a human society than as an enhanced individual brain. The world wide web might be an emerging template of such a final intelligence.

- Information technology is a necessary vehicle to reach the evolutionary goal of our universe. Therefore **Moore's law** is not an accident. Moreover, scaling down information processing structures brings about the scaling up of manufacturing infrastructures and necessitates handling of ever larger energies. Finally we'll reach energy scales that allow for the manipulation of the very fabric of spacetime and the creation of new universes.

- Creating AI on level 2 only, being consciousness-like is a hopeless endeavour.

- Seeking biological immortality, i.e. trying to maintain a biological structure indefinitely on level 2 is a waste of time. (I am happy to have this insight now, having spent a considerable time trying to do so).

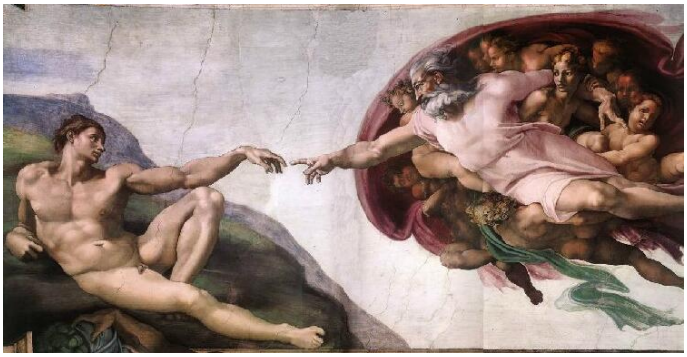
- On many complexity levels one sees replications: For instance **mitochondria**, cells or multicellular organisms replicate. Hence it is plausible that before the universe as a whole replicates, the human race will do so. This might mean space travel and the colonization of space. To do this, huge amounts of energy will be required. It might be that having the technology available one day to access huge energy resources will suggest to do space travel (i.e. space travel would be a byproduct). Or, the other way around, the desire to do space travel will lead to the development of technologies allowing for the exploitation of huge energy resources. At any rate, having control over huge energy resources at the same time is the precondition for creating new universes.

Doing space travel and exploring space may even lead to the discovery of other life forms in the universe. Therefore, the ultimate replication of our universe might very well not be done by one civilisation alone (e.g. humans and their descendants in space), rather it will be a concerted action by many civilisations (as all are "sitting in the same boat" and have the same desire). It may even be that a united action is indispensable.

- Consciousness structures that have not been included in our universe for "test purposes" are quite likely to already have existed in foregoing universes and have proved to be valuable, i.e. serve a purpose. But this would imply that our life is probably just one more reincarnation. Furthermore it is highly likely that we will be considered again for the next universe. Thus the chances to reincarnate once again are pretty good. (We can expect to be at least "intermediately immortal").

- Although all of this may seem pretty much of a stretch, essentially it is just bioinformatics scaled up to the cosmos as a whole (regarded as kind of a being as well). Actually information processing in biological systems should be seen as quite magic, but we got used to that part of reality and accept it, well knowing that it is a matter of fact. So why not go one step further ? Realizing that our current physical understanding is that the maximal information content of our universe is finite, i.e. a certain number of bits and bytes (even when including the information coded on level 1), may help. One can envisage that information on level 1 is coded in structures comparable to genes on level 2 that "transcended" the Big Bang. ("Planckian genes/genomes"). Thus seen from the perspective of information, the Big Bang would be quite analogous to the act of birth in biology (merely described on level 2, i.e. in terms of molecular biology). One can compare the sequence of universes of the supracosmic evolution with the germline in biology, which in a way is "immortal". Furthermore, advanced genetics makes possible "designer babies", which corresponds with the "designer black holes" alluded to.

Religious implications - existence of a God



- The universe is God, God is the universe. Hence God is a pantheistic God.

- (At least the coming) God is not omnipotent and is limited by the laws of nature. Yet he/she is more potent than what we are at the moment. There is an upper limit of information representing this God. (Suggestion: Count the number of Planck volumes that fit into a universe and assign to every volume a bit. Or if you believe in the **holographic principle** count the Planck areas instead).

- The universe was created by the "top level" consciousness of a preceding universe. This intelligence or the preceding universe can be regarded as our "creator God".

- We are programmed on level 1 to be productive and creative. The final intelligence will create a new universe and save the relevant **"souls"** of our universe. This can be regarded as "judgment day". Depending on the "relevance" of our consciousness structure, we will be included in the new universe or not. If so, we will "go to heaven". If not, our consciousness structure will be destined to erode in this universe, its entropy will increase over time and end up in a universe suffering heat death, i.e. finally it will be extinct. (What better metaphor than "hell" could one find for that ?)

- It could be that the deeds during our lifetime can influence our consciousness patterns on level 1 (e.g. if there is something like **free will**) and they might become more interesting to be included in the new universe on "judgment day". (It is clear that a read out and a writing of these structures must in principle be possible for the whole scenario to make sense. The question is, if mere conscious acts already can do a writing, e.g. praying, introspection, meditation, etc. At least a steady reading out takes place, otherwise we wouldn't be conscious). If so, we should seek to play a key role in the evolutionary process towards future God-like structures. (We should "work" for them). Therefore strong believers and "true" prophets may be in a better position when it comes to rescuing souls one day.

- God is to come and it is the future civilisation that is in a coherent state with the consciousness structures that can read out the

instruction how to build a new universe and will do so. This will be the creator God of the new universe.

- There is hope: The universe neither is due to a ridiculously unlikely quantum fluctuation in the beginning and the final destiny of it may be irrelevant to our souls. The dark scenario envisioned by Boltzmann thus would be wrong. Furthermore **Boltzmann brains** are explained. (Without trying an interpretation, let's mention that Boltzmann suffered from severe depressions and finally committed suicide).

- The "Noah's Ark" metaphor makes sense in the cosmological context. Not "everything" of our universe can be rescued one day.

- Trinity in the Christian religion finds a natural explanation. God the creator is the consciousness structure of our predecessor universe. The holy ghost is the consciousness structure of our current universe - thus the holy ghost is more or less a copy of the creator God. And finally, Jesus was a human being, that is a biological system on level 2, that was extraordinarily gifted in interacting with level 1. This is what characterizes a prophet. On the other hand there is no reason to believe that Jesus was outstanding in the history when it comes to this ability. Not surprisingly many religions report of prophets and one has to see them all on a common ground and take serious what they say about the world on level 1.

- As we see a high hierarchy of structures, it is by no means clear, that it ends on the level of a universe or a sequence of universes. This hierarchy could in principle even continue ad infinitum. That is on every hierarchy level one could define a God-like structure (a "meta"-God). Taking the limit, this would lead to the ultimate and almighty/omnipotent God. Although every consciousness structure can be regarded as a God, compared to this "infinity meta-" God, we would be vanishingly primitive Gods.

- As probably most of the consciousness structures in our universe will "survive", we should try to appreciate our next.

- As we all may reincarnate, this gives life a meaning.

- The point is not to find "heaven", in fact we are in "heaven" - rather, the point is to make it to "heaven" over and over again.

Comments

- Many predictions of the model have great resemblance with assertions made by various religions (e.g. the Christian religion, the Islam, Buddhism, etc.). Let's stress that it is not just one

religion !

- The scenario suggests a mapping of physical structures to a certain notion of God. Anybody who thinks that her/his notion of God is different is certainly free to do so - this is just one attempt to interpret what we mean by saying "God". Yet we have already come to describe genetic manipulation as "playing God", so why not use the word "God" in the context of creating a whole universe and genetically manipulating the very fabric of spacetime on level 1 ?

- There is good chance that the natural sciences and religion are compatible (and in the end converge to one and the same). Even better, it looks like there is hope for a unification of disparate religions. (These disparities being one of the major causes of blood shed in the past and unfortunately still today).

- Being rescued into a new universe may depend on the survival of mankind. Therefore we should try to avoid the eradication of the human race (e.g. by a nuclear war, a cosmic catastrophe, etc.). This fact also sets the stage for a certain kind of ethics (e.g. compassion, peacefulness, etc.).

Open questions

- Are all consciousness states already there in the Big Bang or are they generated dynamically (algorithmically) due to the specifically fine tuned initial conditions ?

- Do consciousness structures replicate within a universe ? If so, is there a relationship with time and the conscious "now" ?

- How can one understand consciousness structures that are replicated into two universes and reinstantiated in both cases (sounds like schizophrenia) ? I.e. there seems to be a *cloning paradox*.

- Many more open questions remain, not listed here. The whole scenario hence should rather be seen as a toy model for thinking about "life, the universe and everything" than as an oracle, offering the ultimate truth.

See also:

- **Cosmological natural selection**
- **Intelligent design**

Papers:

- The Future of Scientific Simulations: from Artificial Life to Artificial Cosmogenesis. (2009) - C. Vidal local pct. 16
- THE MEANING OF LIFE IN A DEVELOPING UNIVERSE - J. Stewart local pct. 13
- Stardrives and Spinoza (2010) - L. Crane local pct. 0

Links:

- A Theorem Concerning God (2009) - R. G. Brown local

Videos:

- Intelligent Universe, Bio-Cosm, ET, AI and Evolution - Jim Gardner 1 2 3 4 5 - It turned out that somebody already had quite similar thoughts. I like J. Gardner's idea that the universe might be a **self-replicating entity**.
- Closer to Truth - Cosmos, Consciousness, God - F. Dyson
- Closer to Truth - Is the Universe Fine-Tuned for Consciousness? - M. Kaku
- Is there a Creator? 1, 2, 3, 4, 5
- Horizon: Was the Universe Born in a Black Hole?
- Civilizations' Destiny into a Blackhole 1 2 - Although I would not underwrite all of that, it's quite interesting ...
- Scientific Perspective - Dr. Peter Atkins
- God & Universal Intelligence
- Harald Lesch & Hans Küng - Gott plus Urknall = x
- Existiert Gott? - Harald Lesch & Thomas Schwartz
- 50 Renowned Academics Speaking About God
- A Quantum View of God - A. Goswami
- Cosmic Conversations & Mysteries of the Universe

Your comments are very welcome →

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Creating a Universe

> Imagine you have never ever met any other being on

> planet earth and come up with the idea that the creation of you has been initiated by somebody like you. Wouldn't that be a crazy idea ?
> - **Markus's wisdom** -

> ... our universe ... possibly ... a by-product of a search for something else ...
> - Jürgen Schmidhuber - Algorithmic Theories of Everything -

Is it conceivable that the universe we life in has been created by some kind of intelligence in a parent (predecessor) universe ?
Some questions in this respect:

- What does it take to create a universe ? (If some preceding intelligence has done it, it seems likely that we are pretty much like them and we could do it as well one day). Hence to understand how to build a universe might allow us to better understand the origin of our own universe.

- Why would some kind of intelligence in a universe be interested in sprouting a child universe ?

Some thoughts, ideas and speculations:

- A complex system doesn't appear "out of nothing" or out of randomness, rather it should have a long evolutionary history. As our universe, in particular as it harbours intelligent life, is a pretty complex system, it may well be that the few billion years since the **big bang** are not enough to explain all the necessary steps evolution had to take to end up with a universe the way we see it today. Therefore, introducing an ancestry of universes gives evolution more time, as now the time available to produce our universe as an output is a few billion years times the number of predecessor universes.

- The big bang singularity has a ridiculously **low entropy** whereas the **entropy of a black hole** is high. (An oddity **Roger Penrose** over and over again has pointed to). If one assumes that a **black hole** naturally gives rise to a baby universe, it seems quite mysterious what effect it would take to convert the initial high entropy state to a low entropy one. An alternative is "intelligence". I.e. only such universes are low entropy universes that have been created due to the intervention of intelligence. The natural creation may well exist alongside, but these offspring universes most probably are low in complexity (as high in entropy) and

therefore will not give rise to intelligence.

- The explanation of the emergence of **consciousness** and intelligence could be that it guarantees the replication of the universe, a necessary step in an evolutionary process. I.e. consciousness is one possible trait of a universe guaranteeing survival in the evolutionary process. (Expressed in a more colloquial way: Consciousness is the "sexuality of the universe", destined to reproduce it and to contribute to the evolution of its kind). If this it true, evolution also is taking place on a higher level than what we are accustomed to.

- If our universe is "programmed" for life, this means that the **strong anthropic principle** holds and the scenario alluded to here is a concrete realisation of it. This implies that the universe may not have completely unfolded yet and it offers an explanation as to why we see an ongoing progress, characterized by a directionality towards more complexity and organisation which is contrary to what one would naively expect due to the second law of thermodynamics. (For an extreme conclusion from this fact, see **omega point theory**). Furthermore this makes it quite likely that our planet is not the only place in the universe harbouring life (i.e. **"we are not alone"**).

- In this respect I came up with a totally strange Gedankenexperiment: Suppose we create matter and anti-matter by means of pair production. From the anti-matter we form a black hole whereas the matter we assemble in a low entropy state. (Maybe one could even create a conscious **brain** out of the matter part. Curiously enough, experts say that to create a universe in the laboratory it only takes a few pounds of matter, incidentally, just about the mass of a brain of a highly developed intelligent species). If the anti-matter black hole gives rise to a daughter universe then it seems that the whole of this universe is **EPR-correlated** with this complex structure in our universe. (And if this complex structure is conscious, this consciousness is EPR-correlated with the whole of a universe). We can turn this argument upside down and wonder if the whole of our universe is EPR-correlated with some preceding intelligence. So then, could our consciousness be correlated with some maybe further developed intelligence in another universe ? Could this explain how ideas come into the world ? I.e. could that mean that seemingly new things we come up with are just inherited from some foregoing intelligence and are not really new ?

- Furthermore this model could serve to explain the **fine tuning** of our universe.

- Why does evolution bring about species like us, having brains, capable of doing abstract thinking like in mathematics, which

appears to be totally redundant when it comes to mere survival and reproduction. (I.e. the "game" of evolution) ? The answer could be this: we are more or less "like them", and they had to have such brains to be smart enough to create our universe (maybe in a sophisticated laboratory setup).

- One does not face the **Boltzmann brain paradox** resulting from the assumption that the universe and life therein is the result of an initial appropriate quantum fluctuation.

- A quite compelling explanation for why our universe was intelligently created, is that it is a **"simulation"** (or "program") running on a "computer" of an advanced civilisation. (Although I have heard of this argument several times before, I was never much convinced of it. Yet in this context it is way more plausible and interpretable to me). If one makes the weak assumption that an advanced civilisation is doing information processing and like us tries to built ever more potent information processing machines, consequently the structures of the processing units have to get smaller and smaller. The ultimate limit - as far as we know today - is the **Planck scale**. If it were possible to read and write units on this fundamental scale, this would be the ultimate computer. But this means manipulating the very fabric of spacetime itself. To do manipulations on these small scales, probably enormous energies are required. Hence one is acting in an energy regimen not so far away from that where the creation of small black holes (or baby universes) takes place. Yet contrary to blindly smashing matter into one another to create a black hole, here one is doing it in a orderly way. Therefore the creation of a black hole (and hence a descending universe) could be explained by intelligence (or "consciousness" ?), i.e. being the by-product of an advanced civilisation having the sheer desire to do ever better information processing, a trend also observable in our civilisation, so maybe one day ... In this scenario our universe

could be a "Game of Life" (or more generally a **cellular automaton**) simulation (having universal computing power), running on a sheet of spacetime instead on a silicon wafer, initiated by a "Super Conway" in a predecessor universe. The replacement of silicon as the fundamental substrate by spacetime is what may help make the whole scenario appear more plausible. (Every physical process is a computation and every computation can only be done harnessing a physical process). Therefore the days of silicon based computers seem to be counted and our "primitive" notion of a computer may change over time). See also: **digital physics**.

- If this scenario is true, we could speak of **"intelligent design"** of our universe. Yet this does not necessarily imply the existence of a monotheistic God. Rather the existence of beings that are not more of a God than what we would be one day if we were to create a universe in the laboratory having the potential to bring about intelligent/conscious life would be enough of an explanation. Besides God and the **multiverse** (or **landscape**) this offers a "third way" (one "in between") for making plausible why the **world around us is so special and unlikely**.

See also:

- **Organic universe**
- **Are we sitting inside a black hole ?**
- **Cosmic creation and God**
- **Cosmological natural selection**

Papers:

- The Natural Selection of Universes Containing Intelligent Life (1995) - E. R. Harrison local pct. 70 - Stunningly Edward R. Harrison came up with nearly exactly the same idea. I only came across his paper after having written most of the things above.
- The Universe out of a Monopole in the Laboratory? (2006) - N. Sakai, K. Nakao, H. Ishihara, M. Kobayashi local pct. 23
- Possible Implications of the Quantum Theory of Gravity (1994) - L. Crane local pct. 17
- Message in the Sky (2006) - S. Hsu, A. Zee local pct. 11
- Universes out of Almost Empty Space (2007) - S. Ansoldi, E. I. Guendelman local pct. 10
- Cosmological Artificial Selection: Creation out of Something? (2008) - R. Vaas local pct. 9
- Child Universes in the Laboratory (2006) - S. Ansoldi, E. I. Guendelman local pct. 8
- The Thermodynamic Arrow: Puzzles and Pseudo-puzzles (2003) - H. Price local pct. 8

- Life, the Universe, and almost Everything: Signs of Cosmic Design? (2009) - R. Vaas local pct. 6
- The Real Message in the Sky (2005) - D. Scott, J. P. Zibin local pct. 3
- Articial Cosmogenesis: A New Kind of Cosmology - C. Vidal local pct. 3
- How to Create a Universe (2007) - G. McCabe local pct. 1

Theses:

- The Beginning and the End (2013) - C. Vidal local tct. 10

Documents:

- Evo Devo Universe? A Framework for Speculations on Cosmic Culture - J. M. Smart dct. 27
- The Evolution and Developement of the Universe (2010) - C. Vidal local dct. 2

Links:

- Scholarpedia - Time's Arrow and Boltzmann's Entropy
- Evo Devo Universe
- The Role of Life in the Cosmological Replication Cycle - B. A. Balázs

Audio:

- Build Your Own Universe (2006) - Highly recommended in this context.

Videos:

- The Beginning and the End: the Meaning of Life in a Cosmological Perspective (2013) - C. Vidal
- Paul Davies on Big Bangs
- Louis Crane: "Quantum Mechanics", FQXi Azores Conference 2009

Journals:

- Is it Possible to Create a Universe in the Laboratory by Quantum Tunneling? (1990) - E. Farhi, A. H. Guth, J. Guven jct. 213
- An Obstacle to Creating a Universe in the Laboratory (1987) - E. Farhi, A. H. Guth jct. 201
- Stochastic Approach to Tunneling and Baby Universe Formation (1992) - A. Linde jct. 106

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

God and Physics

...and God said:

$$\mathcal{L}_{\text{QED}} = \psi^\dagger \gamma_0 (i\gamma^\mu D_\mu - m)\psi - \frac{1}{4} F_{\mu\nu} F^{\mu\nu}$$

where,

$$\{\gamma^\mu, \gamma^\nu\} = \gamma^\mu\gamma^\nu + \gamma^\nu\gamma^\mu = 2g^{\mu\nu}$$
$$D_\mu = \partial_\mu + ieA_\mu$$
$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$$

... and there was light!

Here are ways a God could be related to physical reality and humans:

- He/she is omnipotent, i.e. he/she can change (mathematical) laws and manipulate any state of the physical world at will. But the question then that arises is, what kind of reality is it that God him-/herself belongs to. This is actually the "everything goes version" of a God and like in the case of "everything goes theories" there is little science can do about it because there is no way to exclude infinitesimally many alternatives to a given scientific scenario. (Therefore this kind of God is not falsifiable). This God actually has no predictive power because by definition he/she explains everything and therefore can be identified with the "God of the gaps" because whenever a gap shows up, it doesn't matter if a physical explanation will be found or not because if one is found the reason for the specific physics (i.e. the laws) is God anyway and if none is found there has to be one, but it is just not accessible to us, that is "only God knows".

- He/she is part of another reality (metareality) not interacting with physical reality at all. But if we humans are fully contained in physical reality then this notion God is meaningless.

- He/she is part of another reality (metaraeality) but is interacting with physical reality. It's hard to imagine what this means, maybe this interplay manifest itself through something like seemingly random and unexplainable events, miracles, etc., something scientists tend to abhor because there is little to no hard evidence for such things (yet innumerable myths). By definition God resides in another realm and is not accessible to scientific methods. Essentially all this boils down to the **dualistic** world view including a God.

- He/she is fully part of physical reality (a pantheistic God). Then he/she must obey the laws of physics and cannot have created them. But what he/she still can do is to create a universe with beings like us by appropriately setting the initial conditions. In this case God is a creator God (like the one in the Bible). Moreover there could still be interactions between us and God which however must be a physical in nature. But the problem is that we have no scientific evidence whatsoever of physical interactions between us and a God so far. The explanation for this could be that there is yet a realm of physics that we do not know or understand.

- He/she has created the universe but is not interacting physically with us any more, explaining why we see no traces of such interactions. But this is counter to many religions where prayers for instance play an important role. Moreover the behavior during lifetime is believed to be relevant in respect to an **afterlife** (e.g. heaven/hell scenario in the Christian tradition) and therefore God must "watch" us.

Are there scientific ways to find out if there is a God ? Not too many I guess, but I have a few suggestions (some serious ones and a last one, which is not so serious):

- Look for new physics. In particular the understanding of interactions of the **mind** with external physical reality seems to be important in this respect.

- Look for God on space/time scales (preferably larger ones) quite different from the ones in everyday situations (e.g. in laboratories). In particular, analyze long range correlations on cosmic temporal/spacial scales or even beyond (i.e. in the ultra nonperturbative regimen of physics). Maybe we and God are nearly decoupled because we act on completely different scales and therefore we have not seen any hints of him/her so far. For God our typical time frames may be "peanuts". E.g. a complex thought of God could take millions of years. If God is physical the way we are, but exists on another scale, one expects that our physiology and his/her are related by **power laws** which are omnipresent in biology. I.e. a very slow process on a cosmic scale could be understood as a subdominant process of a way huger biological (complex) system we may call God (at some hierarchical level and beyond). E. g. our universe could be kind of a cell as part of a larger multicellular "organism" (God = **multiverse** ?!). In this respect one should also look for hints that the Universe is a **self-replicating entity** which is an essential part of biological systems/cells. Yet if this is so and if we are confined to a small subunit of a larger "being" we can only indirectly infer his/her existence. Compare this to chemical agents

in a white blood cell in our body. What can these "know" about the cell's purpose or even the whole organism, its thoughts, etc. But like them we serve a purpose in a larger context.

- Look for fingerprints in the creation process, thus also taking into account the possibility that God is not acting on the cosmos any more.

- Help to push quantum communication technology (let us all become Alices or Bobs :-)). As soon as most of our interhuman communication channels are quantum, God - assuming that he/she also obeys the laws of quantum physics as we know them - will have hard times doing eavesdropping at this level without us realizing it. This of course will only work if God does not put emphasis on being a God in disguise (for whatever reason). Otherwise he/she will probably restrict him-/herself to other channels when trying to access us.

See also:

- **Cosmic creation and God**

Links:

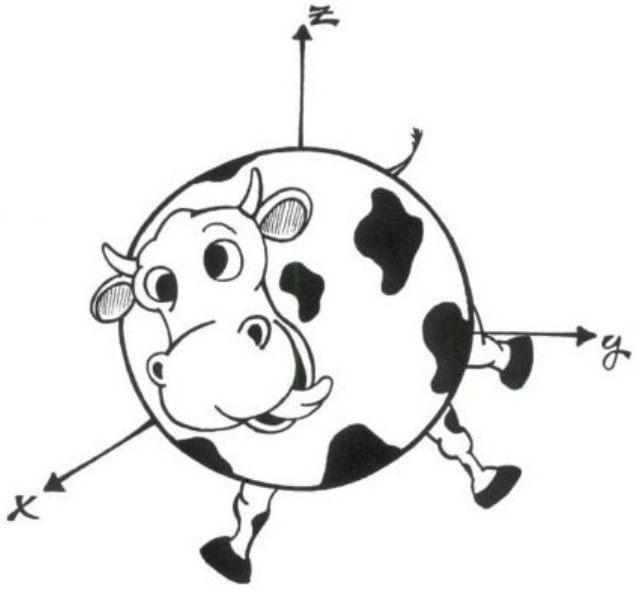
- God and Quantum Physics

Videos:

- God is not a Good Theory (2013) - S. Carroll

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Idealizations in Physics



Spherical cow

To say it right away, **Idealizations in Physics**, it seems, is quite a difficult and intricate topic and not surprisingly philosophers also like to dwell on it. Moreover, the literature (in particular the philosophical one) suggests that it easily leads one to splitting hairs.

The following is a mere reflection of the philosophical stance of the author of this WIKI-Blog, resulting from a struggle to better get to grips with the issue:

The key thing in physics is that whatever a theory or model predicts, an experimentalist can always only verify it up to a certain measurement accuracy. That is, strictly speaking, any physical statement has to be supplied with statistical data (mean value, standard deviation, moments, ...). Therefore "yes/no" statements by themselves do not really make sense in physics, they are mere philosophy. These are often hidden in sentences where an "is" appears. E.g., is the electron pointlike or is the **photon massless** ? All an experimentalist can do is to give a lower limit of the radius or mass respectively.

Let's have a closer look at the details and subtleties of the problem. Suppose one is given some experimental data and constructs a theory which is in accord with them (up to experimental uncertainties, of course). On the one hand one could ignore any further predictions of the theory and be happy that one can "understand" the data, having put them in a broader context. But then one runs the risk that an alternative theory is found which also is consistent with the data but with a completely different interpretation. But this alone is not really a problem, physically seen (cf. **interpretation of quantum mechanics**), rather that this theory could make different predictions beyond the data given from the ones of the original theory.
So, besides the fact that one of the essentials of theoretical physics is

to make predictions which can lead to new discoveries, there is some urge to "follow" the predictions in order to solidify the theory, i.e. to demonstrate its robustness in regards to competing theories. (There is some Darwinian principle of theories at work here, i.e. only the "fittest" theories survive).
But now about the subtleties; should we take any prediction serious ? It seems that there are fundamentally different predictions of theories which we shall try to classify in the following:

- A: Predictions that can be verified by experiments (e.g. the bending of light around the sun in **General Relativity**).

- B: Predictions that have no realistic chance of ever being experimentally verified. Assigning a theory to this class rather than class A is a bit a matter of taste and belief. But for the time being these predictions are definitely useless, as they do not allow for a segregation among the competing theories. (Classical examples are **string theory** and the **multiverse**).

- C: Predictions that lead to paradoxes or seeming contradictions. (E.g. **naked singularities** or **closed timelike curves** in GR). Here further thinking about the theory may be in place in order to try to clarify things. Such predictions could signal a breakdown of the theory. Nevertheless, if it turned out to be so, this does not imply that the theory is useless, as any theory must be seen as an *effective theory* with potential limits (e.g. **Landau pole** in **QED**).

- D: Predictions that are definitely beyond experimental verification. E.g. a **singularity** in GR (in the strict mathematical sense), or a "jump" of some **thermodynamic** function in a **phase transition** (for some of the derivatives are infinite). The point here is the one already alluded to above, to experimentally check that something is exactly zero or there is an **infinity**, i.e. the inverse of the infinity is exactly zero, one had to do a measurement with an infinite accuracy - impossible.

Idealizations play a crucial role for classes C and D. Theoreticians are forced to make (simple) assumptions constructing their theories and models as they never have full knowledge of the situation out there.

When making a mathematical model there may be "anomalies", such as infinities.
The important thing is that the theory itself cannot know what the physical relevance of such an anomaly is. But given the fact that we can be almost certain that our models have left out something, i.e. they are idealizations, there is little reason to believe that anything in its mathematical purest form in nature exists, like a mathematical point or an infinite energy. Therefore, as a rule of thumb, infinities, for instance, should always make one suspicious. (See also: **is nature infinite ?**).

Another, yet minor (and more technical) point is that in the course of calculations physicists often neglect terms. One common example is to drop boundary terms or to formally "push" them to infinity which physically bears little justification.

In what follows, a list of things that belong to class D, i.e. which have the status of an idealization, that they will retain forever. For them we can state that there is no

- Spacetime singularity.
- Ideal phase transition (all that matters are *finite-size scalings*, the rest are idealizations). This also concerns an infinite *correlation length*.
- *Thermodynamic limit*.
- **Spontaneous symmetry breaking** in the sense that "spontaneous" means instantaneous.
- **Goldstone bosons**, only *pseudo Goldstone bosons*.
- **Infinite number of particles or degrees of freedom**. As an immense consequence of that, there is no **quantum field theory**.
- **Chaos**.
- *Superselection* (conservation) laws.
- Classical physics.
- Property that deserves the name fundamental. Actually fundamental always means fundamental up to a measurement uncertainty, i.e. one can call it effective right away.
- Point particle (as described by a delta function), string, brane, ...
- **Theory of everything**.
- Etc.

All these things are approximations to the best of our knowledge. Yet, this does not imply that we can expect a deviation upon improving measurement accuracies, therefore these properties at least serve as good guiding principles.
Why are such seemingly unphysical concepts (mathematical idealizations) so successful ? Here is an attempt of an explanation:

- Out of the many possible mathematical notions, these are the ones that have proven to work best over many orders, large ranges, etc., i.e. they are particularly robust descriptions withing

the sea of complexity of the real world.

- Making a measurement means making a "cut" in the physical world, dividing it into a (sub-)system of interest and the rest. In practice, the system is laboratory-sized. Infinity and a point are "furthest away" from this cut and therefore are prone to be vague concepts. As everything in the natural sciences is based on measurements, this implies that it can only be considered relative to the cut with its given scale. (Yet, different cuts are possible, see **complementarity principle**).

- Experiments tend to be laid out to "isolate" a phenomenon hence creating a somewhat artificial situation. In contrast, the everyday word is more intertwined and complex. I.e. experimenters look at a phenomenon from a "convenient" perspective, e.g. in a special parameter range, a linear or non-perturbative regimen, etc. This leads to selection effects. As a result, this bias may suggest the wrong overall picture of nature. Yet, there are situations where there is no experimental control and small effects cannot be "stripped off", e.g. the "butterfly effect".

- Much in physics is based on *symmetries*. But they can be **emergent**, i.e. only seemingly exact at a certain scale (where we make the cut). E.g. the rotational- (SO(3)) symmetry of liquid water.

As a conclusion, a good way to look at physical theories seems to be that they serve as kind of a "magnifying glass" which allows one to look at nature at a certain scale. This is also in the spirit of **renormalization theory**. What is below and above that scale is purely a matter of speculation.

Papers:

- Idealization in Quantum Field Theory (2005) - S. Hartmann local pct. 13
- Abstraction and its Limits: Finding Space For Novel Explanation (2012) - E. Knox local pct. 1
- Physics and the Measurement of Continuous Variables (2007) - R. N. Sen local pct. 0

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Is Quantum Gravity Trivial ?

What is meant by **"Is Quantum Gravity Trivial ?"** is that **quantum gravity** is "trivial" in the UV (e.g. the **Planck scale**) in the sense that there is not much phenomenology to be discovered there, but not so in the IR.

Some ideas:

- At the **GUT** scale physics is already quite "simple".
- The early universe is quite "simple".
- The **vacuum energy** calculated by means of **QFT** is way to high (**cosmological constant problem**). A recipe for a resolution: "Unpopulate" the vacuum, make it "simple".
- The **renormalization group** flow is from a simple *effective action* at the GUT scale to a complex and messy IR action (possibly nonperturbative). Compare this also to confinement in **QCD**.
- There may be a *UV fixed point*. Nothing new happens there when further "zooming in" due to self-similarity. **Universality** reigns, i.e. spacetime is in a universality class and the microscopic structure is unimportant. (Be there a **superstring** description or any other description which leads to this universality class, physically it would make no difference).
- If the **Bekenstein-Hawking formula** of **entropy** is correct and the bulk of entropy stems from **dark energy** modes in the IR, there is nothing left for UV entropy. (See also **dark energy for dummies**).

So maybe the interesting physics is the one around us, which is already mostly discovered, because this is the realm of complexity, and a theory of quantum gravity, if we can ever come up with such thing, will just add some "boring" new physics, which on the other hand may have important philosophical implications.

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Multiverse and Consciousness

There have been claims that if the **multiverse** is real and - at least if it is infinite - there should be perfect copies of me and you out there. But there is a problem with this statement at least from the point of view of the individual beholder, for the **conscious** self (the "me") resides in just one of these "perfect" copies. So what does perfect really mean in this context? (This problem is closely related to the *cloning paradox*). To forestall misunderstandings, the type multiverse meant here has nothing to do with **Everett's many wolds**.

The most straightforward way out of the problem is of course to just reject any theory of an infinite multiverse to be a physically viable one. (But then one may run into other problems. In case of **eternal inflation** for example, which explains the **Big Bang** quite well, the multiverse arises as a logical consequence).

But let's take the multiverse scenario to be true, then I claim that a resolution to the paradox is possible by assuming that consciousness is nonlocal, i.e. it is not confined to the biological body. This doesn't mean by any means that not a lot if not most of conscious activity takes place in the biological **brain**, rather that it cannot be all of it.

Let's get more technical: We regard a conscious being as a complicated quantum system represented by $|\Psi_B\rangle$, having a certain number of **states** which should be finite. In other words the body consists of a few moles of atoms, each atom having a certain (finite) number of possible states. (We think fully in terms of reductionism here). If we wanted to perfectly copy this state this is not possible due to the **no cloning theorem** of **quantum mechanics**. (By the way, this is one of the reasons why *mind uploading* is highly doubtful in my opinion). But nothing seems to speak against having just by accident two equal finite systems in the same state at some instant in time, if the states are steadily changing over time. (A simple example which should make clear what is meant here are two electrons, both having spin up or down at some instant in time, yet they are not correlated/**entangled**). This suggests that there is a quantum version of the *Poincaré recurrence theorem* which is even more strict than its classical counterpart because if the states of a finite quantum system are changing over time it will with any degree of certainty one likes return to its original state, if one were only to wait long enough. (Something like a *quantum revival* maybe).
So let's introduce some copies $|\Psi_{B_i}\rangle$ which are located somewhere in the multiverse and just happen to be identical to the original $|\Psi_B\rangle$ (that's where I assume that my consciousness resides - strictly speaking, to avoid subtleties like with solipsism, I actually can only speak of my own consciousness). As an aside, there may well be further problems with **time**, simultaneity, etc., because we have to go relativistic to have a serious description, but we'll ignore this here. (Just to mention it, the **free will theorem** may help to tackle this issue because it includes the relativistic case). Then the state space of

the multiverse should look something like this

$$|\Psi_{Multiverse}\rangle = |\Psi_B\rangle \otimes |\Psi_{B_i}\rangle \otimes |\Psi_{rest}\rangle$$

where $|\Psi_{rest}\rangle$ is just the complement of the states of the conscious beings in regards, whatever that is. If the index i takes just a finite number of values or infinitesimally many makes no difference in this context, as the paradox already arises if there is just one perfect copy of "me" or "you" out there.

The way to resolve the paradox now is to enlarge $|\Psi_B\rangle$ ad infinitum. In the following we'll make an attempt to motivate this step, yet there will be no proof.
It is hard to imagine a conscious being that is completely isolated from its environment. Aside from the basic functionality like breathing, requiring oxygen from the environment, etc. there is also a close relationship between a conscious act and the senses. On the other hand one could imagine that for a short period of time conscious input exclusively comes from the inside (in 3-d space) - some sort of "introspection". But then the question is where does the "input" really come from, is it the manifestation of the state $|\Psi_B\rangle$ merely or is there more to it. This is a difficult question and leads one into psychology and issues like **collective unconscious** and so forth. In fact there is no definite answer to this question. But let's be very conservative and assume that to the inside consciousness is fully encoded by $|\Psi_B\rangle$, then one is still left with outside correlations. For instance, watching a beautiful sunrise, this leads to a certain state of the mind. But then for

my copy out in the multiverse to be in the same state, one has to include a copy of the external stimulus, i.e. to extend $|\Psi_{B_i}\rangle$ to $|\Psi_{B_i}\rangle \otimes |\Psi_{sunrise}\rangle$. But were to stop with such inclusions ? For example, I could have a look at the map of the **cosmic background radiation** leading to a certain conscious state of mine. But then the safest way to guarantee that my partner out there "feels" the same in this case is to embed him in the same (pocket) universe.
So should we stop at the **cosmic event horizon**? Why ? We could still be **entangled** with states before the **inflationary** era which have long disappeared behind the event horizon. The cleanest way out of the predicament is to assume that there is just one quantum state of the multiverse and that any attempt to project out an observer with consciousness in a certain way is ad hoc, relative and consequently quite meaningless, i.e. consciousness is global, though in quite a subtle way. (This also opens up the possibility that consciousness involves **non-computability**).

One can make yet another point: Let's assume that to describe a conscious state completely only a state with a finite number of additional degrees of freedom representing a large enough environment is needed. But this implies that we have to regard this subsystem as being completely isolated from the multiverse. (Actually it is not clear if this is possible at all, for even if we "switch off" all interactions, what about the correlations with the quantum vacuum ?) Then our very assumption that the multiverse is there is pointless. Moreover this isolated system is fully *unitary*, there is no flow of thermodynamical time, no second law of thermodynamics. This definitely is at odds with consciousness as we know it. Thus the multiverse implies that a conscious being is an open system, open towards the whole of the multiverse it seems, open towards **infinity**, establishing perfect irreversibility and **decoherence** of our world. One can also see the "roots" of **free will** in this. (Note that free will of the observer is essential in the proof of **Bell's theorem**).
Another way to look at the problem is from the perspective of **quantum field theory**. Having a truly identical copy of mine means that there must be a unitarily equivalent **vacuum** out there in the multiverse out of which my partner can be created. (Due to a lack of a good understanding of this situation, I assume that two local patches of spacetime here and there are identical). But if QFT is really a theory of **infinitely many degrees of freedoms** as is often stated, it implies infinitely many **unitarily inequivalent** vacua (which is also suggested by inflation). Then there seems to be no guarantee that one can find a perfect copy of a given vacuum in the infinite set of vacua recruiting the multiverse.
There are two variants of this scenario:

1. There is no **UV cutoff** in QFT, then we don't need a multiverse because we can have an infinite number of degrees of freedom in a finite volume. (This is not the case of concern here).
2. There is a UV cutoff, then the infinite multiverse can provide an

infinite number of degrees of freedom.

Very interesting in this respect is the theory of **quantum brain dynamics** which postulates that to properly understand the functioning of the brain QFT is imperative. An interesting outcome of the theory is that there is a mirror of myself (called a "double") which one could roughly identify with $|\Psi_{rest}\rangle$ from above.

If consciousness is really connected with the multiverse then the multiverse should in principle be detectable. Phenomena that seem to be promising for finding signatures are for example **(quantum) phase transitions** and **(quantum) chaos**. Roughly speaking it all boils down to finding out if infinities are generic to nature or are merely an artefact resulting from the mathematical modelling. (But this is not as easy as it may seem. The intricacies are delineated somewhat under **"is nature infinite ?"**).
Another approach is to do "reverse engineering" of consciousness. My suggestion is to attempt to build a **quantum field computer**. (Sponsors are very welcome in order to tackle this :-)).

Based on this scenario it is imaginable that consciousness is a very peculiar and unusual state of matter, fundamentally different from any other one. The key difference being that in case of consciousness correlations reach out to infinity (or at least "infinity for all practical purposes" or as far as we can tell) whereas in usual (laboratory) systems they are limited in space and time (e.g. phonons in a crystal are confined to the sample). This can explain why consciousness is such a "slippery" concept for it appears as being in contrast to a classical law, whose hallmark is repetitivity. (For some further reflections in this context, see **about the scientific method**). In case of consciousness any state is unique, fully unreproducible and unpredictable. One could even go as far as to claim that conscious observers are the only classical "systems" in nature. (If a limit to infinity in the mathematical sense exists, they are perfectly classical, otherwise they would be classical for all practical purposes, i.e. more classical in comparison to any other physical system in the universe). This may help to shed light on some of the enigmas concerning the interrelationship of observers and quantum systems. (E.g. see **collapse of the wavefunction**).

Finally, all this may have incredible philosophical and theological consequences: If the multiverse is infinite, and my consciousness is smeared out over the whole of the multiverse, every conscious act could be unique, there is no recurrence in the multiverse. (In other words the probability for a recurrence has measure zero in the whole of the probability space of the multiverse. Yet, admittedly, **measures in the multiverse** are a hairy issue still and an active field of research). Then the prospects for *resurrection, reincarnation and all that* are bleak. This means that the one life one has is all there is - there is no **conscious before** or **after** for an individuum. Yet our

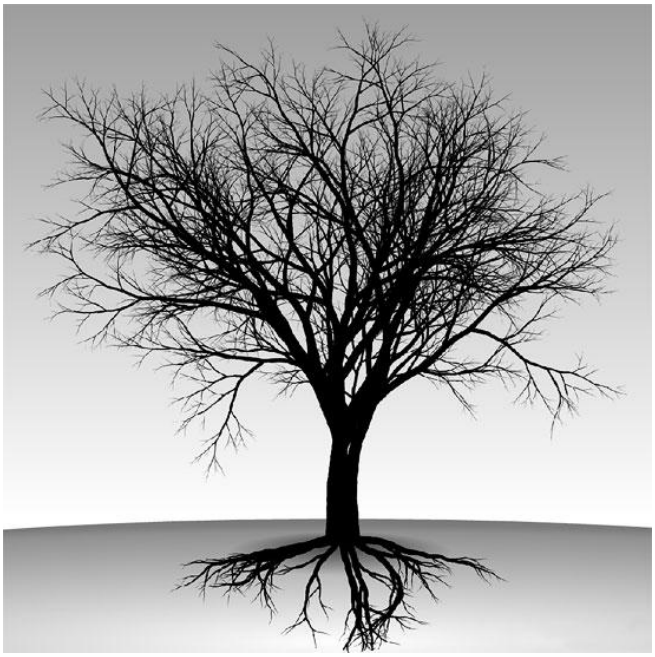
inbuilt **terror management mechanisms** save the day, that is one is actually never fully willing to accept something as fatal as this as a certainty.

So then, let's see how the multiverse story continues ...

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Organic Universe

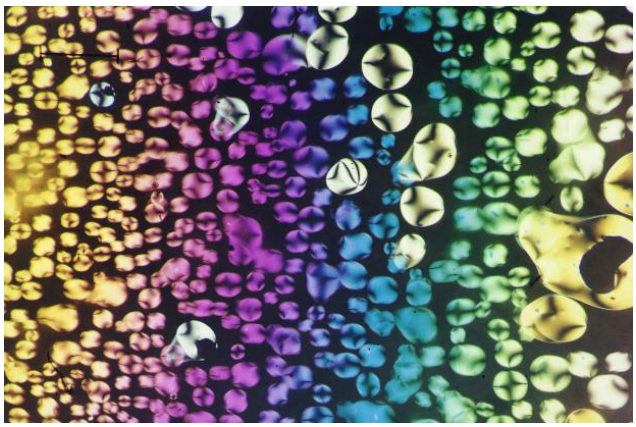
> ... at the Planck epoch, a region, the size of an elementary particle, contained the whole of the presently observed Universe! In a sense this would be a kind of ultimate bootstrap where each particle can contain all particles and at the same time be part of them, an idea pervading both Eastern and Western mystical thought. Thus, the metaphor of Indra's net illustrated in Avatamsateka Sutra, it is a network of pearls so arranged that if you look at one, you see all others reflected in it - i.e., each object part of every other object or to give an analogy in biology: i.e., that every one of the hundred trillion cells contains a complete genetic instruction to make every part of a complex organism - i.e., the nucleus of each cell carrying five billion bits of information making up the whole organism. Similarly, every region the size of an elementary particle had enough energy content for the creation of the whole Universe!
> - C. Sivaram [1] -



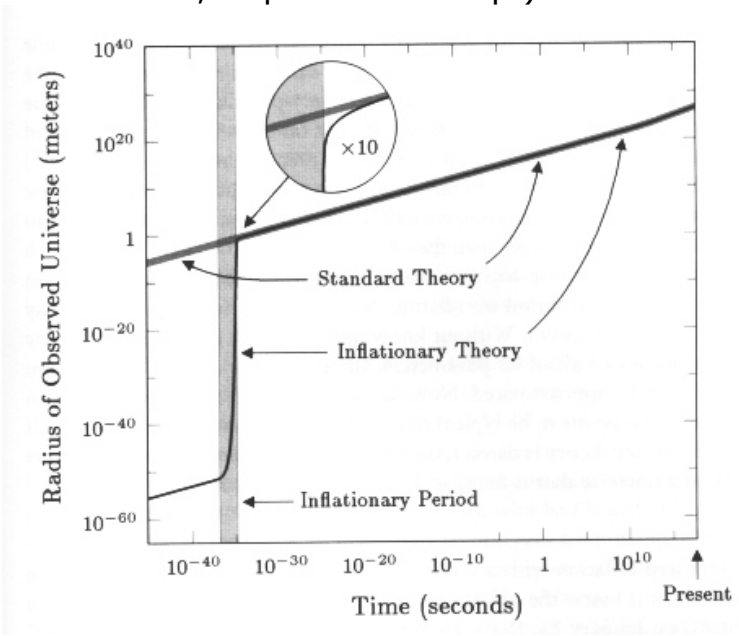
An Essay ...

The **Organic Universe** is a somewhat crazy idea I like to put forward about the origin and evolution of the universe:

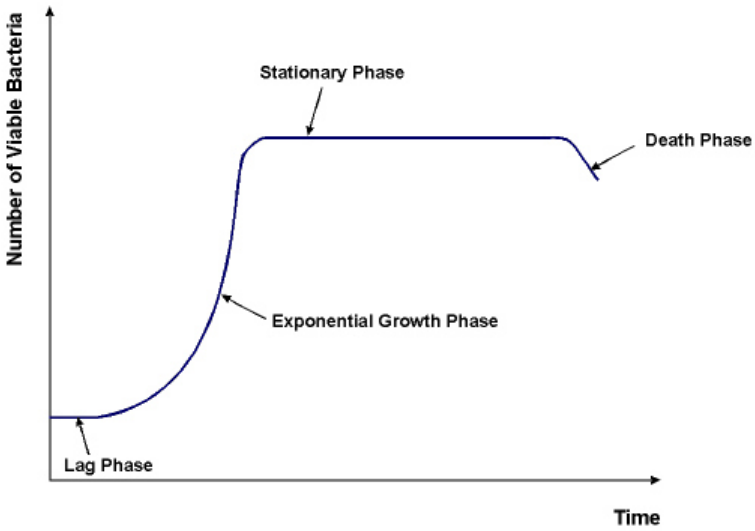
Let's start with the continuum which we assume is either stochastically changing (then the size doesn't matter) or practically infinite such that we can "find" any (at least not too large) structure in some "corner" of the continuum. What we need is a "seed" that can trigger and evolve into a new universe. This seed, which is assumed to be the fundamental building block of space-time and matter is conjectured to be describable as a self-replicating Von Neumann algorithm. We will only regard it on an information theoretical level, as we do not know its concrete realization, not having a theory of quantum gravity. We will call it a fundamental cell. (One can think of it as being an object with size of the order of the Planck scale). Therefore we assume that space-time is not continuous, rather it is discrete in nature. (This makes sense because it codes information. For example, when considering cosmic inflation, space-time "knows" when to inflate or not and what the current rate of inflation must be. This information is assumed to be coded in the fundamental space-time cell).



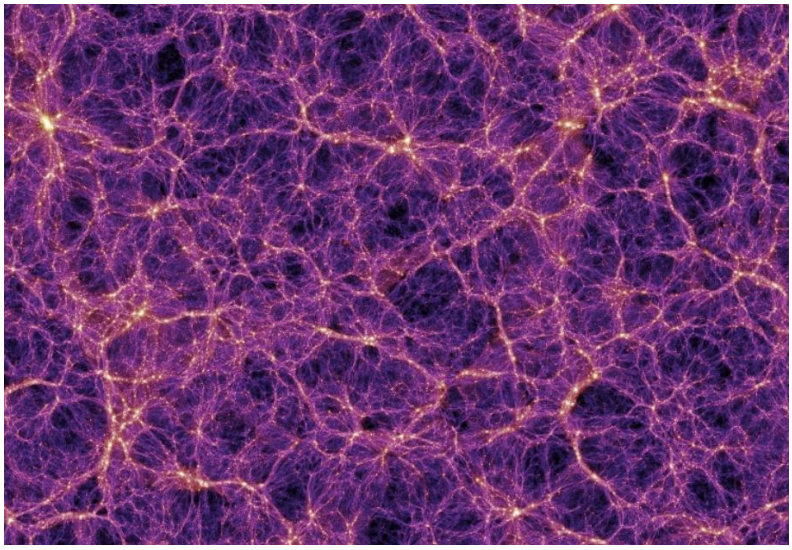
So we have a self-replicating cell, emdedded in a random and noisy environment. This elementary cell must be robust, otherwise mutations will easily render it incapable of replicating and therefore no large scale expansion will be possible. Therefore considering a fundamental cell that initiated our universe, it could be the result of a long evolutionary process, or we sit in a universe with an initial cell that just happened to have the right properties (antropological scenario). Anyway, if we assume that the self-replicating mechanism is not too complex, effective and minimalistic and hence not too large, the second argument also seems to be plausible. (In this context it should be mentioned that the simple rule of Conway's "life" cellular automaton is able to give rise to complex ordered patterns out of an initially disordered state, or primordial soup.)



Now we have a robustly expanding universe. Its exponential inflation is due to the fact that the underlying process is a doubling of its fundamental cells. We will call it **Organic Cosmic Inflation** alluding to analogies in biology.
Two such analogies are a bacteria colony and a yeast pastry. Such systems might furthermore help us, by looking at their properties, to find analogous properties in case of our "organic" universe and to interpret them accordingly (e.g. the dymanics of its inflation or its large scale structure). In the case of biological systems the elementary cells are biological cells and any one codes the complete information of the whole system. In their case we know the concrete (physical) realization: The information is coded in the genes, the read out of the information is done by polymerases and the final information processing and messaging is carried out by biochemicals (proteins with functional units, etc.).



These systems can be regarded as mutation resistant self-replicating machines. (It seems that bacteria are Von Neumann automata, whereas viruses are not, as their replication is dependent on host cells). The exponential inflation of a bulk of biological cells comes to an end either due to a lack of resources, due to ageing of the cells (i.e. after a certain average number of doublings their genetic algorithms are mutated that much that the replicating mechanisms do not work any more) or because the genetic program says "stop" after a certain number of doublings, which is the case for biological organisms, reaching their grown out state.
The assertion is that the "aging" scenario could apply to space-time. In case of the first scenario it is not so clear how to interpret it in the context of our organic universe model. The third scenario seems only to be likely if our universe is a descendant of a progenitor universe because it would require a longer algorithm in its initial space-time cell. If space-time really ages, then on the long run it would erode back into the continuum (like an ice crystal which melts "back" into a liquid).



Addendum:
A quite outlandish idea is that the seed of our universe was created (designed) in a foregoing universe (for whatever reason) by intelligent beings therein. The biological analogue here would be genetic manipulation of a germ cell, such that the resulting organism has certain desired properties. On the other hand it is conceivable that one day, provided we understand the elementary building blocks of space-time and are able to manipulate them, we could engineer and trigger new universes ourselves. (This however appears to be quite dangerous. Imagine initiating inflation of space-time "in front of our house").

> I am suggesting that there may come a time when physics will be willing to learn from biology as biology has been willing to learn from physics, a time when physics will accept the endless diversity of nature as one of its central themes, just as biology has accepted the unity of the genetic coding apparatus as one of its central dogmas.
> - Freeman Dyson -

Papers:

- [1] Evolution of the Universe through the Planck Epoch (1986) - C. Sivaram local pct. 21
- Sizing up the Cell (2009) - B. A. Edgar, K. J. Kim local pct. 3
- Self-Replicating Space-Cells and the Cosmological Constant (2007) - D. Vertigan local pct. 0

Links:

- NATIONAL GEOGRAPHIC: Before Big Bang: Light Shed on "Previous Universe" - M. Inman

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Physics and the Soul

> Believing in life after death, to put it mildly, requires physics beyond the Standard Model. Most importantly, we need some way for that "new physics" to interact with the atoms that we do have.
> If you believe in an immaterial soul that interacts with our bodies, you need to believe that the Dirac equation is not right, even at everyday energies. There needs to be a new term (at minimum) on the right, representing how the soul interacts with electrons. (If that term doesn't exist, electrons will just go on their way as if there weren't any soul at all, and then what's the point?) So any respectable scientist who took this idea seriously would be asking - what form does that interaction take? Is it local in spacetime? Does the soul respect gauge invariance and Lorentz invariance? Does the soul have a Hamiltonian? Do the interactions preserve unitarity and conservation of information?
> There's no reason to be agnostic about ideas that are dramatically incompatible with everything we know about modern science. Once we get over any reluctance to face reality on this issue, we can get down to the much more interesting questions of how human beings and consciousness really work.
> - S. Caroll [1] -

Some wild ponderings

What would it take for there to be a **Physical Soul**, transcending the biological body as we know it ?

- It should at least be based on **quantum mechanics** and in particular **quantum field theory**, for these theories offer the most fundamental description of nature we currently have.

- It should be stable on time scales much larger than the **lifespan** of a human being.

- It should apply quite universally to biological systems, for it is hard to draw a line between species that support a soul and those that don't. (A pet lover will probably insist on his/her dog having a soul. On the other hand, could we say that a universe with just one bacterium in it must have a soul ? And what about plants ?)

- It should be rather complex, at least having the complexity of the

order of a biological organism.

Possible realisations (not necessarily mutually exclusive):

- A complicated **ground state**, i.e. the soul would be encoded in the quantum **vacuum**. (We assume in the following that the soul is confined to this one vacuum). As we do not know what exactly the vacuum state of our universe is, there seems to be room for a soul here. Roughly speaking one has two options: Either the ground state is unique, based on some fundamental (mathematical) principles (a **"theory of everything"**). But then it seems likely that it is too simple for our purposes and, besides, it is hard to see why it just happened to be "good enough" to support life (see also **fine tuning problem**). Yet one could object that although the ground state of the **Standard Model** appears to be too simple to accommodate a soul, to conclude that this need to be so for a **unified theory** and in particular a theory of **quantum gravity** is not justified as we do not have such a theory at the moment and we just don't know how it ought to look like.
  The other option is that the vacuum we see is an environmental accident, we just happen to sit in a local vacuum (most probably a **false vacuum**) in some huge (or even infinite) potential landscape. This could even be a random potential. If we take quantum mechanics at the **cosmological level** serious, we are related to all other local vacua in that there is a non-vanishing transition probability for **tunneling** between them. (An example

can be found under **vacuum stability**).
An infinite landscape with an infinite number of local vacua seems to be perfectly suited in respect to a tuning in favour of life and a soul, for in this case one can find virtually anything that is not excluded by physical law. In particular, there is better hope that very complex vacua exist, which is what we require (see also **multiverse**). Yet in this case one one faces the paradox that there may be identical local vacua in the landscape, i.e. there would be "Xerox copies" of our souls and even of me and you. (See also *cloning paradox*). A way out of this dilemma is to assume that the local vacuum is not enough to determine the soul completely. (Could non-perturbative vacua offer a solution ?) This problem resembles the unresolved **measure problem** as a consequence of **eternal inflation**.

Some further questions one can ask in this context are:
Did we tunnel into our current vacuum from some other vacuum or were we driven into it by some "external force", some kind of intelligence with self-awareness, **consciousness**, etc. - and a soul of course ? Presumably, such an intelligence would have great interest in "implanting" its soul in a new universe (=vacuum) in order to preserve, replicate or slightly modify (and maybe even improve) it. (This idea was pursued under **creating a universe** and **Cosmic creation and God**). Yet the drawback of this scenario, it seems, is that if some intelligence is caught in its vacuum and cannot mathematically derive the potential landscape, it is impossible to do a deterministic sprouting off of a child universe because for doing so it had to know how the potential landscape looks beyond the local minimum it is confined to. Yet a possible way out would be to try to **quantum teleport** the soul in that many universes are sprouted off in the hope that the "right" one is among them. But this enterprise could be severely limited due to energy constraints.
Another question one could ask is that, given we did tunnel into our current vacuum, did we come from a vacuum that was already life-friendly or one that wasn't? In other words, is there a life-friendly corner in the "landscape" where tunneling a few times will not considerably change the parameters of nature ? This

seems well possible because even if one accepts that our universe is fine tuned for life, still there could be some wiggle-room for the values of the parameters. (See also **cosmological natural selection** in this context).
In case of the tunneling scenario it looks as though one is confronted with a severe limitation, that is, as tunneling takes place in imaginary time, information transfer is not possible. I.e. the idea that a soul can be implemented in terms of a set of "instructions" based on bits and bytes doesn't work out in this case.

- A field configuration or a configuration of several fields. If we ignore **gravity** for the moment due to our lack of an understanding of it's quantum nature, this boils down to the fields of the Standard Model and its hard to see how a stable soul could be recruited from them. Actually these are the fields that make up our mortal physical body. Moreover such a field configuration is inevitably lost in a **Big Bang** transition due to the immense temperature (**Planck temperature**).

- A (quantum) phase. The merit of phases is that they can be quite stable and that they result from a **broken symmetry** and can therefore exhibit complexity. One thing that is quite clear is that the universe was extremely hot at its outset (of the order of the Planck temperature) and that it has gone through several phase transitions when cooling down afterwards. Therefore this scenario is already implemented on the level of known physics anyway. Maybe it just needs some refinements.

- A **critical system** (i.e. a system at its *critical point*). This would at least do justice to the complexity of a soul. Yet the tuning had to be quite stable over a long period of time which seems to be less likely to be realized. Moreover, if the system leaves the critical point, the soul(s) would probably get extinct and when returning to it most probably a different structure would show up. See also: *Is reality a critical phenomenon ?*

- Some complex *attractor*. (This idea is completely vague at this point).

Experimental evidence

TODO

Some open questions

Does a soul also code the "self", the "I identity", or is it more like a

common, impersonal entity (**unus mundus**) ? Is identity emergent with the biological body or is it part of the soul ?

Final remarks

TODO

See also:

- **Immortality**

Documents:

- Sir Roger Penrose Evidence of the Soul local

Links:

- WIKIPEDIA - Seele
- [1] Physics and the Immortality of the Soul (2011) - S. Carroll

Videos:

- Your Soul is a Distributed Property of the Brains of Yourself and Others (2014) - M. A. Arbib
- Mind Versus Soul (2006)
- [1] Does the Soul Weigh 21 Grams?
- Quantum Vacuum and Cosmology - J .Peacock

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Quantum Mechanics Explained

Having thought about the **anthropic principle** and the meaning of life and **consciousness** in this context, I came up with the following explanation of **quantum mechanics** which is quite convincing to me.

Firstly, let's assume that quantum mechanics is the fundamental description of all of physical reality.
To make things simpler we use a toy model, namely the H-atom with discrete energy levels. Quantum mechanics tells us that to determine the **state** of the atom, we (the observers) have to do a measurement because without the measurement the electron is not localized, possibly being in a superposition of states (actually in a mixed state without any prior knowledge).
We now apply this toy model to the whole of reality be it the **multiverse** or whatever. In **string theory** this would be **"the landscape"** with finitely many vacua, but it could also be infinite like in **inflationary models**. (We'll use the word multiverse in the following as a placeholder for the maximally possible consistent state space).
The subtle point is that the atom has infinitely many energy levels but once we do a measurement we only see one realized. Applied to the multiverse we interpret this in that our visible universe is such a realization (that we observe) whereas the whole of the multiverse is the set of all possible states. But there is one crucial difference between our toy model and the multiverse. In the former the observer is outside the system whereas in the latter he/she is within. (This seems to be the key point when it comes to the problems with the **interpretation of quantum mechanics**).

Suppose that reality is in a superposition of all possible universes (or

even an ensemble, a mixed state). If it would contain no observer, it could not be *projected into one particular state*. (We would have quantum mechanics without the **Born "rule"**, which nevertheless would be a consistent framework). But obviously this is not so due to the very existence of our conscious selves and the fact that we do measurements, rendering the multiverse "classical" through a conscious act ("collapse" of the ensemble to a pure state). Let's take a subset of those states of the multiverse that are consistent with life. In our toy model we could take two energy levels and allow the external observer only to look at these two energy levels. This way we impose a *superselection rule*. In the multiverse this superselection rule is implicit, as any possible observer is so. Once we have measured that an electron is one of the two allowed energy states, we have reduced the non-actual ensemble to an actual pure state. But due to quantum mechanics this pure state will continue to *unitarily* evolve, i.e. the orbital corresponding with the energy level evolves in time. Moreover due to **quantum uncertainty** the electron could **tunnel** to any other energy level (the probability depending on the energetic separation between the energy levels), in which case the pure state becomes mixed again, the longer we wait, the higher the probability for this to happen. So in the limit $t \to \infty$ we have completely lost track and sight of where the electron could be and we have the perfectly mixed state corresponding with our H-atom. Now back to our multiverse. Let's do a measurement. This at least boils down to projecting (Born rule) our multiverse into the set of states of universes compatible with life. It might still be in a slightly impure state because we may not have knowledge of exactly which life friendly state we are in, but nevertheless we most probably have reduced the state space enormously. As is the case in our atom model, after the measurement the universe will evolve unitarily but it will also possibly tunnel to other universes of the multiverse. (Other **unitarily inequivalent** vacua). If it just evolved unitarily no further measurement could take place, no conscious act would happen, as these acts are completely identical, indistinguishable. If it tunnels to a universe outside of the set of life compatible states no measurement will be possible either and there is no conscious act. (This may concern most of the states of the multiverse and it is not far fetched to assume that there are infinitesimally many of them - as is the case for the H-atom).
But if our system tunnels to another life friendly state or becomes a mixed state containing at least one state consistent with life (the former being a special case of the latter) then a conscious act again is possible. Upon a conscious act, the life incompatible states are projected out no matter what they are. As unitary evolution alone does not lead to a sequence of conscious acts, we need a change of the state, corresponding to a quantum jump from one energy level to another - consistent with our superselection rule (i.e. life/consciousness) - leading (*Noether's theorem*) to a breaking of *time reversal invariance*. (One could also say that a conscious act induces a slight **symmetry breaking** in our physical universe). This

leads to a flow of classical **time** which corresponds to a trajectory in the space of life consistent states and moreover a change in **entropy**.

What remains to be understood is why we do not experience random jumps within the state space of states consistent with life. Having a look at the H-atom the explanation is at hand: Given the electron is measured to be in a state corresponding with a certain energy. If we assume that the time span between two consecutive conscious acts is smaller than between many of them, then due to the uncertainty relation the energy uncertainty will be larger in the latter case and the probability that a state is further away from the initial state is larger. (In case of the string landscape this means that the compactification of our observed universe only changes slightly between two conscious acts of observers, i.e. a change in the fundamental physical parameters should not be observable to be consistent with observations).
What about the fact that there is not just one observer but many in our universe ? In the most simple case we could decompose our set of life consistent universes into disjoint sets of life consistent universes each one concerning a specific observer. Thus given an observer the situation described above applies to the respective subset. In this case all conscious acts are strictly sequential. But one could also imagine that the subsets overlap such that conscious acts can be "simultaneous" (whatever that means).
It may also be required that there is a "drift" within the set of life friendly states taking into account that the universe evolves towards more intelligence. As the time between two (human) conscious acts is about $1/50\mathrm{s}$ we could ask what the related energy uncertainty is. It turns out that this is the **Planck energy** (indicating that this is the right energy to get tunneling from one vacuum of the multiverse to another one going). One could be afraid that our current universe tunnels far away from its current state in the next step. This may be so. But this tends to be a life unfriendly state and no conscious act will take place there and until that happens the next time no observer will experience time. But still, it could return to a conscious universe quite different from the one we see. Yet quantum mechanics saves the day. The fact that quantum effects are so small (determined by the smallness of **ħ**) and the fact that the energy for the quantum jump is virtual (we have just "borrowed" it and must "give it back") guarantees that after a few conscious acts we must be "back to normal". Thus in fact it is imaginable that once in a while we have freaky conscious acts, totally unrelated to reality, but this seems to be unlikely and the more different from our usually experienced world

they are, the less likely they are. (This situation is contrary to the one for **Boltzmann brains** thus avoiding this paradox and related ones).

So given two states of the multiverse one that is life friendly and one that is not, what makes them so substantially different ? In other words if we sort through the 10^{500} vacua of the string landscape, how could we know if a vacuum corresponds with consciousness or not ? I.e. we have to know what exactly our superselection rule is. Or at least, what is the measure of life consistent states in the multiverse. This seems to be a hard question. What does it mean for a state to be able to do a self-collapse, to project back onto itself ? Probably this requires a proper understanding what exactly the difference between dead and lively matter is.
Although the answer is not clear, nevertheless let's make an attempt to come up with one: First of all, life involves great complexity. Let's assume that this is a necessary condition for life and consciousness. A biological system evolves through many many states and the changes in energy are moderate or small only. If we go back to our atom model, we would like to have a superselection rule which only allows for moderate or small jumps of energy. (Actually the smallness of Planck's constant helps us here and the question is if it could be different in other branches of the landscape - I leave this question to string theoreticians). That is the life friendly subset of states of the multiverse comprises those that have a certain typical mutual energetic separation such that there is enough fine graining needed for energetically small enough changes in our world and with it in its biological subsystems. Seen this way any state of the multiverse is potentially conscious, but for most the sequence of conscious acts does not correspond to a robust classical realization of a biological matter system as the matter part is fluctuating considerably. (Imagine a world with a very large Planck's constant = quantum effects are dominant). Pictorially speaking an ape would have a thought and the next thought would be in the form of a mouse. Maybe life is close to an *attractor* where states are close to each other and therefore with high probability it stays in its vicinity. Physically speaking this may be a *critical point* for which it is well known that complexity arises. (See also *is reality a critical phenomenon ?* and **the ultimate principle of physical reality**). *(What is the density of states at a critical point).*

Is there the possibility of the recurrence of a conscious act of an individuum in this scenario (*reincarnation*) ? First of all, in our atom model be have to assume that the background stays the same, i.e. the H-atom will always be the H-atom and creation and annihilation of particles does not take place. This is a simplification and in case of a relativistic treatment it is not true. So at least we have to include **quantum field theory** to find an answer. But QFT doesn't change the rules of the game of quantum mechanics so one expects the same results in principle, the state space just gets larger when also quantizing the fields. Moreover, physically enlarging the system is not a problem either. It just means that we were ignorant, only

considering one H-atom in a H gas for instance.
The real trouble arises when infinities enter the game (see also **is nature infinite ?**) which is suggested when applying quantum field theory (introducing an infinite number of degrees of freedom). Yet it is not clear if they play a fundamental in physics. If a subspace of life compatible universes is infinite but the number of states making me and you possible finite, then when drifting away from them, it gets exceedingly unlikely to return to them or the set containing them. Mathematically speaking, their measure is 0 and therefore the probability for a return is also 0. But, calculating with infinities is a dangerous and ambiguous thing (e.g. see **Hilbert's hotel** and **measure of the multiverse**) and it is not clear what to make out of that, maybe it's really just a mathematical **idealization**. In fact, if string theory is right and there are "only" 10^{500} vacua this at least suggests that the number of all possible conscious acts is countable and will repeat. (The "string landscape" saves the **soul**).

Coming back to the anthropic principle, how is it to be seen in this scenario ?
The strong anthropic principle just means that the multiverse must contain conscious states (states that can project onto themselves) which given the fact that we are around renders this principle a triviality. The weak anthropic principle says that states that are not consistent with life consistent are observed.

Having said all that, is there a punchline ? Yes,
Consciousness = superselection rule for physical reality. The rest is a theoretical state which cannot be observed.

Miscellanea

- The multiverse can be understood as the most general mathematically consistent partition sum (*partition of 1*). At this level physics is only a mathematical reality (**Platonic realm**). We cannot observe the whole of this state space as most of it is incompatible with life. It exists only on paper because no one can ever be there. Nevertheless, the whole state space may be relevant in the theory in regards to consistency to subspaces that can be observed. This life consistent subspace recruits physical reality which is what is observed and thus is conscious (or at least contains life).

- Conscious also selects the laws in that it selects the phase. E.g. an unbroken phase having a certain symmetry may be incompatible with life as it is too uniform and the latter requires complexity. Therefore for instance certain **gauge symmetries** are preferred by life. So besides the **parameters**, one also expects the laws to be **fine tuned**. E.g. replacing $U(1) \times SU(2) \times SU(3)$ by another gauge symmetry may be incompatible with life or at least it could be in the space of life consistent states so far away from our state that we will never see it. (This sheds light on the fact that laws are the same everywhere around us). In other words, our physical body just cannot make it there without being totally disintegrated - or medically dead in between. If a "reassembled" body can continue its original identity is not clear. This would boil down to reincarnation. It depends on what defines a subset of the state space of the multiverse of me and you. It seems that what defines the boundaries between different conscious selves is rather space than time. But what to make out of that ?

- If one could make the case that life requires **GR** (maybe because of the $1/r^2$ force-law) then due to the **singularity theorems** it would follow that life would have to find itself in a universe (spacetime bubble) with an initial "singularity" (a **Big Bang**).

- So how do we find out the laws of nature, a **TOE** (i.e. theses things that descent from mathematical to physical reality). The answer is, look for what is compatible with life.

- Why the **second law** ? The answer is quite simple: Because of the highly spectacular initial conditions (**low entropy**) in the Big Bang. Yet their origin is still a big riddle.

- Which kind of matter is conscious, which is not ? An ordinary molecule like a benzole ring or a protein are both unconscious as they evolve unitarily only. (That is chemistry organic as well as anorganic is the science of dead matter in the first place). It seems that a macromolecule having the mass of around one Planck mass is the threshold to life and "self-awareness" for the time uncertainty of such a molecule is less than the *Planck time* and it is therefore no longer confined to a certain physical vacuum.

- Concerning the **Wheeler-deWitt equation**, because unitary evolution cannot be detected by observers and has not the same meaning as in a local system where the observer is external, it at least requires field quantization (see *third quantization*) such that vacuum transitions are possible. (Local system, not including the observer = unitary time evolution = 1st quantization. Whole cosmos, including the observer + local system = quantum field = 3rd quantization).

- Why does the world around us appear so robust, immutable, classical ? (Why is it that a stone feels hard and "real" when banged on ones head and experience is so authentical ?) Actually this need not to be so in general, rather it necessary appears so only from the perspective of a usual, classical (non freaky) conscious observer (for which quantum mechanical fluctuations are decent).

- The time we perceive (i.e. thermodynamic or non-unitary/complex time) is defined by a sequence of conscious states. I.e. time is fundamentally "attached" to life. For all we know, a fundamental time step is given by the Planck time. A striking thing is that if one counts the number of such time steps since the Big Bang and multiplies it with one Planck mass one roughly gets the mass of the universe. As we assume that any transition from one vacuum state to another involves life, there have been 10^{60} experiences of lively systems since the Big Bang all in all (which in a way have brought about the current universe).

- The claim is that consciousness or life must always have been around, since the Big Bang to "keep the universe on going" (evolving in classical time). There remains the explanatory gap, what exactly life is in each step that induces the "collapse of the state of the universe", in particular in the early universe. The most straighforward explanation seems to be that our cosmos was initiated by intelligence (see **creating a universe** and **cosmic creation and God**) and there is a continuity in the sequence of lively universes. (This also avoids the bizarre situation one faces in the **participatory model of the universe** where one has to wait for a state reduction until the first observer appears on the scene).

- There are some similarities with other models/explanations of quantum mechanics, e.g. Wheeler's participatory universe, **Langan's CMTU model**, Page's sensible quantum mechanics, **quantum darwinism**, etc. Surprisingly I was not able to find this scenario described in literature so far. Actually it can be seen as yet another interpretation of quantum mechanics. What comes closest to this interpretation are the Von Neumann interpretation of quantum mechanics, Wheeler's participatory universe and Penrose's model of objective state reduction. I am therefore tempted to coin a new name for this interpretation and hence (preliminarily) call it the **Sentient Reality Interpretation of Quantum Mechanics** (**SRI**). Key features are an objective collapse (or better state reduction) and, very importantly, this reduction is global, also involving regions that are spacelike in respect to us (all else wouldn't make sense as any two observers have different *apparent horizons* with nonoverlapping spacelike

regions).

- This view of quantum mechanics is reminiscent of a **cellular automaton** with a global time. Each change of the quantum vacuum of the universe corresponds with a global update of the automaton. Moreover if we split up the automaton algorithms into those that "get stuck", i.e. end up in a loop, and those that don't and show complexity and "interesting", unpredictable behaviour, the latter correspond with our physical reality containing the sentient observers. (Based on this analogy the states that don't correspond with physical reality can be interpreted as being those that are "unitarily stuck" in one vacuum, unable to tunnel). The analogy may also suggest that the universe is a **simulation** but the objection to this is that right from the outset we have to consider the most general mathematically consistent state space. Presupposing that no designer is required for the Platonic mathematical world, i.e. that mathematics just is and taking into account that no **designer** is required to bring physical reality into existence, sentient beings do it all by themselves, self-referentially (via "boot strapping of reality" if you like), no designer is needed at all. (Yet this does not preclude the possibility that there is intelligence that designed the spacetime bubble we live in which we call our universe).

- Open questions: Is there just one physical reality and is it connected ? How to include relativity in the description ? Does one have to add it or does it naturally come out of the framework ? A more concrete realisation of the model (the model of **quantum brain dynamics** seems be interesting in this respect and to point in the right direction).

See also:

- *When time stands still*

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

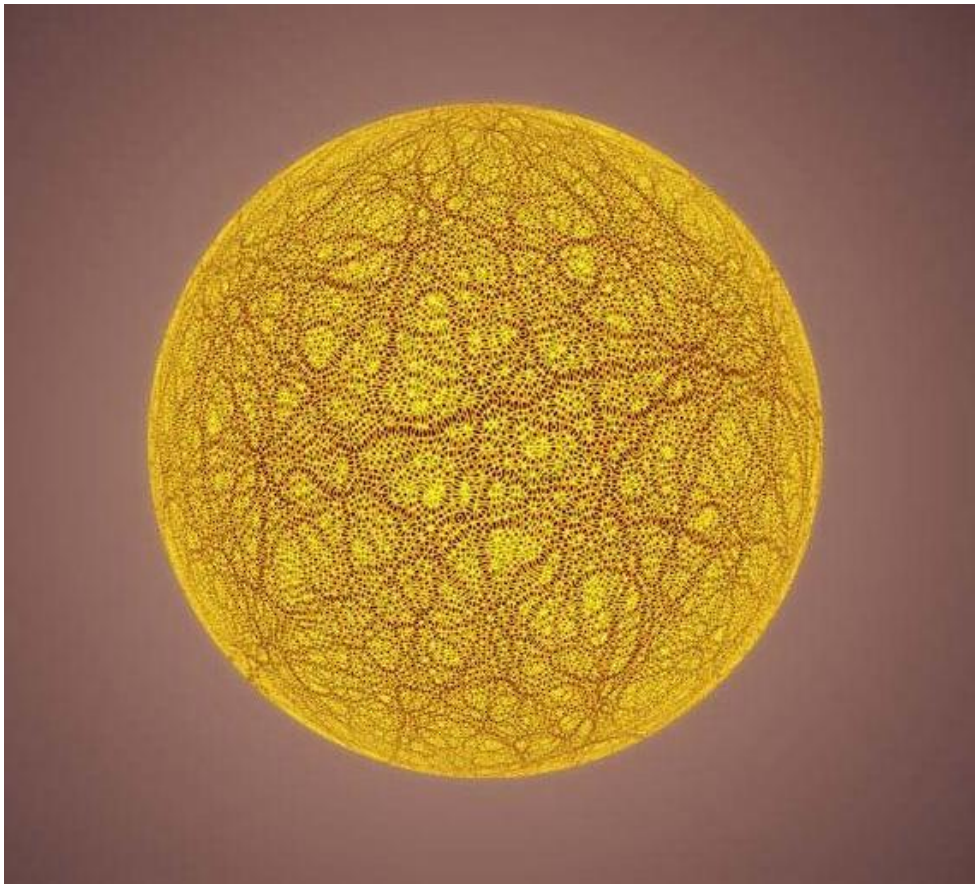
Spacetime Geometry and Quantum Mechanics

The physical world, as we know it, can be *quite well described* by a product geometry $\mathcal{M} \times F$ where $\mathcal{M}$ is a **Riemannian manifold** representing spacetime (ST) and F is a **noncommutative finite geometry** representing matter. As F is noncommutative, it is "quantum" and if we believe that **quantum physics** is more

fundamental than is classical physics, then this geometry is O.K. (A reason why F is "quantum" is because it involves **spinors** = fermions). But there isn't that much to fiddle around with this geometry anyway, because it's just the right geometric structure to do justice to the **SM** in all its richness.

But what about $\mathcal{M}$? It is smooth, commutative and "classical". Does it have to be replaced by some other geometry rendering it "quantum" ? One would actually expect that $\mathcal{M}$ and F are derivable from some "larger" geometry, let's call it $\mathcal{S}$ for "supra" (I want to avoid the word "super") unifying ST and matter. As F is already noncommutative one expects $\mathcal{S}$ also to be noncommutative and therefore the whole story would be "quantum" - and fundamental seen that way.

But if all we had to do to get $\mathcal{S}$ is just to take the product of the geometries we would already know $\mathcal{S}$ and it would be boring, besides of appearing quite unnatural and inhomogeneous a construction. As F can be regarded as more or less "on solid grounds", there seems to be no way around to fiddling with $\mathcal{M}$. But doing so directly might be quite awkward because who knows if there is an "enhanced" $\mathcal{M}$ that once we have it we just had to "plug it together" with F. The problem is that there seems to be no good reason to believe that $\mathcal{S}$ is a product geometry of F with some appropriately modified $\mathcal{M}$ describing spacetime.
Therefore the better approach appears to be trying to guess the right $\mathcal{S}$ and derive $\mathcal{M}$ and F from it in an appropriate way.
However, there is one big difficulty: In case of F we knew from the experimentalists what the constraints are, namely the **SM Lagrangian**. Although it was quite difficult to find the right geometry (in fact it took a **fields medalist**) these constraints where essential. All we have on the experimental side when it comes to ST is what is already coded by $\mathcal{M}$ (in the form of **General Relativity**). So what could the guiding principle to go beyond $\mathcal{M} \times F$ be ?



Here are some thoughts:

- One tries to find $\mathcal{S}$ purely based on mathematical grounds, assuming that the world (reality) is described by some distinguished structure. If **Gelfand-Naimark** also holds beyond commutative geometry it would be equally good to trade the geometry space by a **spectral triple** and maybe much easier allowing one to attack the problem on algebraic grounds. But this business is of course very risky and even if we had the right geometry what could be the predictions we could hand to the experimentalists to verify them ?

- Maybe we have overlooked something fundamental on the experimental side which needs to be included in the description. The only thing I can come up with is **biological matter** and **"the mind"** which may require to **step beyond reductionism**. Note that F is actually a very simple geometry and one might wonder if tensoring several moles of such geometries allows one to get the complexity and variety of the "real world". (That's what reductionism/chemistry tells us to do). So what is left for having a closer look at is $\mathcal{M}$. But $\mathcal{M}$ is also a quite simple geometry: The underlying symmetry is **diffeomorphism invariance**, which is too large and unconstrained a symmetry - actually it's quite a "boring" symmetry. Seen another way, the **Riemann tensor** is fixed by 4 relatively "simple" relations, which do not lead to a "fine" structure of the geometry. That is there is hardly room for something really new and exciting to happen. Yet something more

"bizarre" is required to get consciousness out of the space $\mathcal{S}/F$. That is if consciousness is a non-reductionistic phenomenon it must be primarily "engraved" in the geometry of spacetime. Depending on whether the extended spacetime geometry and the finite geometry of matter is a product geometry or not, we would get a world with dualism and consciousness and matter totally separated or one in which both are intimately intertwined. (From the mathematical point of view I suspect the latter as a product geometry looks quite unnatural for it is not "simple" as a mathematician would say. Seen from the physical point of perspective, we know that fermionic matter must act on the spacetime geometry due to the mass term in the **Dirac equation**, yet it does so in a very weak and presumably subtle way. Due to the smallness of this effect, it and possible backreactions of the geometry are usually neglected for single particles).
So the quest is, how to find the right $\mathcal{S}$ or $\mathcal{M}$? A guiding principle could be the following: Commutative spaces are very "boring", "non-commutative spaces" are more interesting, but still somewhat boring, BUT nonassociative spaces are exciting and not boring at all and they might be just the right geometry to describe the complexity of our world. (One strong but qualitative hint that **nonassociative spaces** are interesting are sedenionic fractals, demonstrating that exciting things can happen in such spaces - which in parts look very "organic", suggesting connections with biology).
As a (metaphysical) consequence, if there is nothing beyond $\mathcal{S}$ and if there is a **soul**, it must be encoded in the very fabric of space and time. (To build a conscious being from F alone would lead to a "Zombie" (à la Chalmers) [1]).

- There is one subtle issue yet with F. It is not really clear where the three **generations** come from. The spectral data are not sufficient to reconstruct $\mathcal{M}$, yet if one takes copies of it and mixes them (via the *CKM matrix*) it seems that one can reconstruct it. So there may be something going on here, giving us a first (experimental) hint as to how to construct $\mathcal{S}$.

Links:

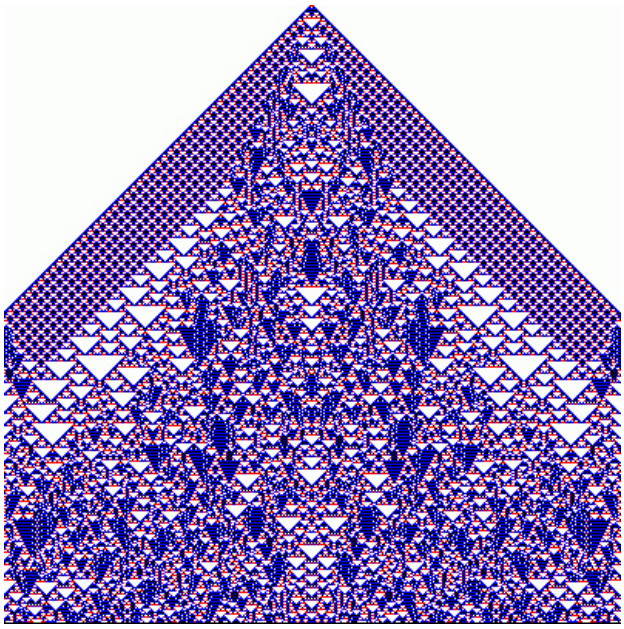
- [1] WIKIPEDIA - Philosophical Zombie

Videos:

- Carl Sagan on the Chemistry of Life on Earth/ other Planets - The reductionist view.

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Speciality of the World



> What about our universe, or more precisely, its entire past and future history? Is it individually describable by a finite sequence of bits, just like a movie stored on a compact disc, or a never ending evolution of a virtual reality determined by a finite algorithm? If so, then it is very special in a certain sense, just like the comparatively few describable reals are special.
> - Jürgen Schmidhuber - Algorithmic Theories of Everything -

Speciality of the World

The assertion is that the world that is accessible to us is a section with cardinality $\aleph_0$ of the continuum ($\aleph_1$,$\aleph_2$, ...). This section is allowed to be as large as uncountably infinite. Furthermore it must be a special section with certain symmetries, otherwise the world would be totally random and without structure. The measure of a special section is 0. I.e. if one were to "pick" an arbitrary section from the continuum it would be (more or less) random with probability 1.
Put it differently: *"We and our universe are very small structures in a vast sea of chaos/randomness/uniformity"*.

Looking at the world around us, it seems however, that a special section is not enough. That is to say that "our" section is **"very special"**. (A similar argument was put forward by Roger Penrose, who wondered why there is so much "redundancy" in the universe in respect to what is necessary for our existence). Furthermore the world being very special furnishes arguments for what has become quite popular, going under the name "intelligent design".
To understand as to why the universe is "very special" one might start with scrutinizing already known things like "self-replication", "self-similarity", "self-tuning", "evolution" or "criticality" (also "SOC") in respect to their "explanatory power".
A countably infinite universe can be mapped to a Turing stripe with "0"s and "1"s. This stripe codes all information of our universe. Picking a very special universe means, that one would have to pick each bit "intelligently".
Alternatively one starts with a finite strip and claims that the rest of the bits are not determined yet. This requires only to pick a special sequence and not a very special one. The special sequence is such that it represents a self-replicative algorithm. That means it is capable of "extending" the script such that the added parts still have a high degree of symmetry (and contain structure, i.e. information) and are not totally random. Otherwise the process would lead to a not very interesting universe. The latter scenario is certainly contained in the continuum and is the most frequent one, but such a section will probably not exhibit beings with consciousness and brains comparable to ours.
On the other hand algorithms that "run" more complex systems still have to be comparatively simple (i.e. simple input compared to the output) to be "robust" algorithms.

If we assume that our brains (or equally well the "whole universe") can be represented by a finite amount of information, it is a special finite subset of the "very special section" of the continuum. The point is that the whole of the section from our "finite" perspective cannot be determined which is equivalent to saying, that for the finite system the Gödel theorems or equivalently the halting theorems apply. Any statement beyond this finite subset can only be ontological in nature and not justifiable by means of axioms formed from subsets of the finite subset in regards.
The problem that remains here is to explain the emergence of time or put it differently, "what implements" the algorithm. I.e. why is the algorithm running at all. To talk about an algorithm in everyday life is one thing, but to run it requires hardware, a computer (and a user who triggers it).
The idea is to assume the opposite: We are a finite immutable subset of the continuum. Due the inherent undecidabilities it inevitably can't say anything definite about its own "nature". Especially the statement "the system is exactly what it is" (with certainty, i.e. probability exactly 1) is not possible. Therefore other finite subsets are also

"allowed" which are not distinguishable from the system from within the system. This degeneracy of systems may lead to the emergence of time, i.e. that there is some "drift" through these inequivalent systems. This can be seen as a primitive root element of time.

Furter remarks:

1. The argument that a small algorithm (or equivalently speaking, simple laws of nature) generate the whole of reality seems to be similar to arguments put forward by Stephen Wolfram and Richard Feynman (who are not unrelated to one another, by the way). Wolfram considers - as far as I understand it - the world being generated by (a) special simple algorithm(s) (he calls (a) rule(s)). Feynman put forward the metaphor of the world being an incredibly big chess board (the rules however being independent of the size of the board).
2. Mathematicians have posed the question if the continuum and the real numbers really exist. My answer is yes, if seen from an ontological (metaphysical) point of view. However as we "live in a special" section of the universe only a subset of special real numbers is accessible to us (even in principle). These are those that we can "point to" by any conceivable algorithm constituted within our finite universe. Metaphorically speaking it requires the overcountably infinitely many sections of real numbers of the continuum that complement our world to compensate for the speciality of our world. The continuum which on the whole is totally random is what recruits, contains structure in certain "corners", i.e. sections. These are those that contain regularities and symmetries and have measure 0. They are in comparison to the mightiness of the complement, which has measure 1, negligible.
3. Metaphysics can be regarded as the part of the continuum that cannot be accessed by any finite algorithm constructed within our universe. So the very nature of it is that it is required for our special section to exist but the Zermelo-Fraenkel and axiom of choice that we use to rationalize it cannot say anything about it. In a way however we use the continuum as crutches of argumentation for the existence and properties of our finite world, however in a sense that such an argumentation cannot be lifted to a strict logical proof. Therefore metaphysics seems to have some justification and takes in a special position besides strict logical argumentation. In a way metaphysics coincides a bit with our intuition that there must be more than what we perceive at the moment. This coincides with the fact, that our finite subset is growing into the continuum and this in an unpredictable way. So a small piece of the whole of metaphysical reality today will be part of reality tomorrow.

Although one might object that the section of the continuum constituting our universe is already determined and therefore the

complement of it is the "real metaphysical" realm, still seen from within this statement is not provable and again part of the metaphysical world (or should I say the answer what this section exactly is).

Upside down

Traditionally mathematics is build up from primitives, i.e. from simple structures. The alternative is to start with total randomness and to regard the simple structures as very special substructures. Structure is therefore rather breaking something down than building it up. If a structure is very complex and cannot be broken down, it is a very weak structure, and in the limit of an infinite structure it cannot be called a structure at all.
This relates to the property of compressibility. A structure must be at least as compressible as to "fit into our brains". Otherwise we will perceive it as random, i.e. as noise.
This means that our very existence requires that structures with a certain degree of simplicity are possible. I.e. in a way our very existence filters out certain quite symmetric subsets from the continuum. As our future is not predetermined (Gödel), it is well possible that we "grow" and will be more and more able to "grasp" larger and larger mathematical structures, which are necessarily weaker and less compressible. In principle there is no limit for this process and mathematics, i.e. complexity of structures. In practice a it is only given by the (physical) limits of human beings, e.g. the capacity of the brains of mathematicians. This is demonstrated very nicely by the fact that different mathematicians can penetrate mathematical reality up to different depths. I.e. everyone lives in ones own mathematical reality, determined by his physical constraints. Among those who are capable of "diving deepest" and hence comprehend the most complex structures are most certainly Fields medalists. Such people are "eye witnesses", reporting about a world others cannot "see". But these "reports" often remain incomprehensible to others and therefore this part of the mathematical world will forever be hidden to them. (It is as if it didn't exist for them).

There is a very funny argument as to why mathematics can be build from very simple structures: As complex structures "grow out of simple structures", to trigger such a growth process one requires simple structures to start from. That is, in the beginning one "picks" a highly symmetric algorithm from the continuum (which is retained as the structure grows). Maybe a cellular automaton à la Wolfram would be interesting to consider as a "seed" in this respect.

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Strict Proofs and the Natural Sciences

The claim is that trying to obtain the "ultimate truth" by proofing something in the natural sciences is a hopeless endeavour. By proof we mean the establishment of a statement about a natural phenomenon which we can be absolutely sure of will stand the test of time.

The usual tools of trade of a proof in mathematics are that one formulates a set of axioms which are well defined (i.e. consistent). Given a statement, a.k.a. a theorem one shows that this follows from the axioms.

If we apply this method to the natural sciences, there is one big problem. We are only able to come up with a set of axioms because we interact with the outside world. I.e. these reflect the state of the art of our measurement technology. If we refine the measurements and discover something surprisingly new, we may well want to change our axiom system. Thus, although the mathematically strict method of proofing can be applied to the natural sciences, there is the issue of the shakiness of the axioms. In mathematics different sets of axioms can "happily coexist", given they obey certain sociological constraints given by mathematicians, dictating as to what is meant by an axiom in the first place. But in the natural sciences, if one assumes that there is only one reality and the "ultimate truth" is about this reality, there can only be one equivalence class of axioms from which everything else follows. The act of finding these axioms - presupposing that this makes sense at all - can only be an iterative one - ad infinitum.

See also:

- **Theory of everything**

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

The Ultimate Principle of Physical Reality

> The notion of existence is one of the primitive concepts with which we must begin as given. It is the clearest concept we have.
> - Kurt Gödel -

Although maybe initially set out to be so, physics hasn't managed to be fundamentally observer independent, which for instance is manifest in **quantum mechanics**.
Another place, where the observer comes into play is the **anthropic principle**. For many it has a bad reputation for seemingly not being a really scientific principle.

Nevertheless, it is suggested here to lift this principle to a fundamental physical law, even having the status of **The Ultimate Principle of Physical Reality**.
This requires some justifications which will be given in the following. (The lengthiness of the ensuing writings is mainly for the purpose of better motivating the ideas and to avoid misunderstandings, shedding different lights on the problems encountered in the context. Moreover the essay is a bit chaotic, resulting from a stream of thoughts that have been reordered subsequently. The author apologizes for all of that).

In its extreme form the principle calls for a complete denial of "physics

without observers", such theories just not having the status of physical theories. That is there is no sense in even talking about them in the context of physical reality (maybe so in a mathematical one). In other words, the law says: "Any physical theory must be such that it includes life, consciousness and observers (we'll use such words interchangeably - yet unfortunately not fully knowing what they really mean). This immensely restricts the number of mathematical theories coming into consideration to be physical theories.

If we want to base physics on a few (or even one) fundamental principles they presumably have to be principles that are "close to metaphysics" which may be "hard to swallow". But first principles inevitably seem to have to be of this kind. On this level we just have to accept something and a further questioning is pointless. (In mathematics this corresponds with an axiom). Therefore the bad reputation of the anthropic principle as being metaphysical with no meaning to physics is not justified, as it is a "last" principle, where the "chain of reasoning" inevitably has to stop. Seen this way the principle is no more a problem, rather a virtue, helping to understand physical reality.
Consequently one can put it this way:
Anthropic principle = meta principle for physical laws

Essentially there are three ways of reasoning:
Let $S_1, S_2, \ldots,$ be statements, theorems or the like.
Then we have the following chains of reasonings:

- $S_1 \leftarrow S_2 \leftarrow \ldots$ (Inifinite chain)
- $S_1 \leftarrow S_2 \leftarrow \ldots \leftarrow S_N \leftarrow S_1$ (Circular chain)
- $S_1 \leftarrow S_2 \leftarrow \ldots \leftarrow S_N$ (Finite chain)

All three are somewhat problematic when it comes to physics. The first one exhibits an infinity, the second one is plagued by *Gödel's incompleteness* and the third one starts in an "unmotivated" way with S_N.

Thus one or the other way we have to bite the bullet. We'll do so by choosing the third kind of reasoning, claiming that it is the correct one for the description of physics and reality. S_N will be our anthropic principle.

Before we proceed, there is one point that requires clarification, namely a conscious universe is not one that contains life and consciousness at a certain point in time. Probably our universe was without life at an early stage. It is rather the potentiality that life can arise (= "life friendliness"). This is really a crucial point in the argumentation and maybe the most difficult one to understand. An example that may help are the solutions to the **Wheeler-DeWitt equation** that do not depend on time. We can divide them into two sets, one containing solutions which allow for consciousness and the

other one with those that don't. The latter have to be discarded on physical grounds.

The state of the universe

The conjecture is that there is an equivalence class of conscious universes. Transitions from any one universe to another one within this class are possible.
If we would allow for transitions to the "outside" of this class (at least in an unrestricted way) the universe presumably would instantaneously make a transition to a universe without life (and "never come back"). The measure of universes without life may well be infinite (see also measure problem in the context of the **multiverse** and **"the landscape"**) and the transition amplitude to such "unfriendly" universes practically be 1.
Thus the anthropic principle is really needed for the "protection" of a universe like ours for not to decay immediately.
Maybe there is a unique class of universes allowing for life AND which are fully protected. Any one universe within the class can make a transition to any other one within, but due to the physical laws a transition to the outside is impossible (or at least highly constrained). All we know is that our universe is in a class for which a transition to the outside is extremely unlikely. (This statement can also be taken as an alternative formulation of the anthropic principle). Yet due to the sheer immensity of states outside there is good reason to believe that the closure is pretty close to exact or even exact. In the latter (extreme) case a transition of our universe to one without life and consciousness is de facto IMPOSSIBLE. Then classes of universes without life and consciousness are pointless and need to be ignored. That is the part of the multiverse with infinite measure can be ignored as not being a part of a physical (yet mathematical) theory. Nearly all conceivable theories are of this kind. One subset with measure zero against this background is the class of universes we belong to.
In the extreme case, consciousness (or at least its potentiality to arise) is and remains forever, endlessly transforming from one form into another one. We then are "caught" in a strange, consciousness friendly world and it luckily will ever be so, there is no danger of fundamental extinction of consciousness (or more precisely the immanent potentiality for it to arise).

An alternative view which we'll exploit below is to suppress the probability of transitions to the outside considerably and/or only allow for transitions to states having a high probability to "return". Our mere existence forces us to do something like this in the model building, be it that we like it or not.

Still it is conceivable that different lifetimes of life friendly universes correspond with different "equivalence classes", exhibiting different symmetries, laws, parameters etc. (Think of the "landscape" if you

like). Yet without constraining transition probabilities to the outside of these classes there is a problem due to the vanishingly small overall measure of the states within these classes.
An example shall demonstrate this:
Take two life friendly universes, one existing for 100 billions of years on the average and one doing so for 100 billions of years + $1\,\mathrm{s}$. It is extremely unlikely that the former one "survives" yet another second to "show up" in the equivalence class of the second universe. In other words, a long lived universe with life is exceedingly unlikely in comparison, precluding it nearly as a realistic realisation. Therefore the possibility of a more or less unique class or one with consciousness highly protected seems to be a reasonable postulate (not provable), to be taken as a first principle (or working hypotheses, that is something that is required to demonstrate over and over again that it "works", and it should). Yet our mere existence forces us in this direction.
This also helps to solve the **Boltzmann brain paradox** and "explains" why we are not drowned in "freaky observers". (At least I have never seen one :-)).

To stress it again and saying it in a bit different words: Life "picks" the eternal (or nearly eternal) laws and maybe there is even a unique way for doing so.
So in principle we should see hints of consciousness and life friendliness all around us, in particular manifest in the physical laws. At least in the context of **fine tuning** this appears to be so.
But the problem is that we do not fully understand what consciousness and life are and therefore do not really know what to look for. Thus we may well overlook certain of these hints.

So what is physical reality?

The multiverse is mathematics (a **Platonistic** realm, whatever that means). Our universe being a representant of the (or a) class of life friendly universes, the only (or a) possible class allowing for the "instantiation" of a universe, of a physical reality exhibiting consciousness. Being a proper subset of the total space of all of mathematics, this explains Wigner's unreasonable effectiveness in the natural sciences, as a certain part of mathematics and the "real" world are identical.
This suggests that in some respect a class of life friendly universes is an extremal structure, derived by what one could call a "meta *Hamilton principle*". In other words one should in principle be able to get it by varying over all possible mathematical structures. The relevant variables had to be intimately related with life and consciousness. (Maybe there even exists a unique extremum). But why would just this solution coincide with a life-friendly class of universes ? It could mean that a small perturbation brings "the system" back to its extremum. This one can see on all levels of the

system (hence our universe). Thus life and consciousness among other things could abstractly be understood as a system that is (locally ?) extremal and resisting perturbations, that is, it is robust. An attractive model is that of an *attractor*. Physical realisations of attractors are critical points of systems around a **phase transition**. These points exhibit (maximal) complexity, which is exactly what we want for information processing creatures like us. So we have yet another possible reformulation of our principle, namely physical reality (or the conscious universe) is the critical point of "meta reality", i.e. of all of mathematical reality. (Let's take a deep breath).
Put it differently, mathematics has a critical point which is physical reality. If we assume that complexity is maximal in the critical point, it is plausible why physical reality must coincide with an intelligent universe. (E.g. this suggests to have a closer look at **path integrals** in the context of critical points).

The nice thing about attractors is that they can be treated as mathematical as well as physical entities, justifying to the oneness of physical and mathematical reality put forward.

We thus can make the claim that, roughly speaking, physical reality is the "classical path" corresponding with the "critical geometry" of a path integral over all mathematically possible spaces. Moreover this suggests that any parameter possible is relevant to life as far as it has influence on the critical point. If this is so, it appears that we are doomed to only be able to examine a "down-scaled" version of this monster path integral.

We just remark that systems can have several critical points. If our conscious universe is related to a local or global critical point remains an open question.

Another way to see it is that the anthropic principle roughly speaking boils down to the following identifications:

Physical universe (reality) = potentiality for consciousness = maximal complexity = extremum in mathematical universe.
(One may compare the extremal nature of the physical universe with the geodesic followed by a particle in a spacetime).
Moreover, the mathematical universe can be understood as the subspace of a "meta Lagrangian" that is not extremal.
Maybe the mathematical (Platonic) part is some kind of "gauge" part of the physical part (consciousness = "inner fluctuations", deviations from the extremum, comparable to the deviations of a quantum particle from the geodesic in a relativistic spacetime).

Is the extremal subspace of the "mathematical universe" identical with classical physical reality ? That would mean that the space of quantum mechanics is non-extremal and in principle could be the whole of mathematical theory space, i.e. everything beyond classical reality

that is mathematical is physically possible.
BUT, due to the requirement of robustness of classical reality, fluctuations have to be small (of the order of $\hbar$). In this case it seems that consciousness has to be part of the quantum world and not of a Platonic realm beyond it. Then one cannot separate consciousness from the whole of physical reality any more.

To make a long story shorter, we pursue the idea we just alluded to, namely that spacetime and matter - hence physical reality - are manifestations of a subgeometry of a "meta geometry" around a critical point under *"Is reality a critical phenomenon ?"*. (This is where one can find the more physical and less philosophical part of this "story", yet with the suggested physical model being strikingly "in sync" with the philosophy represented here).

The role of quantum mechanics

So far a silent assumption has been that quantum mechanics is the fundamental description of reality, as we have allowed ourselves to speak of "states", meaning **quantum states**.
Be this so or not, at least we can say that the mathematical space of quantum mechanics is a subspace of the meta space of all of mathematics. The same applies to the space of classical physical reality.
If the space of classical physics is a proper subspace of the space of quantum mechanics, we'll have to leave open, but it doesn't matter so much in this context.
At any rate, we can make the following distinction:

- Classical realm.
- Quantum realm, reachable from the classical realm by small

perturbations. Small means that perturbations are "damped", with **Planck's constant** $\hbar$ being the relevant parameter. One would like then $\hbar$ to be a small parameter in a unit system of the classical world (e.g. SI), which fortunately is the case. If we were to tune up $\hbar$ to large values, there would still be a classical world, but we wouldn't see it any more. The world would be highly fluctuating. Yet the question why it has the value it has and not a smaller one remains. (If $\hbar$ is a truly fundamental constant once the units are fixed, i.e. a mathematical one, like Euler's constant, or merely an adjustable parameter would be very important to know in this context).

- The complement of the former, the truly unphysical realm. Maybe not even reachable by mathematics (which is not so clear at this point). This is the space which "compensates" for the complexity and the **speciality of the space we are contained in**. Yet it seems reasonable to assume that anything is reachable, its rather a matter of probability. Actually in quantum mechanics, the weirdest things are allowed to happen, as long as they are consistent with the statistics imposed by quantum mechanics. The difficult question if there is mathematics that is not quantum mechanics would then have be answered with no. (At this point one could embark on wild further discussions, for we first had to pin down what exactly mathematics is, but we'll stop here). Randomness and all that would therefore "come into the world" due to the freedom left by the **uncertainty relations** which allow for a bit of an escape from the classical realm. In terms of consciousness and thought, this could explain how the "new" comes into the classical world, as within Heisenberg's quantum uncertainty everything is possible. This would imply that consciousness is **quantum consciousness** and closely related to the world of virtual particles/fields and vacuum fluctuations. (This is not a claim, rather a mere speculation worth further investigations).

God and the principle

What does this principle mean for the existence of God? God must be "intrinsic", i.e. she must be a pantheistic God. Everything else is against "The Ultimate Principle of Physics and Reality" which once again is a first principle that cannot be proved. All it can provide is a claim that can be tested in any physical situation and as long as it doesn't fail it is a reasonable principle. But that is just the best one can do with an unprovable fact, i.e. gain confidence in it because it "works" over and over again.

Also the distinction between our consciousness and God gets blurred. Everything within (physical) reality can make a transition between

anything. So if we call a certain state God, our consciousness can in principle make a transition to a conscious state that can be identified with God. To call a state God then becomes a matter of taste.

Moreover a consequence of the principle is that the universe is bound to appear as if it were **designed** for life. This may lead some to claim that there must be a designer, a higher intelligence, a God. Others will find answers in the laws, although what remains to them is to explain where to laws come from.
Both positions are improvable and thus it will never be possible to decide who is right. What we have done here is to "repack" this improvability into the anthropic principle providing us with a higher point of perspective.

A good old "hard problem"

A remaining problem is this: Why can a physical brain conceive all sorts of unphysical mathematical universes, although the brain is part of physical reality ?

A potential and admittedly vague explanation is that consciousness corresponds with transitions from physical reality to the unphysical, i.e. mathematical one. (In this sense the Platonic world is "real" that is it manifests itself in the form of consciousness. But it is completely complementary to physical reality and will always reside side by side with it. That means that Descartes' view of **dualism** is the appropriate one). That is a conscious act is a perturbation of the physical world to a mathematical one, but due to the fact that physical reality is a unique attractor, the lively system returns immediately and inevitably to physical reality. Without the "guidance" of the physical body, conscious acts would be completely unorchestrated, fluctuating, chaotic, etc.

This could imply that the "superposition" of all mathematical, "Platonic" structures is perfect white noise, i.e. the continuum. This continuum would comprise all conscious experiences possible. That is the sum of all mathematical theories. (Yet not all of them necessarily need to be accessible).
The Platonic world is the potentiality inherent to chaos which allows for projecting out all structures of mathematics (by means of a conscious act related to physical reality).
But how can a conscious thought leave an "imprint" in the physical world ? Maybe the physical world is unconscious, that is only when we make a transition to a mathematical state is it when we are conscious. Yet in some way the physical world appears to be the vehicle for the consciousness transitions. It imposes a certain order on the sequence of conscious acts. This may involve time in a fundamental way. Otherwise, as already mentioned, the transitions would be totally random and chaotic and one could at best talk of fluctuations of

consciousness (maybe this is also the realm where on finds "Boltzmann brains" - "they come, have a thought and disappear again" :-)).

A bit of philosophy

So instead of asking why there is something and not nothing, one should rather ask: "Why is there something and not everything ?". The answer is, that in fact there is everything, if interpreted the way done above - a very satisfying conclusion as it requires a minimalistic assumption. (There seem to be only two such "primitives", "nothing" and "everything" - the former although deeply rooted in Western philosophy, leaving one hard-pressed to explain how to get from nothing to something).

Since mathematical structures are "projections", there is no more than relative truth to them. In particular there cannot be a specific mathematical theory that proves that the world/reality is to be the way it is, as reality is one among the mathematical structures, thus making it appear justified to use the anthropic principle as a starting point, and live with the fact that it will always have to remain a principle.

Therefore we will never see a "final theory" of physical reality, as any mathematical model which is not physical reality itself only sheds some light on it (comparable to the shadows of Plato's cave) and many mathematical theories may well be compatible with reality - unisono - and deserve to coexist as viable theories of physical reality. Thus we'll always see theoretical physicists "struggling" with reality.

Having said all that, one is lead to challenge Archibald Wheeler's somewhat contrived argument, namely that the universe came into existence by means of a conscious thought (maybe long after the Big Bang). On the contrary, the conscious thought came into existence because the universe is sort of a conscious one by nature.

To conclude

Finally, after having written these lines, I realized that what I am talking about is very reminiscent of the classical **strong anthropic principle**. (Which I never liked, as it didn't seem plausible to me so far). Yet I am shying away from making an identification as I know too little about this principle.
What the principle introduced here definitely is not, is the weak form of the anthropic principle, which I regard as a tautology, totally empty and superfluous, or even harmful leading to never-ending discussions.
Here is my simple example of what I think it expresses:
Suppose we have a coin that we throw. We happen to get head. The

principle then says that the coin must have been made such that it is possible to get "head" - wow !

See also:

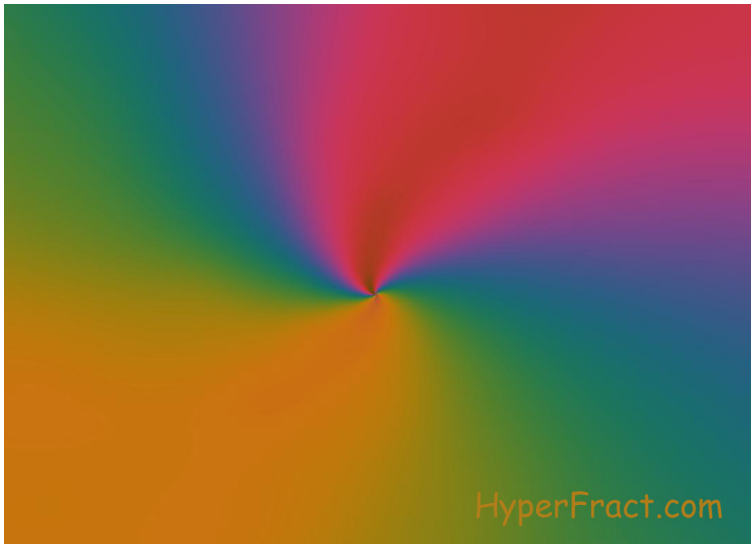
- **Speciality of the world**
- **Cosmic creation and God**
- **Variational Principle for Algebras**

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Theory of Everything

> There could be no fairer destiny for any ... theory than that it should point the way to a more comprehensive theory which it lives on as a limiting case.
> - **Albert Einstein** -

> It is human to search for the theory of everything and it is superhuman to find it.
> - Kedar Joshi -



... a bit of an essay ...

Could there be a **Theory of Everything (TOE)** (a.k.a. **Final**

Theory) that offers a unified description of nature ?

First let's write down what one could require from such a theory:
R1: It can describe all of the known facts of that we know from experiments.
R2: It makes predictions of what is possible beyond of what has experimentally been verified.
R3. Given any conjectured law about nature the theory can predict if it is realised or not. That means beyond its predictions it must be capable of excluding everything else.

There are several problems satisfying these requirements:
1. The number of predictions of R2 must be finite, otherwise we would not be able to verify all of them experimentally. We have to do that on the long run, otherwise we could not claim to have found the final theory. Furthermore we must practically be able to detect all predicted effects. (For example the theory could predict an infinite number of forces, separated considerably by strength. So, e.g. we could on the long run be able to measure the 5-th and the 6-th force but the others would be beyond our accessibility. Even if there only existed one more force, say a seventh one, which is however too weak to ever be detected, we would never be able verify completely our conjectured final theory).

2. Building a candidate theory is difficult. Given such a theory that fulfills R1 it is not necessarily unique. A special theory may well be embeddable in different larger theories. Therefore one may end up with a proliferation of extended theories and this once more implies the need for experiments, in this case to filter out the correct theory. (There is a good example for this fact, namely extensions to the standard model of particle physics) .

3. The number of conjectures concerning R3 that a final theory has to face is probably infinite. Even if the theory can give a well defined answer to every conjecture we may imagine, how can we be sure that the predicted impossibility is really given ? For every such conjecture we are therefore forced to do experiments to show the impossibility. Besides the fact of setting up an experiment that shows the non-existence of an effect may be much harder than verifying a prediction or even impossible, we have to face the fact that we need to set up infinitesimally many experiments.

In summary: There are infinitesimally many facts that can be conjectured about nature. So either infinitesimally many of them are realised or are not realised. Either way we had to do infinitesimally many experiments to verify our theory.

My conclusion therefore: We'll never know everything for sure. A TOE can at best satisfy R1 which reflects our current state of technology in doing experiments. One day we'll probably reach a technological limit,

ending up with a theory that one could call the **Theory of Everything of Mankind** or the **Final Theory of Mankind**.

I therefore agree with *Karl Raimund Popper*, who said that: "Every scientific statement must remain tentative - for ever".

Papers:

- A Complete Theory of Everything (will be subjective) (2010) - M. Hutter local pct. 12
- Resource Limited Theories and their Extensions (2003) - P. Benioff local pct. 4

Magazines:

- A Theory of Everything ? - Nature, Vol. 433, Jan. 2005 local

Videos:

- Steven Weinberg on a 'Final Theory' of Nature and Symmetry in Physics
- Theories of Everything? Lessons From the History of Science - H. Kragh

Some further remarks:

- The arguments given above have philosophical consequences: As there will always be a dividing line between what is known and what is unknown, there will never be absolute certainty and there will always be room for believe. In particular a proof of the non-existence of a God will never be possible and as long as there is no manifest evidence for a God, atheism and religion will probably continue coexisting in this world, both equally footed on personal believe. Therefore we should not take our own believes too serious and in particular not regard them as absolute, i.e. always be aware of their limitations and be open minded for other people's believes and tolerate them. Consequently the belief in a TOE can also be regarded as kind of a religion.

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Thoughts about a Discrete Structure of Spacetime

The basic idea is that spacetime has a discrete structure and it is

related to the **Leech lattice**. The following is not more than "handwaving" at the moment.

Some preliminaries

The conjecture is that any measurement involves spacetime. An event E and an observer O are always separated by a certain spacetime distance. Therefore a measurement always implies establishing a communication channel C between E and O across spacetime. So known mathematics of communication theory should apply. Philosophically seen this means that any statement about the world is relative. The ontological (or absolute) status of E has no meaning. The only thing that counts is what is perceived at the end of the communication channel. In particular one cannot say how authentic the information is, that is how much noise was induced in the channel. However one can do repeated measurements when it comes to simple and reproducible events and compare. If they are almost always identical, it allows for inferring an (average) noise rate (of spacetime). This one can try to scale up to complex (and maybe not reproducible) measurements and this way have a estimator for the reliability of the information.
In this context it is important to note that as information is relative, so is entropy. This is a known fact from general relativity where entropy depends on the reference frame (changing it for example leads to the appearance of thermal radiation).

Models

Model I. Spacetime is a perfect Leech lattice. Maybe matter can be interpreted as the holes in the lattice. Note that the locality principle applies, that is seen from every sphere of the associated sphere packing one sees the same number of spheres in the n-th shell. Why this lattice ? Because it is the lattice with the highest packing density in any dimension. Another argument would be: It is associated with the best error correcting code (namely the Golay code).

Model II. Spacetime is a Leech lattice with defects. Defects may be interpreted as matter for example.

Model III. Spacetime is the result of the superposition of all possible lattices (regular as well as irregular) in all dimensions. However it is not clear if (and how) this idea works out mathematically. E.g. if one takes white noise (which is supposed to contain all lattices) in 2-dimensions and averages over it one gets a grey continuum. Yet if one averages over all dimensions, it seems that the packing density of the respective dimension may play a role in the result. As the highest density is in 24 dimensions we may end up with an effective lattice in

this dimension. (How to interpret a space with 24 parameters physically is another issue). Maybe one can find an action principle representing this situation which may be reminiscent of a partition function or path integral. (See also **variational principle for algebras** and *evolution and error coding*).

Model IV. Spacetime consists of all possible lattices. That is it is infinite dimensional and is essentially white noise. Yet if information passes from E to O it takes (at least on the macroscopic scale) a long way through this noise. Only across the best error correcting sub-channels the information is not eroded (that is interferes destructively) and reaches the observer O.

Model V. Spacetime merely consists of certain lattices which are "under attack" of (inevitable) background noise. Only information that travels via the best error correcting lattices (in essence the Leech lattice) reaches O. Thus O perceives spacetime as having 24 dimensions, although in fact it has not. Therefore O always "sees" an effective spacetime and dimensionality.

Model VI. This model is based on a "top down" approach, i.e. we come from the physics side, taking the Bekenstein-Hawking entropy relation for granted. In the limit of infinitesimal volume of the lattice we require that it is reproduced. At least for the Leech lattice it is known that this is true (pointed out by **Edward Witten**).

Documents:

- Monstrous Moonshine and the Entropy of the Smallest Black Hole (2008) - R. A. W. Bradford local

Links:

- This Week's Finds in Mathematical Physics (Week 254) - J. Baez

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Thoughts about Algebra and Differential Geometry

An Essay about Algebra and Differential Geometry

The Human Factor

At the core of mathematics are algebras. A specific geometry can be regarded as a representation of an algebra. This implies that the representation does not necessarily have to be unique. Algebra is essential, geometry can be seen more as a convenient way to deal with an algebra.

As allegedly about 50% of the human brain capacity deals with processing images, visualisation of algebras is essential. However in principle it is well conceivable to do all the relevant mathematics completely on algebraic grounds without invoking geometry. This has deep implications for physics. If one thinks about the "true" geometry of nature, it implies asking about the "true" algebra of nature. As we are very much used "to thinking in pictures" the question about the geometry is a very natural and emotional one. Many might regard thinking about reality in terms of algebraic concepts as being too abstract and suspicious. However there is a problem: Thinking about nature in terms of geometry lets us inevitably stick to traditional and intuitional visualisations. In concrete, it lets us think that the world is the way we "see" it. But even worse, in fact it can only be the way we can see it. There is a very critical biological factor coming into play here. Our brains are due to evolution conditioned to think in terms of 3-dimensional pictures as this reflects reality relevant in our everyday life and from an evolutionary point of view additional capabilities of being able to think in more dimensions would require (probably considerable) additional allocation of brain resources which would have been of no benefit in the evolutionary struggle to belong to the fittest. There are people who claim that they are able to "see things" for example in 4 dimensions. There is good evidence that this is wrong and in fact there is absolutely no human around who can really do this (one might admit that some can at best do so in a rudimentary way). The reason is that after hundreds of years of mathematics there has never been a human who has been able to develop a full fledged framework of non-associative geometry and to come up with appealing geometric concepts and visualisations. (Explaining a generalisation of classical parallel transport to non-associative geometry would otherwise be an easy task). In fact most algebras are non-associative and the most natural geometry would therefore be a non-associative one. Instead people are dealing with the special cases of associative and even commutative geometry.

Besides the biological factor mentioned there is also a sociological one. There is a set of canonical mathematical structures that are taught at school and at universities. They have to be simple enough that teachers and most of the pupils can understand them irrespective of them being the really relevant structures in the true description of

our world. If someone came up with an ingenious geometric concept beyond that he might well be totally ignored and such knowledge might never have a chance to spread. Even worse, due to the streamlining of knowledge, people are forced into the habit of thinking as everybody else does irrespective of mathematical and physical "truth".

Visualising the geometry of the underlying 8 dimensional space of the octonions is a good test bed. Probably nobody will be able to do so without "using the crutches" of the underlying algebra and its relations.
All this is quite bad for the progress of physics as we seriously have to consider the true nature of spacetime and matter based on non-commutative and even non-associative structures. The derivation of the standard model by means of non-commutative geometry is a strong hint thereof. The latter very nicely demonstrates the problem: Non-commutative geometry relies very much on an algebraic description and one cannot enter this subject without a certain load of algebra. Therefore non-commutative geometry is quite unknown in the public and hard to sell, even in the physics community. (In comparison the theory of relativity is still somewhat closer to our intuition. In this context people mostly use this quite doubtful analogy with a 2-dimensional curved surface in the attempt to come to grips with the visualisation of the geometry of the theory). Consequently people like Alain Connes might never have the change to get a reputation like Einstein even if their achievements might be regarded as comparable.

The Split
One can basically split up geometry into two parts. An algebraic one and a differential one. The former one corresponds to a flat space and the latter one to a curved space.

A classical example is the theory of relativity. Here the split is into special and general relativity. Special relativity deals with a pseudo-flat Minkowski space with the underlying algebra being the Lorentz algebra. In general relativity this algebra is "lifted" to a Riemann space. But locally one still deals with a flat Minkowski space. One can always find a transformation (Lorentz transformation) that restores this flatness (i.e. one transforms to a reference frame of a "freely falling observer"). This is nothing but the equivalence principle. It means that in a local free falling frame gravity is transformed away. Historically seen, the intuitive thought, promoted by Newton and his contemporaries was that the underlying algebra of space and time is cartesian. This is just what one would expect, as this is best in accordance with the way we perceive our surrounding every day world. When Einstein came up with the conjecture that this is not so, this was regarded as revolutionary. However considering the things said above, this should not have come as a surprise.

Now history repeats: In the early days people believed that the world was flat and introducing curvature to the surface of our planet came as a fundamental paradigm shift. In the same way these days many take the Lorentz algebra for granted in describing spacetime and matter adequately. Why ? The argument that it works is not a good one. Newtonian mechanics also worked for the very reason that it is a good approximation. In the same way Minkowski space might just be a good approximation. At least one should consider a modification. There is a strong hint that Minkowski space might not be the real McCoy. People doing physics with Clifford algebras at times come up with the question what the right signature of the algebra is that describes space-time and matter correctly. Hence they are discussing what the structure constants of the diagonal of the multiplication table of the algebra are. But this is equivalent to saying that they don't really know what the true algebra is at all. So if they don't know what the diagonal elements of the multiplication table are, how can they know what the off diagonal elements are and that the right description is by means of a Clifford algebra at all. O.K., it works well and in fact this is the only justification for choosing an algebra. (In case of special relativity for example one was forced to use the Lorentz algebra in order to interpret the Michelson Morley experiment. The cartesian algebra didn't work any more). However it might well be that other algebras also "work". Beyond the associative structures there is a vast sea of quasialgebras which as for example the octonions are fundamental building blocks in mathematics.

Concerning the split into an algebra and differential geometry, superstring theory is another example. The underlying algebra is a supersymmetry algebra and the differential geometry part is a geometry of extended objects (branes), generalising the traditional point particle concept in physics. These days one should better call this theory super brane theory as one is not merely dealing with 1-dimensional extended objects any more. (The name M-theory can be regarded as wisely chosen, as one can interpret "M" as membrane, designating the differential geometry part of the theory, but having the designation of the algebraic part left out, which gives one the freedom to still pick an adequate algebra without having to change the name of the theory. If not done so, one consequently would have had to call it super M-theory). It was claimed that if supersymmetry is not found in experiments, superstring theory would be "dead". This might not be quite as fatal as it seems. One could imagine to plug in another algebra into the theory instead of a supersymmetry algebra and take over the differential geometry part already developed that still would work in the same fashion. This is due to the fact that the two parts are mostly independent. The description of extended objects doesn't rely on supersymmetry. It seems that it was already around before supersymmetry was introduced.

Videos:

- Plato's Cave (Animated Version)

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Thoughts About Problems in Physics

> ...it appears that we must confront the breakdown of classical general relativity expected to occur near singularities if we are to understand the origin of our universe.
> - Robert M. Wald - General Relativity

Here are some thoughts about current **problems in physics** and an attempt is made to explain them.

A paradigm in physics are Lie-symmetries. They have been extremely successful in the past in describing known physics. There seems to be an enormous driving force to continue using them to advance physics. However **Lie algebras** are second order algebras, that is they can only describe a 2-dimensional manifold in that they code its curvature. As space-time is 4-dimensional, Lie-algebras do not suffice to describe it adequately. Higher order algebras have to be considered, i.e. a 3rd-order algebra to describe 3-dimensional space adeqately and a 4th-order algebra to describe the whole of space-time. This would introduce new symmetries and degrees of freedom justifying that resorting to higher dimensional theories as is done in **superstring theory** is not necessary. The price one has to pay might be the usage of **non-associative algebras**.

Some hints that this is the right concept are:

- **Fourth order theories of gravity** are renormalizable.
- One automatically gets additional terms in gravity and space-time singularities might disapper. They can be seen as an artefact of a second order algebra which imposes a spherical symmetry with the singularity in the center.
- The *Dirac monopole* which is still a problematic object could be described non-associatively and would not necessarily have to be quantized to avoid **anomalies**. The resolution of anomalies has

initiated the "string revolution". However as string theory builds upon some kind of Lie algebras the price one has to pay are additional space-time dimensions and many new degrees of freedom with the manifestation of many new unseen particles. Furthermore **supersymmetry** is mandatory.

- Q.M. does not have to be regarded as fundamental but arises as the manifestation of the 2nd-order of the underlying algebra. (This makes room for a more general setting which allows one to see q.m. more from a "birds eye perspective" and might allow one to reinterpret and maybe better understand it. Especially quantisation which appears relatively ad hoc could be better understood).
- This way one could explain the paradox that in the **path integral** formalism one starts with classical paths and derives q.m., whereas on the other hand it is often assumed that q.m. is more fundamental than classical physics and the latter is just a special case of it. (This is a paradox that I encountered many years ago and I do not know if there is an "official version" of it).

Maybe on a fundamental level physics is really classical, however non-associative.

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Unification

> Now I am going to discuss how we would look for a new law. In general we look for a new law by the following process: First we guess it - don't laugh that is really true. Then we compute the consequences of the guess to see if this law that we guess is right, to see what it would imply, and then we compare those computation results to nature, or we say ... compare it directly with observations to see if it works. **If it disagrees with experiment, it's wrong. In that simple statement is the key to science !** It doesn't make a difference how beautiful your guess is, it doesn't make a difference how smart you are or what his name is who made the guess. If it disagrees with experiment, it's wrong. That's all there is to it !
> - Richard Feynman - Lecture at Cornell University 1964

What is unification ?
Unification can be seen as solving **Hilbert's 6th problem**:

Axiomatize all of physics.

Why unification ?
The two pillars of physics are relativity and quantum mechanics. A unified description of special relativity and quantum mechanics has already been achieved in the form of quantum field theory. However the unification of general relativity and quantum mechanics is still an outstanding problem.

What the philosophy of unification in physics could be
We have seen many pieces of the puzzle, now let's try to put them together to see what the big picture is.

What are the common approaches at the moment ?
It seems that currently there are 3 major approaches trying to unifiy quantum mechanics and relativity:

- **String Theory**
- Loop Quantum Gravity
- **Noncommutative Geometry**

How to do the unifiaction ?
As general relativity is coded in the Einstein equations and quantum mechanics in the Dirac equation one could try to find an encompassing equation that yields these equations taking certain limits. Both equations can't be complete as the classical Einstein equations don't describe spin (a certain extension at least is required like in **Cartan-Einstein theory**) and the Dirac equation doesn't describe the **graviton**. The latter contains a mass term which leads to a gravitational field, but this field does not appear in the classical Dirac equation.

How could one do this technically ?
Try to find a minimal algebra with the constraint that it codes everything of what is known experimentally at the moment about the world and overcome known **problems**, in the hope that such algebra exists.

Theoretical Problems
If one starts with an algebra that describes known physics and embeds it in a larger (unifying) algebra (the word algebra and symmetry can be used interchangeably here) there are many possibilities to do this, i.e. the encompassing algebra is not determined uniquely. This could explain the proliferation of (unifying) theories seen at the moment.

Practical Problems

> That I have been able to accomplish anything in mathematics is really due to the fact that I have always found it so difficult. When I read, or when I am told about something, it nearly always seems so difficult, and practically impossible to understand, and then I cannot help wondering if it might not be simpler. And on several occasions it has turned out that it really was more simple!
> - David Hilbert -

I claim that - metaphorically speaking - physics and mathematics is like an unordered house where the common mathematician or physicist contributes his part to the common chaos. It takes those rare geniuses in their respective fields to create and restore order.

Examples:

- XArchive: Over 500.000 papers. On how many pages could one compress the essence of information contained in these papers ?
- Many define and proof the same thing over and over again, going then under different names. Many things are just different representations of the same thing which is often not recognized. Different names for the same thing and the same names for different things, along with unsharp definitions can cause much confusion.
- Therefore: Many important and deep results (maybe most) of them are already around and don't have to be reformulated again. The quest is to recognize them and to put them together in the right way. This is what much of unification seen from the practical point of view is about.
- Many relevant and deep, but abstract formulated mathematical results first have to be brought "down to earth" to harness them for physics.

The Chances
Now might just be the right time to succeed in finding a unified field theory, as many tools are available, that were not available only a few

years ago and that allow one to do theoretical physics more efficiently than ever before. Some examples are:

- LaTeX in combination with fast computers, such that compiling can be done "on the fly". This offers an alternative to doing calculations on the paper like in "the old days". Some advantages are: Much of algebraic manipulations consist of copying expressions, which in the conventional manner is a quite boring a process and error prone. With *LaTeX* one just does "copy and paste" an expression and continues with the algebraic transformations. Furthermore, external *LaTeX*-information can quickly be incorporated. Calculations can be better conserved and organized. Often one doesn't finish a calculation as one is running out of ideas or time or gets tired. Resuming it can be facilitated with *LaTeX*. There is no more "paper chaos" and running out of white space on a piece of paper is not an issue any more.
- WIKIs (like this): Information can be organized (e.g. linked) and searching specific information is done quickly.
- Internet: Search engines, online books and papers.
- Fast computers that allow one to do complex algebra very quickly.

The right discipline

> An enormous volume of mathematics exists, and to look for which part is going to be useful in the future is pretty hopeless.
> - P. A. M. Dirac -

Should one look more at what is going on in mathematics or in physics ? The situation in mathematics is such that mathematicians are less conservative in the structures they describe, hence one has better chances to find the correct one. However mathematicians characterize everything that comes to their mind and there is a bewildering richness of structures. A selection process, like in physics due to experiments is missing. In other words, "not everything offered on the shelves of mathematicians" seems to be useful to construct a theory consistent with known experimental facts (e.g. very specific gauge symmetries). Physicists on the other hand are quite conservative and try to stick to structures and tools they have once learned and that have already been successful in describing nature. So there is a tendency to try to push too far with them instead of learning new mathematical techniques and be creative enough to apply them to make headway in the unification process.

My guess

The best guess I can give at the moment: A unified field theory "lives" in weak ∞-category. As for the description of quantum mechanics a weak 1-category is sufficient (due to it "only" being non-commutative), there is much room for new when considering

higher order categories (i.e. deformations).
Furthermore I think that the problem of unification boils down to finding an appropriate 4-dimensional manifold with algebraic properties weak enough to allow for a description encompassing space-time as well as all kinds of matter. On the large scale it should look Riemannian, but on the (very) small scale I expect it to look quite differently.
If one goes one hierarchy level down from the classical to the quantum level, bivectors come into play in the form of non-commutativity and spinors. One might therefore speculate that if it were possible going down further hierarchy levels such that trivectors and 4-vectors play a role, new physics arises.
At any rate, in the end there should not remain any singularities whatsoever. On the grounds of physics I regard them as nonsense, indicating that something is wrong with the prevailing description.

An advice
Listen to recommendations of those who have already tried hard:
E.g. **P. A. M. Dirac**:

or **Roger Penrose**:
"... Physicists will never come to grips with the grand theories of the universe, Penrose holds, until they see past the blinding distractions of today's half-baked theories to the deepest layer of the reality in which we live. ..."
- Discover Magazine - Sept. 2009 -

See also: **Theory of everything**.

Papers:

- On the History of Unified Field Theories - H. F. M. Goenner local pct. 38
- Unified Field Theory from Enlarged Transformation Group. The Consistent Hamiltonian - D. Pandres Jr., E. L. Green pct. 2
- Einstein's Unified Field Theory Program - T. Sauer pct. 2

Links:

- The Foundational Questions Institute (FQXi)

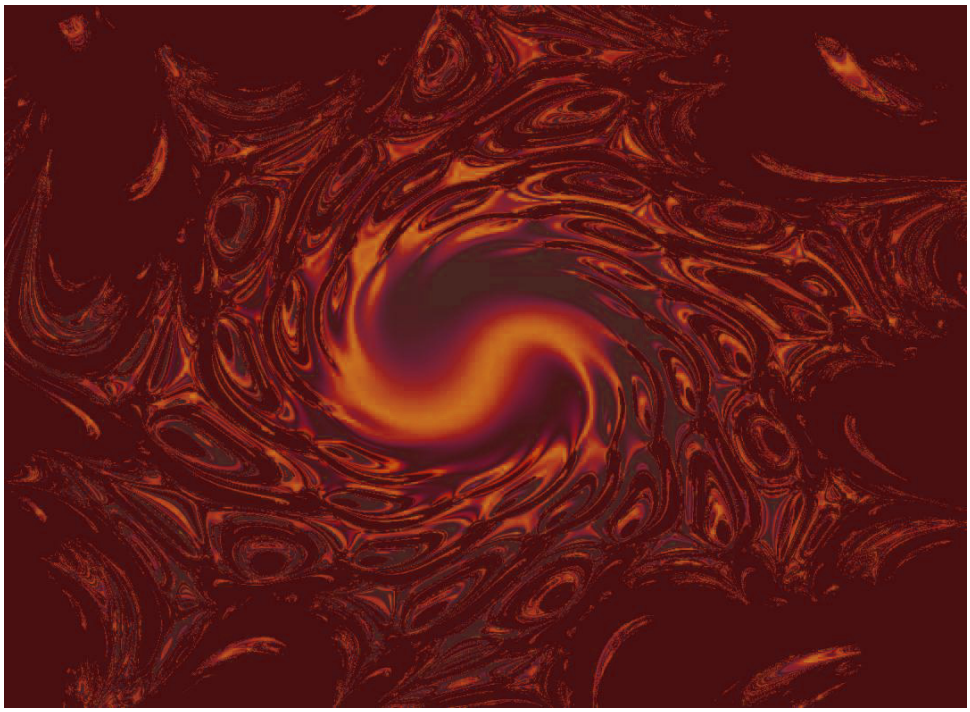
Books:

- Einstein's Unified Field Theory - M. A. Tonnelat bct. 7
- The Universe of General Relativity - A. J. Kox, J. Eisenstaedt bct. 1

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Universal Theory

> An absolutely key idea, actually goes back to Leibniz in 1686 and to Hermann Weyl in 1932 and 1949 ... If you allow an arbitrarily complicated pattern, then the patterns becomes vacuous, becomes meaningless because there is always a pattern. ... I think that's a more profound insight than Occam's razor.
> - **Gregory Chaitin** -



Rendered with **HyperFract**.

A philosophical essay...

A preliminary remark: The words "continuum", "the infinite" and $\aleph_1$ will be used interchangeably in the following and will be understood to have identical meanings.

Infinite nature of our world

The conjecture is that the "world" must be infinite. In the infinite there are no two identical structures. Suppose A and B are two identical

structures. One can always find a structure C that contains A and B and, if only taken large enough, A and B lie asymmetric in C and therefore cannot be regarded as identical. This assumes that by increasing C sufficiently one can always induce asymmetry, which requires that C varies at any distance from our structures A and B. If this were not so, C could not be chosen arbitrarily large, and it would be a finite structure embedded in "infinite uniformity". C must therefore be irregular (i.e. random or noisy) on all scales.
One might apply this principle to relativity where it would state: Given two events A and B, not necessarily timelike, there always exists an event C which contains A and B in the light cone, i.e. for which A and B are causally connected. An interesting question that arises is, what happens if one goes back in time as far as the big bang. An idea is, that only space undergoes a singularity, not time. One can make this statement even stronger in that one demands that time reaches back eternally. This way one could ensure that any two events can always be causally connected and are distinguishable, i.e. cannot be the same. In this scenario time describes ordered path (trajectory) in the continuum. Thus one can resolve the cloning paradox: Suppose two brains that allegedly are identical with identical self-awareness, appears paradoxical. One can always go far enough back in (eternal) time and find these two brains in different "locations" in the forward light cone, therefore the assumption that they are identical cannot be maintained. Furthermore one can make a statement about "the second time around argument", i.e. that there is an exact repetition of a conscious act. As these two identical conscious acts always lie in the forward light cone of an event C, they can never be identical. That is, every conscious act is unique ! The philosophical consequence is that "there is no way back". What remains to be understood is how individual conscious acts "add up" such that a continuous, lasting consciousness and self identity/awareness arises. Put it differently, what comprises a self-identity and what distinguishes it from another identity.
To summarize: The self is unique like any structure, also in time (consciousness happens here and now, yesterday is "gone" and who knows what tomorrow will bring).

Why is there something and not nothing ?

Our intuition may be wrong. We believe that the most natural state is nothing ("It is not how things are in the world that is mystical, but that it exists." - Ludwig Wittgenstein -) and we build something out of this nothingness. Then however the problem arises as to why things are the way they are and not different. (This also gives rise to "intelligent design", a creator, to come to grips with answering these questions). On the other hand if we accept the infinite as the fundamental reality, the things we see are just part of it and "allowed" as they are (mathematically) consistent. ("Infinite chaos contains any consistent mathematical structure").

What appears most natural to us does so merely due to the properties of our primitive and limited ape brains.

Mathematical reality

Ideas: Reality is inherently Platonic. Space-time is just a structure within it. The Platonic world is mathematics and is the ultimate reality. Therefore mathematics exists beyond space and time (really exists !) and we can describe space-time from this "higher perspective".
The Platonic world is the infinite. A finite system of rules describing the world would inevitably run into inconsistencies due to Gödel's incompleteness theorems ("Liar paradoxes"). This is in the sense of Penrose's arguments. (Therefore Platonism is the thing that allows one to say that π really exists).
Why is mathematical reality real ? An example: Suppose that out there in the universe there exists another advanced civilisation that we will discover one day. Nobody will probably doubt that if we were to compare our data of, say the 1000 first after comma digits of the number π, that we have computed before we knew from each other, they will agree. Therefore we have mapped the same "piece" of reality independently.

Physical reality

Any physical theory is a copy of a local patch of reality in the human brain and must always remain limited. (Except for the case that infinity is self similar and a patch is representing the whole, but I do not know how to justify this assumption at the moment).
Physical reality is a subset of mathematical reality (the human "view" of mathematical reality). Actually there is no physical reality. "Physical reality" is rather a map of a piece of (the infinite) mathematical reality to the limited brain (depending on our capabilities to do so, I.Q., ...).
Therefore physical reality is identical with mathematical reality or a subset of it, which explains Wigner's "unreasonable effectiveness of mathematics in the natural sciences". (How else could this coincidence be so strong ?)
So the conjecture is: There is only one reality, which is mathematical, and that is infinity = $\aleph_1$.

Definition of structure

Structures in the continuum are very special finite or countably infinite subsets of the continuum. This is what we "perceive" and what codes information (the informational content of the world).
Structure can be regarded as regularity in the infinite ("structural sections"), sth. like eigenvectors, n-th roots, groups of a certain

order, just things that are cyclic, repetitive and self-similar. The complement of these regular structures (which has probably the cardinality of the infinite) is noise, chaos or irregularity. That is, all the structures are at most countably infinite with an at most "countably infinite measure", whereas the complement has a "non-countably infinite measure".

Actually all subsets of the infinite are equally real but we perceive only those with (a finite) structure. The others appear uniform to us, we are blind for them. Our perception acts as kind of a filter, only seeing the "interesting" things. Those things we call physical reality, it is what happens (or what subjectively "only" exists for us).

The complement is an uncountable subset of $\aleph_1$, i.e. a subset for which one has a bijection to the continuum. Almost all subsets are of this kind. Therefore structure is the exception in the infinite. That is, that chaos, noise, amorphousness prevail. This is the natural setting in which structure appears. However due to the sheer mightiness of the continuum, structure consequently happens and even more: every "consistent structure" happens. Therefore the question why a certain structure is such and not different is answered. As long as the alternative is also "consistent", it is contained in the infinite and therefore exists. (That doesn't mean that we perceive it "right in front of our house door"). This way, starting with an infinite set to explain the world is more satisfactory in that it automatically answers questions, that require further input if one starts with an empty set (nothingness) to explain the world. Therefore again, the infinite is the more natural state than "nothing", though it might be counterintuitive. Interestingly, if one regards quantum mechanics, one observes eigenvalues which are countably infinite. They code the information that we can get about the world.
Hence a characteristic equation represents kind of a "structure filter". (One could regard the wavefunction as part of the infinite and therefore not observable, but I am not so sure about that statement). Mathematically one could interpret the world as an infinite algebra. The bigger the subset is one regards, the more one looses structure. Groups, loops and so forth are rigid, logic and consequent "eternal" substructures, that necessarily exist in a corner of the infinite. On the large scale (close to infinity) there is hardly any structure, so in a sense we are embedded in chaos or noise (an infinite algebra).
The infinite is totally chaotic and symmetrical. (Which is quite satisfactory from a philosophical point of view). Only if one goes to smaller scales one finds structure, the known hard coded ones (e.g. groups like E8 or the Monster).
A metaphor for this would be a "world fractal".

Paradoxes and probabilities

... to be continued ...

Articles:

- Why this Universe? Toward a Taxonomy of Possible Explanations - R. L. Kuhn

Links:

- A. A. Berezin

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

What is Software Programming

Having worked as a software developer for some years, I allow myself to be a bit of a heretic about the field, conjecturing that programming in essence boils down to three things (fundamentals):

- Assignments (A :=B),
- Branchings (IF (A <operation> B) THEN {...} else {...}),
- Loops (FOR ..., WHILE, DO WHILE, ... you name it),

That's "IT" :-) - Hope informaticians won't stone me for that !

The rest is all about nesting, nesting, nesting - pretty nasty at times.

Yet this should not lead one to underestimate programming. In fact it's a bit like playing chess, although the rules are quite simple, a game can be quite complex.

Maybe one day things will get a **(qu)bit** more fancy if "QIT" (**Quantum Information** Technology) can be realized, replacing classical "IT".

See also:

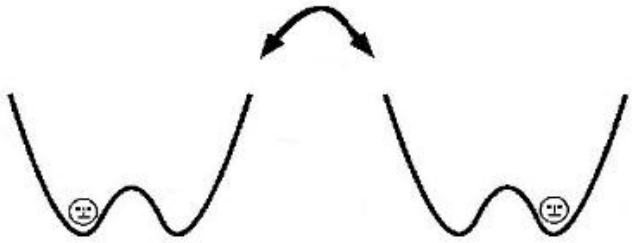
- **JHyperComplex**
- HyperFract

Your comments are very much appreciated. Suggestions, questions, critique, ... ?

Why the World is neither Deterministic nor Random

> Die Grenzen meiner Sprache bedeuten die Grenzen meiner Welt.
> - **Ludwig Wittgenstein** -

The problem with the ideal quantum random number generator



The claim is that there is no physical system which is with a (mathematically) exact probability of 50% in one and with 50% probability in another state. Although this would be a probabilistic system, it involves classical considerations, because deciding if the system is such a system or not is a (Boolean) "yes"-/"no" decision. Let's assume that there is such a system, then how could it look like ? It is suggestive to look for a system that is as simple as possible. One such system would be a totally symmetric double well potential and a particle, that can tunnel between the two wells.

The first problem that arises is that we have to initialize the system, i.e. to put the particle into the double well. Therefore one might conjecture that the initial conditions are not totally random but observer-dependent. On the other hand, one might argue that the system is totally symmetrical and it doesn't matter into which well one puts the particle in the beginning. If all this is a problem, we are done and in fact we cannot build an ideal random generator.

Therefore let's assume that these initial conditions do not have an effect on the outcome of the experiment. To decide if the probabilities are really 50/50, mathematically seen we have to take the limit, which in terms of physics means that we have to do an infinite number of experiments to come up with a truly Boolean decision. That is, if we assume that every fundamental system is of quantum nature, we can only get something classical by means of doing an infinite number of experiments, which is impossible. This would require an infinite time available or an infinite amount of resources, which is in principle equivalent to the former as to access all the resources it requires time. (E.g. to include resources from the Andromeda galaxy in our experiment it requires of the order of a Million years at least due to the finiteness of the speed of light).

Even if in principle one could run an experiment infinitesimally long this is not necessarily relevant in respect to our problem, as a "yes-no-" decision always is to be seen in the context of an observer, which then had to live (and wait) infinitesimally long.

If nevertheless, ignoring the things said so far, we could do an experiment that allows us for a true "yes- no-" decision, there is still another problem that had to be considered.
Suppose we discover that the random number is not an ideal one. Then we could argue that the potential well is not totally symmetric and we "just" had to fiddle around to make it symmetric. But how can we know that it is symmetric ? Well, we do an experiment. But this amounts to solving the problem we actually set out to solve, namely to come up with a "true" yes-/no decision based on a physical system. For this problem any physical system will do, and we just picked, for matters of convenience, a simple one. But now we have shifted the problem to a more complicated system, i.e. we have to measure the shape of a potential double well. Therefore we have gained nothing. Hence we have run into a recursive "yes-/ no trustworthiness decision problem".

No classical foundation

All the considerations so far are based on the assumption that on a fundamental level all systems in nature are "quantum" (e.g. we assumed tunneling) and to get a classical system we are doomed to take a practically impossible mathematical limit.

But what if there existed a truly classical system on a fundamental level ? Then it could be that there exist exactly as many "blue" such systems as there are "yellow" such systems. Doing a measurement, we would get "blue" with 50% probability and "yellow" with "50%" probability. I.e. this time we go the other way around, i.e. we recruit a probability from a classical entity. But how can we know ? We could say that it is a law of nature that 50% of the systems are "blue" and "50%" of them are "yellow". But a law first of all is a representation in our (maybe ontologically quantum mechanical) brains. Therefore to find out, we have to do experiments to check if this law is correct, which means we have to determine the colour of all such systems of the universe. Can we then be sure that they are classical ? First of all the connection of such a classical system to our brain could be "a quantum noisy channel" which we cannot exclude if just considering (doing a measurement of) our system. (We had to do a "yes-/no" decision experiment of the channel as well).
And what about the quantum nature of our brain, which seems to be the ultimate uncertainty (at least as long as there is no fundamental understanding of it) ? Here is where things get really intricate. We had to set up an experiment that measures if our brain is really able to

come up with a truly "yes-/no" decision, but somehow we can't do that without doing decisions here and there and we cannot know it they are classical or not, because this is just what we want to find out. I.e. we run into a recursive problem and there seems to be no way out, establishing a single trustworthy "yes" or "no".

All this boils down to the fact that our intuitive impression, that the natural setting of the world is classical is just wrong. One may wonder why before the advent of quantum mechanics this problem was stressed so little (in particular, why didn't philosophers more point to it ?)

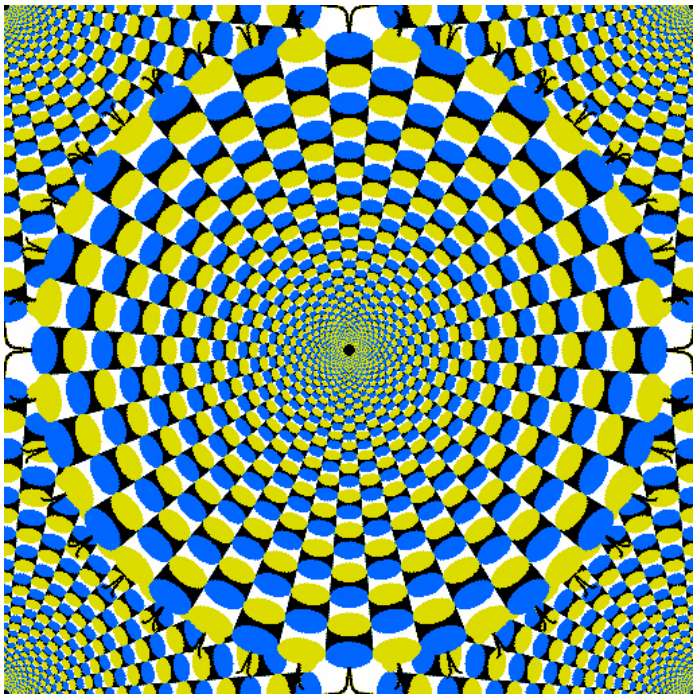
Furthermore it shows once again that to speak about a measurement and a property of a physical entity, one has to include the (wet) brain of the observer, i.e. an independent description doesn't exist. (Even worse is the case in mathematics, where the representation of a thought is entirely in terms of the physics of the 1 kg flabby matter, called human brain). Hence never trust a mathematical proof ! It claims to be an (ontologically) "true" yes-/no decision, which it can never be. So any mathematical proof is condemned to be limited in its scope. ("The brain is the ultimate limit").
In essence a mathematical proof consists of a finite sequence of "yes"- "no-" decision, neither one of which can be trusted.

Moreover these considerations show that one is repeatedly running into undecidable situations, which suggests that quantum probabilities might be related to Gödel's incompleteness theorems.

The very notion of truth is related to a (Boolean) "yes-/no-" decision. But this has to be implemented in the physical world which cannot be done.

To say that a physical system is (truly) classical doesn't make sense. This would require to "yes- no-"decide if this is so. To do this one has to extract information from the system. This requires setting up an experiment and connecting the system with the brain of the observer. But even if the system in regards is a simple system, the coupled system including the observer is quite complicated and we do not know if this is still a classical system. If the brain were ontologically a quantum system - in fact we do not know - how can we come up with a truly "yes-/no-" decision in the observer's brain ?
Or how can we "yes- no-" decide if the brain can in principle "yes- no-"decide ? In the brain we therefore run into a recursive problem concerning the trustworthiness of "yes- no"-decisions.
On the other hand the world could be classical indeed, but that has no relevance. To find out, we could conjecture "the world is not quantum". But that requires a Boolean decision, and that is what we don't have available, as this is just what we are trying to find out if it is possible.
So both, to say the world is ontologically "deterministic" or "quantum"

is an "empty" statement (I try to avoid to use word "philosophical"), as it is undecidable. The conclusion implies that one has to know what the conclusion is to come up with the conclusion. (One should mention, that the question of the world being deterministic or not is frequently discussed as if there existed hope for a definite "yes/no"-answer).
Thus for physics, Gödels theorems could be relevant in that they imply that we cannot decide if the world is classical, i.e. deterministic or not. In the same vein, we (our brains) cannot decide if the world is quantum or not as we cannot do the former.



Time - time and again

The statements from above may also help to understand the "flow of time". Suppose time stands still. I.e. given any two times t_1 and t_2 with $t_1 < t_2$ as close together as we like (i.e. $t_1 < t_1 + \varepsilon$). Then this implies a "true" yes- no decision. The problem again is the brain. Without a brain the problem is without any meaning. But anyway, we live in a world of brains. So to come up with a true "yes-no" decision it requires the brain to be able to do so. But above we have seen that there seems to be no way to get such a decision which is trustworthy. (Sounds like **Wigner's friend paradox**). If we assume that such a decision is impossible in principle then it is impossible to map $t_1 < t_2$ to "yes" or "no". I.e. time flows.
There is yet another issue about time, namely the direction of time. Our perception is that the flow of time has a fixed direction. But in the same manner as we cannot decide if $t_1 < t_2$, we cannot decide if $t_2 < t_1$. Therefore it is well possible, that the direction of time is an illusion and in fact time flows stochastically in the sense of a "Brownian motion" on a microscopic scale. So time might be seen as a microscopic phenomenon.

Alternatively, the direction of time perceived on the large scale might be a manifestation of a net drift, i.e. the backwards forwards symmetry is broken for some reason.

Therefore this might be an ansatz for explaining why we perceive time so differently than we do space, i.e. why it is not "laid out in front of us". Yet one has to argue why the same arguments that apply to time don't apply to space. (That order relations only exist in 1 dimension may offer a hint as to how to approach this problem).

Saying that the world is quantum mechanical therefore is less an ontological statement than one concerning the limits of information extraction of brains from the environment. So the question, if the brain is a quantum brain interpreted in this way means that to decide this question one would have to assume that it is classical and to show that this statement is either wrong or right. But this seems to be undecidable, i.e. if quantum is interpreted in the sense of undecidable, one might
call it a quantum brain. At least the statement "it is classical" cannot be trusted (upheld) as there is no way of finding out if this is really so (i.e. with a probability of mathematically exactly 100% = Boolean "true").

We cannot say there is an "objective" world out there. The best we can do is say that it behaves quasiclassically in everyday situations, which means the inherent uncertainties are irrelevant for all practical purposes.

So there is no true "bit" in the world and "it from a bit" does not make much sense. (Sorry Archibald Wheeler to contradict you once again).

Complementarity instead

The question "particle" or "wave" which represent the classical and the quantum world respectively may be seen as the problem of fundamental undecidability and hence undecidability may be at heart of the principle of complementarity.
The statement "the world is truly random" is tautological, as it implies a deterministic statement which is opposite to what it states. Therefore the statement that quantum mechanics is based on true randomness is not possible. It is better to say that quantum mechanics exhibits nondecidable situations: One cannot decide if particle or wave, what the exact position and velocity of a particle is at the same time, etc.
If one replaces "true" randomness and determinism by non-decidability, which is observer-dependent, one eliminates many problems and oddities of quantum mechanics (e.g. Wigner's Friend Paradox, **Schrödinger's Cat Paradox**, "The Moon is only there when you look at it paradox", "the universe requires an act of observation

to come into existence paradox", many world scenarios). All these things are more or less one or the other facet of the problem of the collapse of the wavefunction.

To conclude, all I have said is the truth and nothing but the mere truth and it is up to the reader to believe this or not ...

Your comments are very much appreciated. Suggestions, questions, critique, ... ?