

# Summary of TGD, quantum TGD, and TGD inspired theory of consciousness and quantum biology

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Who am I?

Physics student 1970, basic idea of TGD 1977, thesis 1982, 6 years as university teacher 1986-92, free researcher (that is unemployed after 1992 . 46 years with TGD.

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## 1 What is TGD?

Why Topological GeometroDynamics (TGD); Why TGD inspired theory of consciousness? Why TGD inspired quantum biology? What is TGD?

1. TGD as a geometrization of quantum physics: Einstein's program generalized.
2. TGD as a number theoretization of physics: something new. All number fields are involved. p-Adics physics. Adelic physics.

Duality between the geometric and number theoretic views:  $M^8 - H$  duality ( $H = M^4 \times CP_2$ )  $\leftrightarrow$  momentum-position duality  $\leftrightarrow$  Langlands duality in mathematics.

3. TGD as a topologization of physics  
Trinity! Geometry-number theory-topology
4. TGD inspired theory of consciousness as generalization of quantum measurement theory.  
Quantum biology.

## 2 Why Topological Geometroynamics (TGD)?

Homepage: <http://tgdtheory.fi>

Summary of TGD: [http://tgdtheory.fi/public\\_html/articles/TGD2021.pdf](http://tgdtheory.fi/public_html/articles/TGD2021.pdf) .

Situation in particle physics at seventies:

Standard model 1967, weak currents observed 1973 . Idea of GUT. Dual resonance model 1968  
→ hadronic string models. Supersymmetry 1971, Superstrings 1974.

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### 2.1 TGD as a geometrization of standard model interactions and of gravitation

Basic idea 1977.

1. What was the problem?

General Relativity has a problem with conservation laws. Space-time curved. Poincare invariance is lost and Noether theorem cannot be used to deduce classical conservation laws.

2. !Proposed solution: space-times are 4-dimensional *surfaces* in higher-D embedding space H with Poincare group as isometries!

Hyperspace  $H = M^4 \times S$ .  $M^4$  the space-time of special relativity. Poincare symmetries lifted from space-time level to  $H = M^4 \times S$ ! They affect the entire space-time surface rather than the point of space-time.

3. It took 2 years to realize that  $S = CP_2$ , 4-D complex projective space.  $CP_2$  codes for classical gauge fields and symmetries of standard model!!

c). Gauge potentials are projected/induced to the space-time surface: surface dynamics makes them dynamical. Dynamics of shadows! No primary gauge fields and metric.

4. QFT limit of TGD from glass plate analogy.

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### 2.2 TGD as a generalization of (super) string model

String models: A point-like particle of QFT replaced with a 1-D string. Infinities of QFTs cancel! Conformal symmetries of 2-D string world sheets have huge symmetry. !Idea:

1. Replace 1-D string with 3-D surface and identify it as a particle in a geometric sense.

2. 4-D space-time surface as orbit of 3-D particle.

Notions of a particle and space are unified. 3-surface looks like a particle on a long scale but like a back-ground 3-space on a small scale.

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### 2.3 Many-sheeted space-time

TGD space-time is topologically non-trivial in all scales unlike the space-time of GRT.

1. Glass plate analogy.

2. Space-time sheets. Finite size. Space-time split into pieces! We see it! Particles as topological inhomogeneities.

3. 3-space around us consists of objects with outer boundaries. Could they be boundaries of a 3-surface?!

4. Wormhole contacts connect sheets. The throats of wormhole contacts as carriers of fundamental particle quantum numbers.

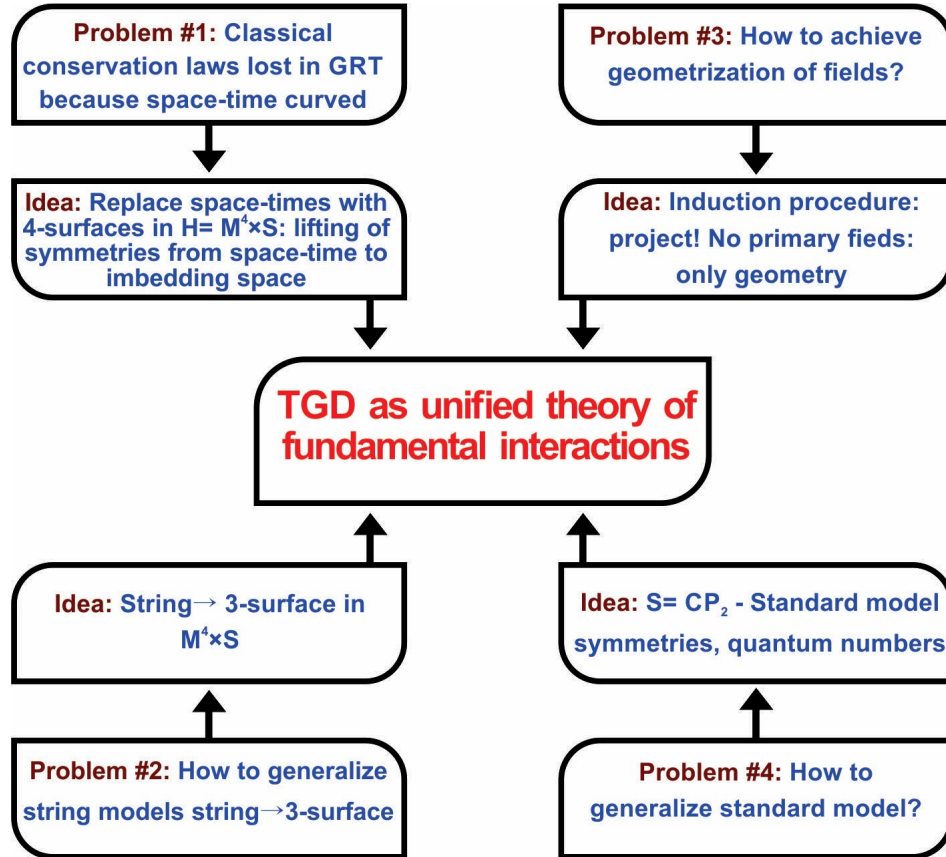


Figure 1: The problems leading to TGD as their solution.

### 3 Quantum TGD very briefly

Philosophy: geometrize entire quantum theory, not only gravitation, not only the classical fields as in classical TGD, but entire quantum theory.

#### 3.1 Problem: Standard path integral of QFT approach fails mathematically

1. General problem: Path integral as an integral of a phase factor  $\exp(iS)$  defined by action exponential do not exist mathematically. The only definition algebraically and perturbatively. Feynman diagrams.

$$\int \exp(ix^2 + ij(x)) dx$$

$$x \rightarrow \{x_1, \dots, x_n\}$$

$$\rightarrow \{\Phi_x \equiv \Phi(x), x \in M^4\}$$

Divergences. Renormalizable theories.

2. TGD variant of the problem: path integral over all possible 4-surfaces in H. The approach fails completely by extreme non-linearity for any general coordinate invariant action expressible in terms of induced fields.

Conclusion: give up the path integral.

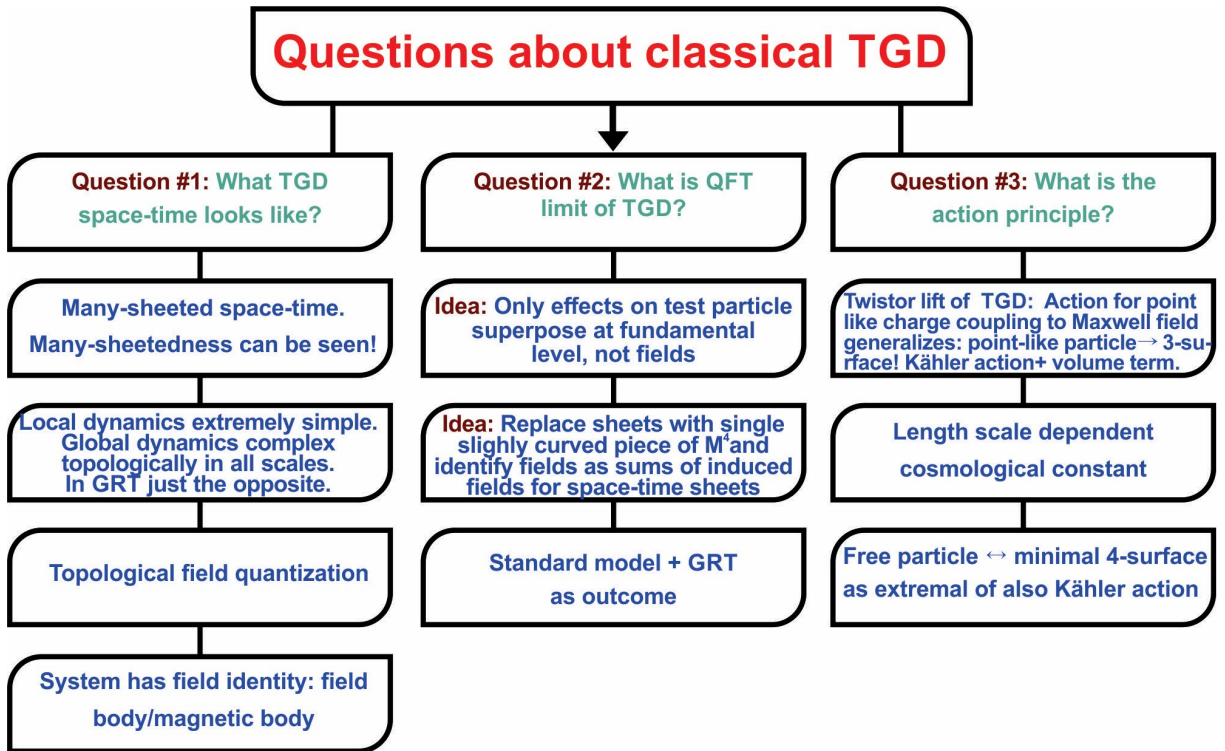


Figure 2: Questions about classical TGD.

### 3.2 Quantum TGD as a generalization of wave mechanics

!!!!Construct TGD as an analog of wave mechanics.

#### 3.2.1 Classical theory as exact part of quantum TGD

1. Point-like particle → 3-surface. Particle orbit → 4-surface.
2. 4-D(!) General Coordinate Invariance (GCI)

Basic gauge symmetry of GRT. It is 4-dimensional!!!!. In TGD, it requires a unique assignment of space-time surface  $X^4(X^3)$  to 3-surface  $X^3$ :

$$X^3 \rightarrow X^4(X^3)!!$$

Action principle does this!! Preferred extremals as analogs of Bohr orbits.

3. Holography from General Coordinate Invariance!

GCI → Holography → Bohr orbitology → Quantum-Classical Correspondence. Classical correlate for Uncertainty Principle (UP).

$X^4(X^3)$  need not be quite unique. Finite non-determinism, which might define classical correlates for cognition, imagination and even free will.

$X^4(X^3)$  4-D minimal surface! 4-D soap film with frames.

### 3.2.2 Quantum theory as generalization of wave mechanics

#### 1. World of classical worlds (WCW)

Counterpart of the 3-D configuration space  $E^3$  of electron.

(a) The first guess:  $E^3$  is replaced with the space of 3-surfaces  $X^3$ . "World of classical worlds" (WCW).

(b) Holography suggests a better guess:

$X^3$  defines almost unique  $X^4(X^3)$  as an analogy of Bohr orbit.

Define WCW as the space of 4-surfaces  $X^4(X^3)$ , preferred extremals of action. Space of Bohr orbits.

#### 2. Wave functions of electrons $\rightarrow$ wave functions in WCW!

Dirac spinors in atomic model  $\rightarrow$  WCW spinor fields. Fock states.

**Challenge:** Construct WCW geometry and Kähler structure! These structure are highly unique from mere mathematical existence. For loop spaces Kähler geometry unique (Freed)!

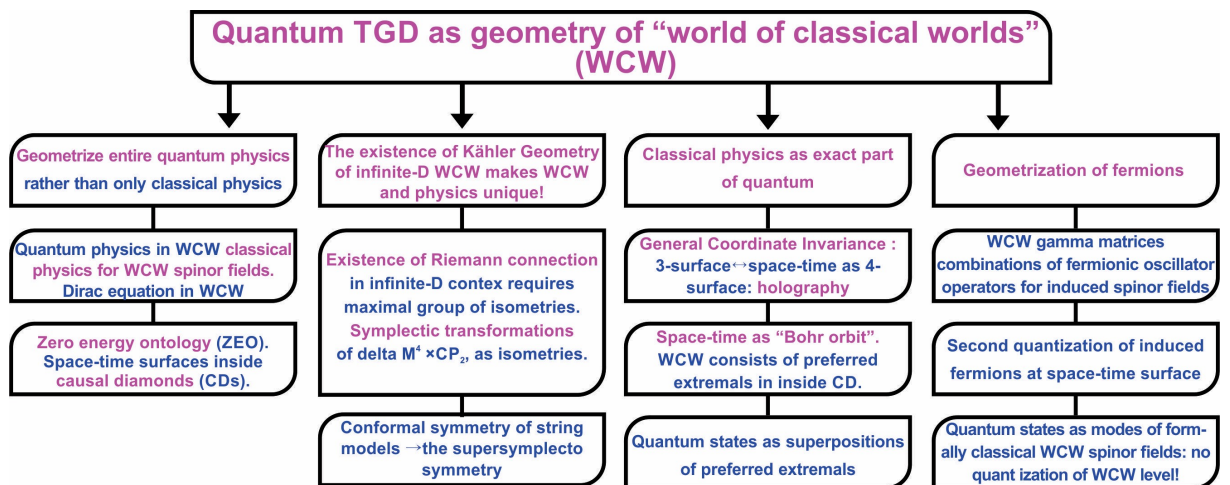


Figure 3: Geometrization of quantum physics in terms of WCW

### 3.3 Zero energy ontology (ZEO)

[http://tgdtheory.fi/public\\_html/articles/zeoquestions.pdf](http://tgdtheory.fi/public_html/articles/zeoquestions.pdf) [http://tgdtheory.fi/public\\_html/articles/ZEOnumber.pdf](http://tgdtheory.fi/public_html/articles/ZEOnumber.pdf)

ZEO is forced by holography forced by GCI.

What does ZEO mean?

## 1. Causal diamond (CD)

$CD = cd \times CP_2$  is quantization volume.  $cd$  is the intersection of the future of past directed light-cones. Space-time surfaces are inside causal diamonds (CD).

CD characterizes physical state: it is not arbitrarily fixed by theoretian but by the physical state.

## 2. Zero energy states

Superposition of space-time surfaces determined by holography inside CD. Conserved quantum numbers for 3-surfaces at opposite boundaries of CD can be taken to be opposite. Just a convention.

## 3. Zero energy state can be regarded as a superposition of pairs of 3-D states at the opposite boundaries of CD. One can fix only the state at either boundary of CD. Holography!

3.4 Hierarchy of effective Planck constants  $h_{eff}$  and dark matter

Relates to the number theoretical vision.

## 3.4.1 Original motivation from neuroscience

Quantum-like effects of ELF em fields on the brain at EEG frequencies. 15 Hz... Blackman et al in the seventies.

$E = hf$  implies that  $E$  is extremely small, much below the thermal energy: quantal effects masked by thermal noise!

## 3.4.2 Dark matter as phases labelled by effective Planck constant

!Planck constant has a spectrum. Its values would label levels for a hierarchy of phases of ordinary matter, behaving like dark matter.  $h_{eff}$  can be arbitrarily large.

1.  $h_{eff} = nh_0$ ,  $h = n_0h_0$ ,  $n_0 = (7!)^2$ .2. Number theoretic TGD:  $n = h_{eff}/h_0$  has interpretation as dimension of extension of rationals associated with a rational polynomial  $P(x)$ , which determines space-time region (number theoretic vision of TGD). Adelic physics/p-adic physics.  $M^8 - H$  duality emerges as an analog of momentum-position duality.

$n$  is a measure of algebraic complexity: kind of IQ. Measure of scale of quantum coherence. Cognitive representations as points of space-time surface with coordinates, which are algebraic numbers in the extension. Unique discretization.

[http://tgdtheory.fi/public\\_html/articles/adelephysics.pdf](http://tgdtheory.fi/public_html/articles/adelephysics.pdf)

## 3. Number theoretic holography appears as counterpart of geometric holography

(a) The roots of rational polynomial  $P(x)$ , define 3-D mass shells  $H_m^3 \subset M^4 \subset M^8$ , which are hyperbolic 3-spaces.  $M^8$  as an analogy of *momentum space*.

(b) The 3-surfaces  $X^3$  at mass shells  $H_m^3$  define holographic data, which determine 4-D surface  $X^4(X^3) \subset M^8$  by number theoretic holography stating that the normal space of  $X^4(X^3)$  is associative:  $a(bc) = (ab)c$ . Associativity replaces dynamics determined by action principle.

(c)  $X^4(X^3) \subset M^8$  is mapped to  $X^4(X^3) \subset H = M^4 \times CP_2$  by  $M^8 - H$  duality. Momentum-position duality of wave mechanics  $\rightarrow M^8 - H$  duality.



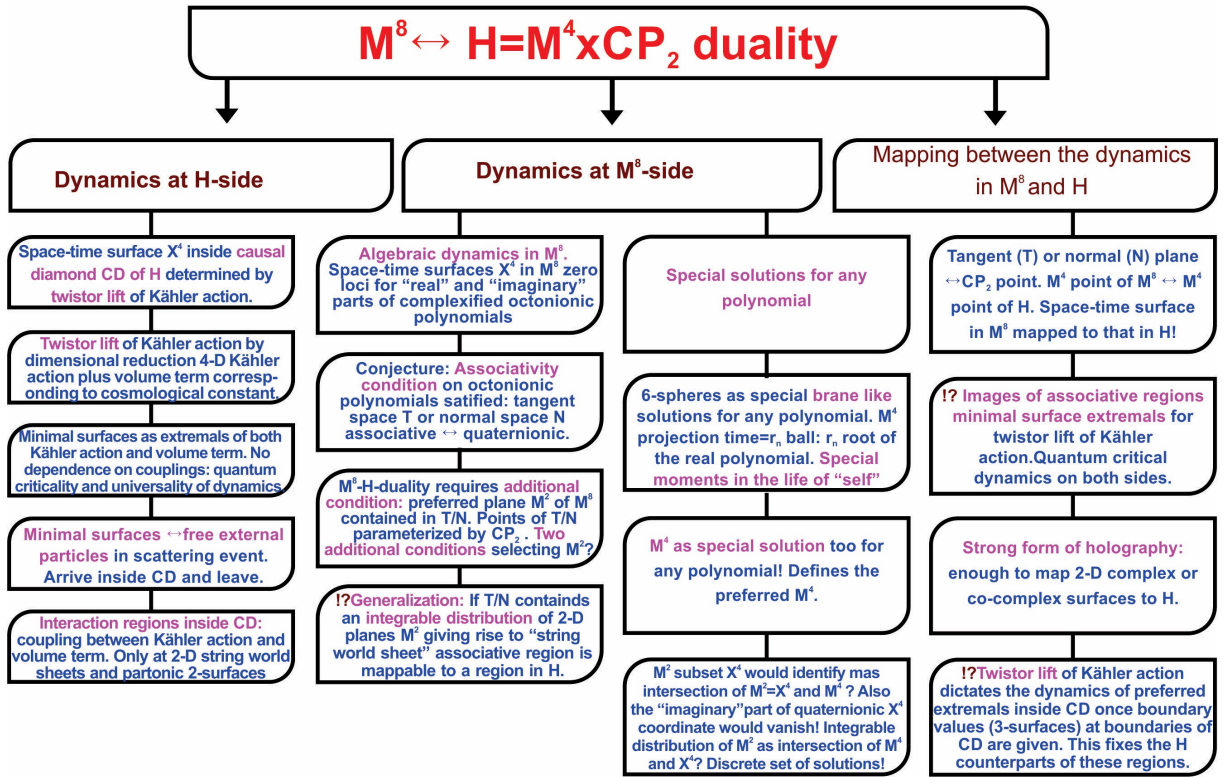


Figure 4:  $M^8 - H$  duality

## 4 TGD inspired theory of consciousness

!Generalize quantum measurement theory to a theory of consciousness!

### 4.1 Why is a theory of conscious experience needed?

1. Physical motivations.
  - (a) The paradox of quantum measurement theory. State function reduction (SFR) is non-deterministic and in conflict with deterministic time evolution of Schroedinger/Dirac equation and unitary time evolution.
  - (b) Observer remains an outsider to the physical world.
  - (c) What systems can perform quantum measurements? Decoherence.
2. Philosophical motivation: Free will is not possible within the framework of classical deterministic physics. Could a suitably generalized quantum theory allow free will?
3. The view of the relationship between experienced time and geometric time is definitely wrong. There is however a correlation between these times.

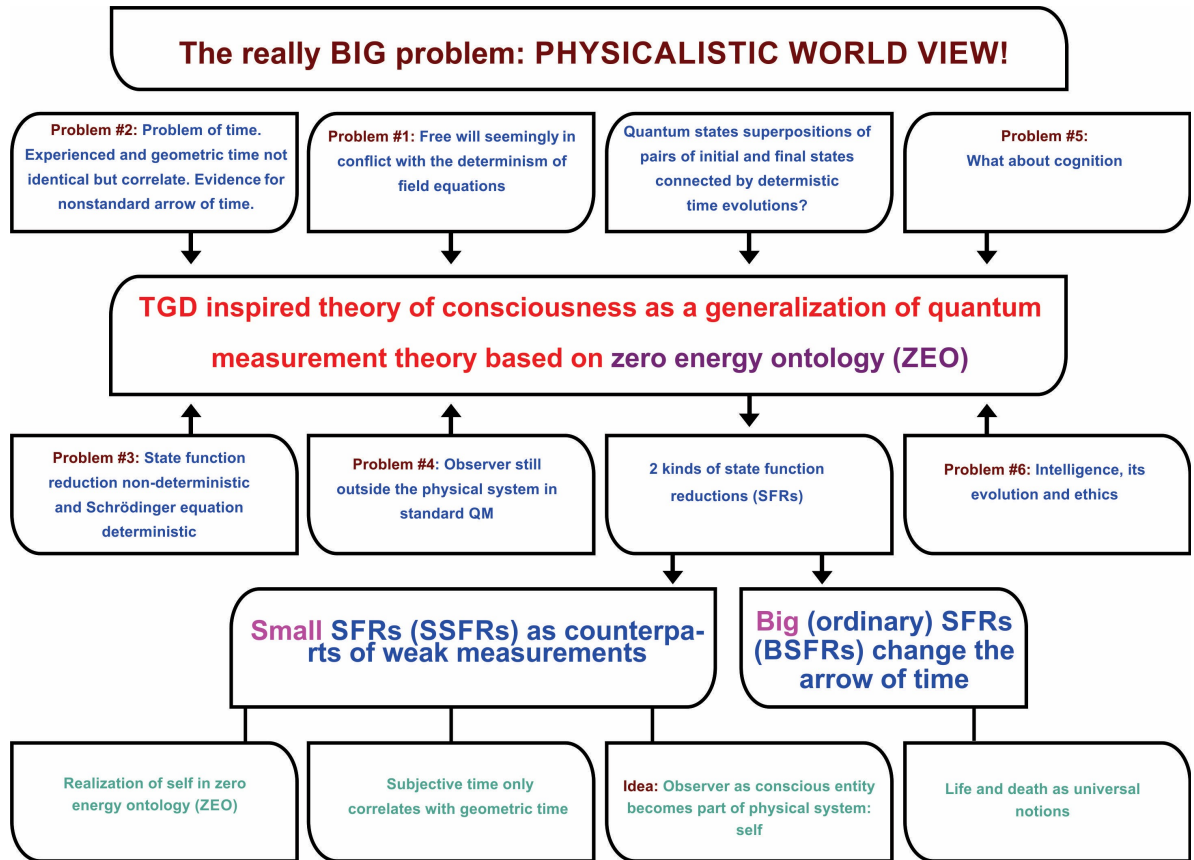


Figure 5: Consciousness theory from quantum measurement theory

## 4.2 TGD view of conscious experience briefly

1. Zero energy ontology (ZEO) as a way to solve the basic paradox of quantum measurement theory.
  - (a) Causal diamond (CD) as a nature given quantization volume.
  - (b) Zero energy states as superpositions of space-time surfaces inside CD.
2. State function reductions (SFRs) in ZEO
3. Superposition of space-time surfaces replaced with a new one. One does not violate classical determinism for a classical time evolution! Also the geometric past changes. Wheeler's delayed choice experiment shows that this occurs.
4. Two times—two causalities. Geometric time and causality of field equations. Subjective time as sequence of SFRs. Causality of free will. Re-creation. Evolution.

## 4.3 Two kinds of state function reductions (SFR)

"Small" and "Big" SFRs. SSFRs and BSFRs.

1. SSFR corresponds to "weak" measurement, almost classical measurement.
2. BSFR corresponds to ordinary quantum measurement.

### 4.3.1 Small SFRs

Start from the Zeno effect: the kettle, which is monitored, does not boil. The measured system freezes to the eigenstate of measured observables!

What does this mean in ZEO?

1. Assumption: either boundary of CD remains invariant in SSFR, the "kettle". Call the "kettle" passive boundary. Second boundary is the active boundary and changes as also the quantum states at it. This is new and brings in self!

Small SFR corresponds to "weak" measurement in quantum optics.

2. Self as a sequence of small SFRs during which the passive boundary remains invariant.
3. In SSFRs active boundary of CD is shifted and also the 3-D state at it changes. The size of CD increases at least statistically. Distance between tips of CD geometric time. This correspond to the flow of geometric time. Increase of CD as increase of geometric time  $\leftrightarrow$  flow of subjective time.
4. Objection: How *discrete* SSFRs can give rise to a *continuous* flow of consciousness?
  - (a) "It is not possible to be conscious that one is not conscious" as an explanation.
  - (b) Alternative explanation: holography of consciousness. The SSFR defines the content of conscious experience until SSFR occurs just like 3-surface determines the space-time surface. One obtains flow of consciousness.
5. Measurement outcome determines qualia. Visual colors as example.

### 4.3.2 Big SFRs as ordinary SFRs

They are needed!

1. There is no reason why the passive boundary of a CD should remain passive for ever. The roles of active and passive boundaries can change in BSFR.
  2. The arrow of time would change in BSFRs!
  3. Self "dies" (or falls asleep). Death (sleep) in this sense would be a universal phenomenon.
  4. After big SFR the self reincarnates in opposite time direction and continues to live until the next BSFR, which brings back the original arrow of time, occurs: analog of reincarnation as it is usually understood.
  5. BSFR has many applications:
    - Libet's findings related to the active aspects of consciousness. The brain activity precedes conscious decision: conscious decision as BSFR changing the arrow of time and the direction of causality.
    - The findings of Mineev et al in quantum optics.
    - Quantum tunnelling as pair of BSFRs.
    - Earthquakes.
    - Stars older than the Universe.
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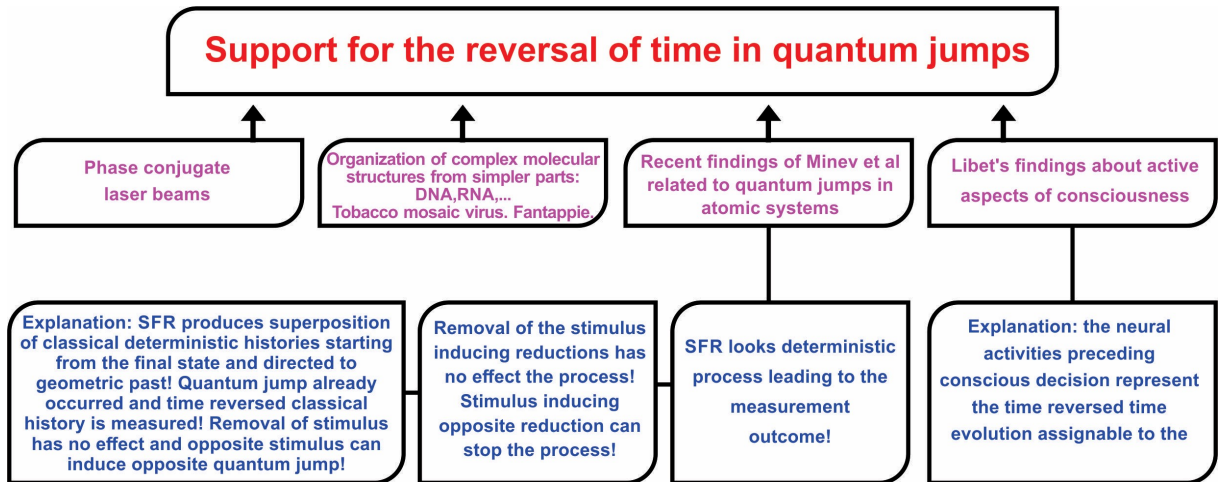


Figure 6: Time reversal occurs in BSFR

#### 4.4 About the general structure of conscious experience

1. The structure of conscious experience reflects the structure of the physical world. Hierarchy of space-time sheets → self hierarchy. Collective consciousness.
2. Selves as systems able to de-entangle.
3. Subselves as mental images of self. Subsubselves experienced as averages. Superego-ego-id trinity of Freud.
4. Stereo consciousness. Visual fields of the right and left brain fuse to stereo vision. Right and left brain. Split personalities.

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#### 4.5 Negentropy Maximization Principle (NMP) as variational principle of consciousness

1. Ordinary real, non-positive entanglement negentropy  $N_R$ : Shannon formula.  
 $S_R = -N_R$  measures the lack of information of observers from the state of either entangled system.
2. p-Adic entanglement negentropies  $N_p$ ,  $p = 2, 3, 5, \dots$ : generalization of Shannon formula.  
 $N_p$  can be *positive*!!  
 $N_p$  is a measure for the information of an entangled pair of systems about *itself*!

- (a) Total p-adic negentropy  $\sum_p N_p$ .
- (b)  $N_R + \sum_p N_p = -S_R + \sum_p N_p$  can be positive!

3. Negentropy Maximization Principle (NMP): In the sequence of SFRs, the negentropy of the Universe increases in a statistical sense. One reason is that the dimension of extension of rationals increases. Evolution number theoretically.

NMP is *not* in conflict with the second law of thermodynamics. The increase of  $\sum_p N_p$  forces the increase of  $S_R$ . Is the pollution caused by the emergence of humans as intelligent species?!

4. Cognition and adelic physics.

[http://tgdtheory.fi/public\\_html/articles/adelephysics.pdf](http://tgdtheory.fi/public_html/articles/adelephysics.pdf)

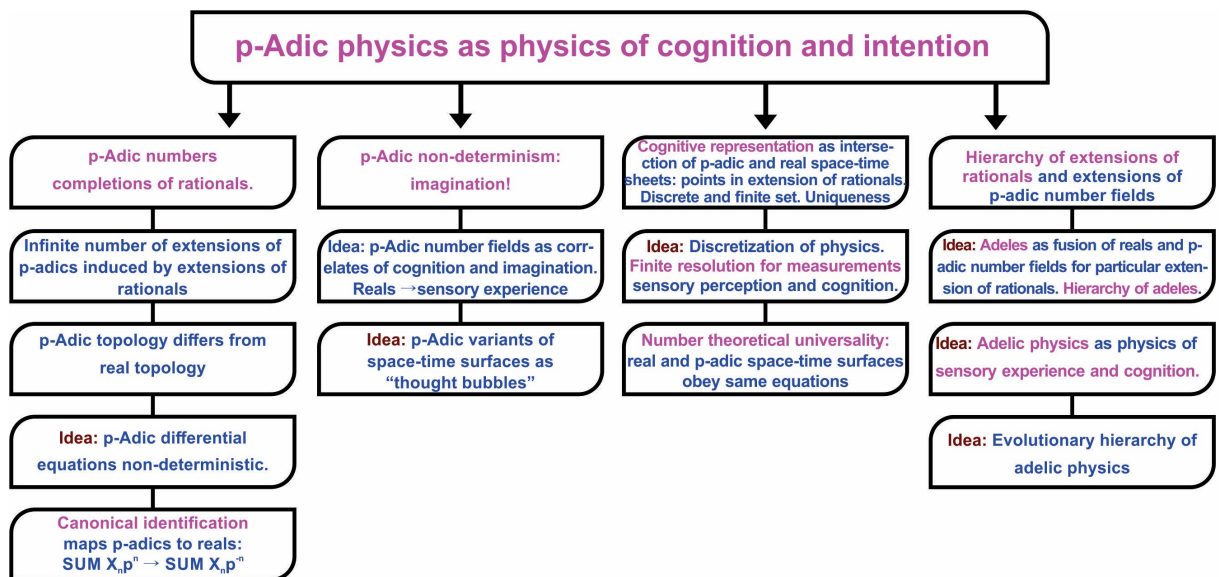


Figure 7: p-Adic physics as physics of cognition and imagination.

## 5 TGD inspired quantum biology

New elements:

- many-sheeted space-time, field body, magnetic/electric body,
- dark matter as  $h_{eff} = n \times h_0$  phases,
- holography,
- zero energy ontology (ZEO).

### 5.1 Many-sheeted space-time

1. Matter in 3-space is replaced with topological inhomogeneities of 3-surface. We directly see the complex topology of space-time! Morphogenesis has a topological description!

[http://tgdtheory.fi/public\\_html/articles/watermorpho.pdf](http://tgdtheory.fi/public_html/articles/watermorpho.pdf)

2. The notion of a field (magnetic/electric body.
3. Fields in Maxwell's sense are replaced with topological field quanta, *field bodies*. Flux quanta for magnetic fields as flux tubes and flux sheets. Electric flux quanta for electric fields.
4. Magnetic body (MB) has an onion-like structure with layers even larger than Earth size. MB as the boss controlling the biological body (BB) because its layers have large  $h_{eff}$  and IQ! Slaving hierarchy.

Support: EEG as sensory communications from BB to MB and control of BB by MB.

<http://tgdtheory.fi/pdfpool/eegdark.pdf>.

### 5.2 Dark matter as $h_{eff}$ phases and macroscopic quantum coherence

Problem: Why is living matter coherent in long scales? Chemistry predicts coherence in molecular scales only.

Quantum coherence lengths are typically proportional to  $h_{eff}$  (Compton length as  $L_c = h_{eff}/m$ ) and increase with  $h_{eff}$ . Large scale quantum coherence.

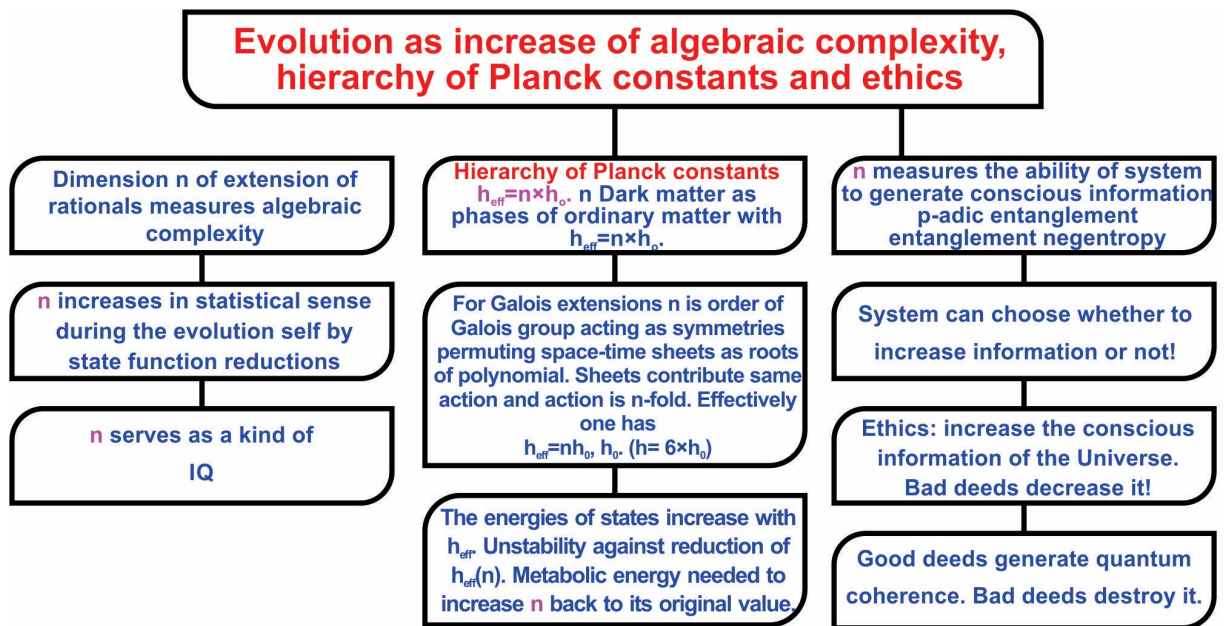
1. In living systems, the layers of MB correspond to large  $h_{eff}$  and are quantum coherent in long scales and have high "IQ". Their quantum coherence induces effective coherence at the level of ordinary biomatter. This explains why we are much more than mere sacks of water with some chemicals.
2. Increase of  $h_{eff}$  requires energy! Explains why metabolic energy is needed. Explanation for metabolism.
3. Evolution number theoretically as increase of the values for  $h_{eff}$ : increase of universal IQ and scale of quantum coherence.

### 5.3 Some Examples of dark matter in biology

1. Effects of ELF em fields on vertebrate brain. Blackman.
2. Pollack effect. Irradiation of water bounded by gel phases creates negatively charged exclusion zones (EZs). Part of protons go to the magnetic flux tubes.

DNA and cell negatively charged.

[http://tgdtheory.fi/public\\_html/articles/Pollacktube.pdf](http://tgdtheory.fi/public_html/articles/Pollacktube.pdf)



**Figure 8:** Number theoretic view about evolution

3. MB, dark matter and biochemistry. MB is an essential part of biochemistry as a controller and generator of long scale coherence.

$h_{eff} > h$  phases distinguish between ordinary chemistry and organic and biochemistry. Crucial for understanding bio-catalysis.

Dark DNA/RNA/tRNA/amino acids paired with DNA/RNA/tRNA/amino acids.

[http://tgdtheory.fi/public\\_html/articles/darkchemi.pdf](http://tgdtheory.fi/public_html/articles/darkchemi.pdf) [http://tgdtheory.fi/public\\_html/articles/valenceheff.pdf](http://tgdtheory.fi/public_html/articles/valenceheff.pdf)

4.  $h_{gr} = GMm/v_0$  (Nottale) associated with gravitational flux tubes of special importance. Quantum gravitation would be central for metabolism, catalysis, and topological quantum computation-like activities.

$$E = h_{gr} f$$

Blackman!

[http://tgdtheory.fi/public\\_html/articles/precns.pdf](http://tgdtheory.fi/public_html/articles/precns.pdf)

[http://tgdtheory.fi/public\\_html/articles/penrose.pdf](http://tgdtheory.fi/public_html/articles/penrose.pdf)

[http://tgdtheory.fi/public\\_html/articles/TQCTGD](http://tgdtheory.fi/public_html/articles/TQCTGD)

5. Number theoretic vision predicts evolution as increase of algebraic complexity.

## 5.4 Holography in biology: structure=function (almost)

Space-time surface as deterministic time evolution analogous to computer programs, functions, behavioral patterns. Connection between fundamental physics and computer science, biology, and neuroscience.

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## 5.5 ZEO and quantum biology

[http://tgdtheory.fi/public\\_html/articles/zeoquestions.pdf](http://tgdtheory.fi/public_html/articles/zeoquestions.pdf)

[http://tgdtheory.fi/public\\_html/articles/ZEOnumber.pdf](http://tgdtheory.fi/public_html/articles/ZEOnumber.pdf)

The role of BSFRs and SSFRs in biology:

1. In SSFR a new deterministic program is selected. Like clicking an icon in the menu of a computer program.
2. BSFR as death in a universal sense. Sleep/hibernation examples of time reversed mode. Occurs already at DNA level.

[http://tgdtheory.fi/public\\_html/articles/whendeath.pdf](http://tgdtheory.fi/public_html/articles/whendeath.pdf)

3. Time reversed modes for subsystems created in BSFRs crucial for self-organization/healing. Thermodynamic arrow of time changes. Dissipation with a reversed arrow of time looks like self-organization or healing for the outsider.
4. Homeostasis as ability to stay near quantum criticality made possible by BSFRs. Repellor looks attractor for the opposite arrow of time!

[http://tgdtheory.fi/public\\_html/articles/SP.pdf](http://tgdtheory.fi/public_html/articles/SP.pdf)