

`%\begin{abstract}`

The notions of information and intelligence are discussed in TGD framework. Possible definitions for the information measures of the configuration space spinor field and information gain of conscious experience as well as the information theoretic interpretation of Kähler action are discussed in detail the first sections of the chapter.

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`\item` The key element of the approach is the number theoretic generalization of entanglement entropy. Quantum entanglement between real and p -adic degrees of freedom makes sense if entanglement coefficients are rational or even algebraic numbers. In this case one can define entanglement entropy using the p -adic variant of the logarithm. p -Adic entropy can be also negative, and the states for which the entropy is negative are stable against self measurements (NMP) and define macrotemporally quantum coherent states. The number-theoretic entropy serves as an information measure for cognitive entanglement, and positive entanglement negentropy can be interpreted as a correlate for the experience of understanding. Number theoretic entanglement measures are natural in what might be called the intersection of real and p -adic worlds (partonic 2-surfaces have mathematical representations making sense both p -adically and in real sense) and this leads to a vision about life as something residing in this intersection. The consistency with standard quantum measurement theory leads to the conclusion that negentropic entanglement must correspond to a density matrix proportional to unit matrix. Entanglement matrix proportional to a unitary matrix characterizing quantum computation gives therefore rise to negentropic entanglement.

`\item` Various measures for the information contents of consciousness are discussed.

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\item The reduction of entanglement entropy defines a natural measure for conscious information gain in single step of the state of state function reduction process decomposing subsystem to a pair of un-entangled sub-systems. If entanglement is negentropic the entanglement negentropy either increases or the system is stable against state function reduction.

\item It seems natural to assume that the information measures are associated with the entire cascade and that they are additive in the sense that information gain is sum over the information gains of the steps of the cascade and that a given step contributes by the sum of the information gains associated with unentangled subsystems which are subject to self measurement in a given step of the cascade.

\item One can also assign information measures to the resulting indecomposable systems. For subsystem which is bound state in the normal sense and thus has entropic entanglement, one can consider all possible decomposition of the system to a sub-system and its complement and define the entanglement negentropy as the negative for the minimum value of entropy obtained in this manner. If the system is negentropically entangled one can define entanglement negentropy as the maximum of entanglement negentropy obtained in this manner. This means that one can assign to the final state of state function reduction unique negentropy as the sum of the negative contributions associated with selves which are internally bound state entangled and positive contributions of negentropic selves.

\item The information content of the conscious experience associated with self is more interesting practically. Since self defines a statistical ensemble, it is straightforward to define entropies associated with the increments of quantum numbers and zero modes defining non-geometric

and
geometric qualia. These entropies characterize the fuzziness of the
quale
and are \blockquote{negative} information measures. One can also
assign to
non-decomposable subsystems the information measures and they give
either
positive or negative contribution to the information content of
self.

\item In principle this allows to define also the net information
gain of
quantum jump as the difference of the total negentropies of the
final and
initial states of quantum jump identified as those produced by the
state
function reduction process. Initial and final state negentropies
would
characterize spinor fields of WCW (\blockquote{world of classical
worlds}).

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\item Information theoretic interpretation of the Kähler function
is
discussed in detail. Quantum classical correspondence suggests that
the
magnetic part of Kähler action would correspond to information
content of
negentropic entanglement and electric part to the negative
information
content of entropic bound state entanglement. Kähler function
defined
as the negative of the Kähler action can be interpreted as an
entropy
type measure for the information content of the space-time surface.
Without quantum criticality entropic configurations carrying strong
Kähler electric fields would be favored. The proposal is that
the
quantum criticality of Kähler action possible for the critical
value of
Kähler coupling strength makes possible large degeneracy of the
negentropic extremals carrying large Kähler magnetic action and
makes TGD
universe maximally interesting and maximizes its intelligence so
that even
infinite negentropy is possible. Number theoretical criticality
would
relate to this criticality very closely. The proposal that living
matter
is near vacuum extremal so that the degeneracy of negentropic
configurations is high is discussed.

\item The physical interpretation for the hierarchy of Planck constants would be in terms of a hierarchy of quantum criticalities concretizing the vision about quantum criticality of TGD Universe. TGD Universe would be like a hill at the top of a hill at The larger the Planck constant the larger the size scale of the hill. Criticality involves crucially the notion of conformal gauge symmetry. The conformal symmetries correspond to sub-algebra of the full algebra isomorphic to it acting as gauge symmetries and with conformal weights coming as n-multiples of those for the full symmetry algebra. $h_{\text{eff}}=n \times h$ would label the levels of the hierarchy. This hierarchy would correspond directly to the hierarchy of measurement resolutions and to hierarchy of hyperfinite factors of type II_1 (HFFs). Also now one obtains infinite hierarchies of symmetry breakings and the identification with the hierarchies of inclusions of HFFs is compelling. Hence various hierarchies reflect the same underlying phenomenon.

The phase transitions reducing criticality would take place spontaneously unlike opposite phase transitions. This vision is especially powerful in biology, where homeostasis could be seen as mechanisms preventing the reduction of criticality but at expense of metabolic energy. The basic goal of living system would be staying at criticality.

Eastern philosophies would formulate this fight for staying at criticality using the notions of ego and Karmic cycle. In the phase transition increasing $h_{\text{eff}}=n \times h$ part of gauge degrees of freedom assignable to a sub-algebra of the full super-symplectic algebra are transformed to physical ones and this implies better measurement resolution. The new HFF contains the previous one as sub-factor. Evolution understood as increase of h_{eff} forced by Negentropy Maximization Principle as also interpretation improvement of measurement/cognitive resolution.

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Concerning the modelling of conscious intelligence the following

aspects
are important.

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\item Zero energy states –which replace the earlier notion of association sequence inspired by the failure of strict determinism for Kähler action in standard sense – can be seen as memes with M -matrices characterizing the time-like entanglement representing \blockquote{laws of physics}. Negentropic time like entanglement makes possible for fully state function reduced states to represent rules as quantum superposition of state pairs representing instances $a \rightarrow b$ for a general rule $A \rightarrow B$. Also space-like negentropic quantum entanglement is important piece of the story. For fermion Fock states this gives Boolean rules as a special case. Zero energy states represent geometric memories, simulations for time development whereas selves represent subjective memories and conscious experience involves always the comparison of geometric and subjective memories telling whether expectations were realized. Quantum theory of self-organization applies also to the evolution of consciousness understood as self-organization in the ensemble of association sequences/selves and implies Darwinian selection also at the level of selves and conscious experiences.

\item TGD Universe is quantum computer in a very general sense. Negentropic quantum entanglement stabilizes qubits but makes them fuzzy. This leads to a modification of the standard paradigm of quantum computation. Quantum computationalism is shown to reproduce the relevant aspects of computationalism and connectionism without reducing conscious brain to a deterministic machine. Holographic brain is also one of the dominating ideas of neuroscience. TGD based realization of memory allows to reduce hologram idea to its essentials: what matters is that piece of hologram is like a small window giving same information as larger window but in less accurate form. This inspires the concept of neuronal window: each neuron has small window to the perceptive landscape and is typically specialized

to detect particular feature in the landscape. Coherent photons emitted by mindlike space-time sheets and propagating along axonal microtubules serving as wave guides, realize neuronal windows quantum physically. Massless extremals allow rather precise definition for the notion of quantum hologram.

A more refined formulation of these ideas is based on the notion of conscious hologram. Many-sheeted space-time is essentially a fractal Feynman diagram with lines thickened to 4-surfaces. The lines are like wave guides carrying laser beams and vertices are like nodes where these laser beams interfere and generate the points of the hologram. The 3-dimensionality of the ordinary hologram generalizes to stereo consciousness resulting in the fusion of mental images associated with various nodes of the conscious hologram. An essential element is the possibility of negative energy space-time sheets analogous to the past directed lines of the Feynman diagram: negative energy MEs are the crucial element of sensory perception, motor action, and memory.

An important element is effective four-dimensionality of brain making possible to understand long term memories, planning and motor activities in a completely new manner. Further important ideas are music metaphor already described and the vision about brain as an associative net. ZEO and the notion of CD (causal diamond) provides justification for the memetic code and relates it to fundamental elementary particles time scales. The codewords of the memetic code consist of sequences of 126 bits and are represented in terms of nerve pulse sequences or membrane oscillations and time varying quark magnetization, is the key essential element of brain as cognitive system. Codewords can be interpreted either as elements of a Boolean algebra or as bits in the binary expansion of an integer in the range $(0, 2^{126})$ so that memetic code makes brain able to assign numbers with qualia. An attractive and testable identification for the memetic codewords is as phonemes of language. \end{enumerate} %\end{abstract}