

Commentary

Some Comments inspired by: Dainis Zeps' Quanta Mathematica Instrumentalis

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Abstract

The ideas introduced by Dainis Zeps in the article *Quanta Mathematica Instrumentalis* and related articles are discussed in the conceptual framework of Topological Geometro-dynamics. The concrete realization for the vision about physics as mathematics is discussed in TGD context and the idea about instrumentalism as key element of mathematics and science is analyzed and criticized. Also the notions of theorem and quantum windows, higher observer, and information field are discussed.

1 Introduction

In the article *Quanta Mathematica Instrumentalis* and also in related articles [22, 21, 23] Dainis Zeps develops the notion instrumentalism and related concepts. The article is highly thought provoking and written in pleasant non-authoritative tone. In the following commentary I try to summarize what I see as the basic points of the article and compare the views represented with my own ones since this is the only manner that I can get grasp about what has been said. Once again I found that this process allowed to identify and eliminate some of the many fuzzy aspects in my own belief system.

2 Mathematics is more than often believed to be

The basic thesis of the article is that mathematics is much more than "maths" or calculus as pragmatic physicists often think. Instead, physics *is* mathematics [21]. This a provocative statement represented also by some other researchers such as physicist Max Tegmark [20]. A pragmatic view held by many mathematicians is that mathematics is just deduction of consequences of more or less arbitrary system of axioms. The message of the article is that mathematics is much more than this. Mathematics is something pre-existing about which mathematicians are becoming conscious and mathematics itself guides this process.

2.1 Physics is mathematics but what is mathematician?

I find it easy to agree with the proposal that physics is mathematics. Consciousness theorists could however argue that this idea does not yet explain mathematician. Something more might be needed to understand mathematical consciousness. I try to formulate this skepticism using the jargon of my own world view.

Also in my personal universe mathematics is what objectively exists. Some basic notions such as zero energy ontology (ZEO) and causal diamonds (CDs) are needed to make this more concrete and the basic notions of TGD are explained in previous articles in *Prespace-time Journal* [14, 15, 16, 17, 11, 12, 13, 10] and in *JCER* [18, 19]. In ZEO the quantum states of the Universe are the fundamental and essentially mathematical objects [2]. There is no need to postulate any physical reality behind them: these mathematical objects *are* the physical realities.

The most recent observation is that zero energy states can be identified as elements of a generalization of Kac-Moody algebra spanned by hermitian matrices representing hermitian square roots of all possible density matrices. These square roots form an infinite-dimensional Lie algebra and are multiplied by powers of S-matrix analogous to a power of phase factor. This algebra acts as symmetries of S-matrix. The zero energy states - Lie algebra generators- are multilocal with respect to the partonic 2-surfaces assignable to the boundaries of *CDs* so that the algebra defines a generalization of Yangian algebra [7]

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discovered in twistor approach to $\mathcal{N} = 4$ SUSY [7]. The various powers of this factor correspond causal diamonds (CDs) with size scales coming as integer multiples of a fundamental scale.

Quantum jump between zero energy states mean re-creation of the quantum Universe in 4-D sense in the sense that the quantum superposition of classical space-time surfaces is recreated. These quantum jumps-moments of creation- would give rise to consciousness and its various aspects. Conscious existence is in this conceptual framework represented by an endless sequence of quantum jump providing conscious information about the fundamental mathematical objects - also as mental images which we do not regard usually as mathematical. Quantum jumps form also fractal hierarchy which relates closely to the notion of higher observed introduced in the article and to be discussed later.

2.2 Physics and logic

Boolean logic is an essential element of instrumentalism. If physics is mathematics, Boolean logic have a direct manifestation in the structure of physical states. Physical states should represent quantal Boolean statements which get their meaning via quantum jumps. In TGD framework WCW ("world of classical worlds") spinor fields represent quantum states of the Universe and WCW spinors correspond to fermionic Fock states for second quantized induced spinor fields at space-time surface. Fock state basis has interpretation in terms of Boolean algebra. In positive energy ontology the problem is that fermion number as a super-selection rule would allow very limited number of Boolean statements to be represented. In ZEO the situation changes.

The fermionic parts of positive and negative energy parts can be seen as quantum superpositions of Boolean statements with fermion number in given mode (equal to 0 or 1) representing yes/no or true/false. Also various spin like quantum numbers associated with oscillator operators have same interpretation. Zero energy state could be seen as quantum superposition of pairs of elements of Boolean algebras associated with positive and negative energy parts of the zero energy state.

The first - and incorrect - interpretation is that zero energy state represents a quantum superposition of equivalent statements $a \leftrightarrow b$ and thus abstraction $A \leftrightarrow B$ involving several instances of A and B . Below a more detailed argument suggesting an interpretation in terms of abstraction of logical implication to $A \rightarrow B$ rather than equivalence is discussed. In any case, the fermionic part of the zero energy state would represent directly Boolean cognition. p -Adic physics for various primes p [6] would represent correlates for cognition and intentionality.

The arrow of logical implication is assigned with the arrow of time. It is possible to understand this highly non-trivial connection in ZEO. The connection with the arrow of time suggests that zero energy states represent implications instead of equivalences.

1. The breaking of time reversal invariance [1] means that zero energy states can be localized with respect to particle number and other quantum numbers only for future or past light-like boundary of CD but not both. M -matrix generalizing S -matrix provides the time-like entanglement coefficients expressing the state at the second boundary as quantum superposition of states with well-defined particle numbers and other quantum numbers. But only at the second end of CD since one cannot choose freely the states at both boundaries: if this were the case the counterpart of Schrödinger equation would be completely non-deterministic. This is what the breaking of time reversal symmetry means. It occurs spontaneously and assigns to the arrow of subjective time geometric arrow of time.

What is the mechanism inducing this choice is one of the key questions of any quantum theory of consciousness and is discussed in TGD framework in [1]. This picture gives a precise meaning to the arrow of geometric time and therefore also for the otherwise fuzzy notion of negative energy signals propagating backwards in space-time playing key role in TGD based models of memory, metabolism, and intentional action [8].

2. Quantum jump begins with the unitary U -process between zero energy states generating a superposition of zero energy states. After that follows state function reduction cascade proceeding from the level of CD to the level of sub- CDs forming a fractal hierarchy. The reductions cannot take independently at both light-like boundaries of CD as is also clear from the fact that scattering state leads from a prepared state to a quantum superposition of prepared states.

The first guess is that the cascade takes place for the second boundary of CD only so that the arrow of geometric time would be same in all scales. This need not be the case always: the geometric arrow of time seems to change in some situations: phase conjugate laser light and spontaneous self-assembly of bio-molecules are good examples about this [8, 9]. In fact, one of the defining properties of living matter could be just the possibility that the arrow of geometric time is not same in all scales (size scales of CD s) so that memory, metabolism, and intentional action become possible. In any case, the second end remains a superposition of quantum states.

The lack of quantum measurements at the second end of space-times could explain why the conscious percepts are sharply localized in time at the second end of CD . This could also allow to understand memories as reductions occurring at the second, non-standard, end of sub- CD s in the geometric past.

3. The correspondence between the reduced state and the quantum superposition of states at the opposite boundary of CD allows an interpretation in terms of logical implication arrow with all statements present in the superposition implying the statement represented by the reduced state. Only implication arrow rather than equivalence is possible unless the M -matrix is diagonal meaning that there are no interactions. If it is possible to diagonalize M -matrix then in diagonal basis one has equivalences. It must be however emphasized that the physically preferred state basis fixed as in terms of eigenstates of density matrix does not allow diagonal M -matrix. Number theoretic conditions required that the density matrix corresponds to fixed algebraic extension of rationals can also make possible the diagonalization without leaving the extension and this condition might be highly relevant in the TGD inspired view about cognition relying on p -adic number fields and their algebraic extensions [6].
4. In classical logic implication corresponds to the inclusion of subset by subset. In quantum case it corresponds to the inclusion for sub-space of state space. The inclusions of hyper-finite factors (WCW spinors define HFF of type II_1) realize the notion of finite measurement resolution, which would suggest that inclusion arrow has also interpretation in terms of finite measurement resolution. All quantum states equivalent with a given state in the resolution used imply it. Finite measurement resolution would mean that there would infinite number of instances always in the quantum superposition representing the rule $A \rightarrow B$. Ironically, both finite measurement resolution and dissipation implying the arrow of geometric time and usually regarded as something negative from the point of view of information processing would be absolutely essential element of logical thinking in this framework.
5. Conscious theorem proving would have as correlate to building of sequences zero energy states representing $A \rightarrow B$, $B \rightarrow C$, $C \rightarrow D$ with basic building bricks representing simple basic rules. These sequences would represent more complex truths.

The state function reduction at light-like boundary of CD implies delocalization at the opposite boundary. This inspires so fascinating questions that I am unable to restrain of starting them aloud them although I know that they are out of topic.

1. Could the state function reduction process take place alternately at the two boundaries of CD so that a kind of flip-flop in which the arrow of geometric time changes back and forth would result, and have interpretation as an alternating sequence of state function reductions and state preparations in the framework of positive energy ontology?
2. State function reductions are needed for sensory percepts. Could the sleep-wake-up period correspond to this kind of process so that during what we call sleep the past boundary of our personal CD would be in wake-up state? Could dreams and memories represent sharing of mental images of this kind of consciousness? Could it be that in the time scale of entire life cycle death is accompanied by birth at the second boundary of personal CD ? Could this quantum physics representation for endless sequence of deaths and rebirths? Could the fact that old people often spend they last years in childhood have interpretation in this framework?

3. State preparation-reduction cycle might characterize only living matter whereas for inanimate matter second choice for the arrow of time would be dominant between two U-processes. TGD based reformulation [4] of entropic gravity idea of Verlinde [25] in terms of ZEO does not assume the absence of gravitons and the emergence of space-time. The formulation leads to the proposal that thermodynamical stability selects the arrow of the geometric time and that it could be different for matter and antimatter implying that matter and antimatter reside at different space-time sheets. This would explain the apparent absence of antimatter and also support the view that the arrow alternates only in living matter.

2.3 Does Platonia exist and where it lurks?

Mathematician talking philosophy cannot avoid mentioning Platonia. I have no problems with the notion since also the mathematical notions are part of reality and must have some physical correlates. For me the space of objective realities identifiable as quantum states of the Universe regarded as purely mathematical objects would represent Platonia. Space-time and imbedding space and the world of classical worlds - WCW- represent the geometric aspect of Platonia. The question is whether the notions of state space (spinor fields of WCW) make sense and do they have some concrete realization.

The hierarchy of infinite primes leads to a replacement of real, complex, quaternionic and octonionic units with infinite number of units equivalent in real sense but having infinite complex number theoretic anatomy. My proposal is that single point of imbedding space could represent the Platonia in accordance with algebraic holography -or stating it in more mystics oriented manner -number theoretical Brahman=Atman identity [5]. 8-D space-time with appropriately generalized notion of number would be all that exists objectively.

At this age one dares to say "I believe" and I really believe that mathematical existence is uniquely determined from the condition that it is maximally general and internally consistent. The Kähler geometry of WCW existing only if it allows infinite-dimensional isometry group and only for $M^4 \times CP_2$ having interpretation in terms of classical number fields would realize this vision. The infinite-dimensional character of WCW would give it ability to simulate all finite-dimensional mathematical structures be they manifolds, groups, algebras or anything internally consistent.

3 Instrumentality

Instrumentality is the central notion of the article. The first essential element of instrumentality is externalization of logical thinking allowing to mechanize it: conscious logical thinking is indeed very difficult and susceptible to errors. Second key element is the emergence of new instruments from already existing ones. Computer revolution is a very concrete example about this process leading to an exponential explosion of knowhow. Standardization is key aspect of instrumentalism meaning at the level of conscious experience standardized mental images making possible communications by using symbolic representations inducing more or less identical mental images in the receiver and sender. Instrumentalism allows also to understand biological evolution as the emergence of increasingly complex structures from simpler ones.

I would not however say that instrumentalism catches all essential aspects of science. Although I like the notion very much but still I think that it codes only one half of the process called science. The discovery of new ideas and conceptualization would represent the second half. Also in the article it is noticed that there is a danger that mathematics reduces too much to coding of computer programs. Science and mathematics have also the spiritual aspect responsible for the insights and overall views making possible great revolutions. Just this is what makes it more than mere mechanical logical deduction of consequences of randomly chosen axioms.

3.1 Instrumental contra conceptual

In the article a distinction is made between instrumental and universalizing/conceptualizing. In physics this would correspond to experimental and theoretical physics. I would not say that instrumentality is the more important aspect of science. What they do at LHC is testing of theories. One must know

precisely what one is looking for since the signal to noise ratio is so enormous and there is no hope of just measuring and then looking how to explain what has been measured.

The recent crisis in theoretical physics could be seen as a consequence of giving too strong weight on instrumentality in the sense that the development of calculational methods is seen as the primary goal. Therefore many people are developing calculational tools for theories having nothing do with experimental reality. As a consequence, rather ad hoc ideas for which empirical data have not given any support dominate the field. Proton decay predicted by GUTs is not observed, Higgs has not been found, supersymmetry in standard sense might be soon excluded completely and it is already now clear that it cannot solve the problem of Higgs mass instability as the original hope was, there are deep problems involved with QCD based view about quark color, neutrino physics is poorly understood, there is a long list of silenced anomalies, and so on. Maybe with more spiritual approach to theoretical physics situation with more respect to facts would not be this.

One could also see the instrumental-conceptual dichotomy as one aspect reductionistic-holistic dichotomy. Development of instruments is very much analogous to differentiation in biology in which each cell specializes to perform some biological functions. Holistic aspect would correspond to what makes organism a single coherent unit. Both views are needed. Without the holistic aspect one has organism suffering from cancer.

3.2 Symbolic representations as one aspect of instrumentality

Symbolic representations are essential in mathematics and key part of instrumentality. It was indeed the development of written language which made possible to write the thoughts down and study them and manipulate them mechanically meaning mechanization of logical thinking. This feedback has had enormous impact in the evolution of mathematics. Instrumentalism which is the key topic of the article can be assigned naturally with symbolic representations.

Classical physics- that is geometrical and topological classical space-time correlates of quantum states- could be seen in TGD framework as extremely abstract symbolic representations for the contents of (basically mathematical) consciousness. Certainly not one-one to one: language never represents contents of consciousness faithfully: it can only induce quantum jumps sequences generating the original experience to some degree and development of language requires evolution of standardized mental images and brain is a factory of them. The information carried by text is relative and determined by the conscious experience it generates. A sequence of five letters representing the name of my cat (got it from my daughter just some time ago and namesake of mine!) can induce extremely complex state of consciousness containing much more information as the bits needed to code these letters to computer.

Quantum classical correspondence makes possible the feedback loop in which part of contents of consciousness is coded to the space-time geometry. Negentropy Maximization Principle [3] with number theoretic entropy which can be negative implies of mathematical consciousness so that increasingly complex mathematical structures (say algebraic extensions of p-adic numbers) emerge [6]. This conforms with the view about deep connection between linguistics, mathematics and consciousness.

The replacement of the quantum Universe with a new, more complex one provides symbolic representation of information about previous quantum jump at space-time level in terms of the properties of space-times in the quantum superposition. What this means that at second end of CD space-time sheets representing the mental images generated by quantum jump emerge. An attractive additional hypothesis is that in the cognition resolution involved one can say that the space-times in the quantum superposition are perceptively and cognitively equivalent so that one can speak of quantum average space-time. Quantum jump sequence implies also a continual extension of axiomatics by bringing in new independent truths serving as new axioms. Deduction represented by state function reduction process and discovery by the U-process would be two key aspects of consciousness, in particular mathematical consciousness.

3.3 Theorem windows and quantum windows, higher observer, and well of information

The meaning of the notions of theorem window and quantum window [23] are intuitively clear but I am not able to concretize them in terms of quantum physical correlates. The windows are said to correspond

to higher level observer. The proposal of the article is that material world and consciousness are in some sense derived from theorem and quantum windows.

I would be happy if I could re-articulate this statement so that it would make sense in my own belief system. I would perhaps talk about self hierarchy and human mathematician would communicate with these higher levels receiving the ideas inducing eureka's. The birth of idea would be quantum jump of particular kind creating something genuinely new and should be distinguished from mechanical theorem proving or calculation. Theorem window would represent communication between different levels of this self hierarchy if my interpretation is correct.

The article also introduces the notion of higher observer. Also the notion of field of information and "well of field of information" are introduced. If I have understood correctly, an analogy with potential energy of classical physics is in question. Potential/unconscious information would become conscious information by transforming to kinetic/conscious information. I am not sure whether "field" should be taken as something analogous to electric field or quantum field or something totally different. This proposal brings in my mind the proposal that the laws of physics could be formulated in terms of Fisher information [24]. This idea is certainly interesting but has shortcomings already in the case of Maxwell's equations.

Consciousness and information are always about something whereas matter just is. Hence my objection is that the "aboutness" of consciousness and conscious information makes it impossible to regard information as any kind of substance, field or anything assignable to a material object. Context dependence is second characteristic distinguishing between information and physical quantities like fields. Written text contains information only in the sense that it can induce a sequence of quantum jumps leading to self-organization patterns representing standardized mental images. Information content is also very context dependent unlike matter: electron is the same everywhere apart from small effects due to its interactions with environment. Because of its "aboutness" characteristic Information represents also something which is at meta level as compared to matter.

Personally I see information as a conscious information assignable to quantum jump rather than quantum state and thus representing different ontological level deserving to be called meta level. Instead of well of information which I understand as existing information storage I would talk about genuine creation of information taking place in quantum jump. Evolution is creation of new information and the more information universe is able to represent, the higher its complexity is.

The title of one of the articles of Dainis Zeps [22] claims that our ability to research comes before understanding of what we research. Also with this it is easy to agree. If the process of becoming conscious proceeds in a cascade like manner from top to bottom, rough overall heuristic idea becomes gradually more detailed as the reduction cascade proceeds.

3.4 Is it possible to understand quantum theory

I cannot share the view that it is not possible to understand quantum mechanics and one must take it as a mere calculational tool. I think that the failure to understand quantum mechanics is due to the lack of the realization that our notion of time is badly wrong. One of the main roots of the difficulties of the official theoretical physics identifies experienced time with geometric time although even child realizes that these notions are different. This leads to the well-known conceptual mess with state function reduction and to conclusion that one must just apply the rules and give up the attempts to understand. I strongly disagree.

My conviction is that an extension of physics to a theory of consciousness by bringing in the notions of quantum jump and self is necessary. To understand quantum theory we must understand how we perceive and cognize. In fact, the notion of self actually reduces to that of quantum jump in TGD framework. The new view about quantum jump allows to get rid of the basic paradox caused by the determinism of field equations and non-determinism of free will. As a matter fact, the entire problem originates from sticking to the materialistic dogma claiming that consciousness and therefore free will is nothing but epiphenomenon. The basic motivation is the erroneous belief that physical laws do not allow free will and non-determinism. One could also see the ethical decline of our society as a consequence of the materialistic world view since it is difficult to validate moral rules if there is no genuine free will. The replacement of monistic ontology of materialism with tri-partistic ontology of TGD resolves the problem

and it is again possible to really understand quantum theory.

4 Conclusion

It is easy to agree with many of the key ideas appearing in the article but I would see instrumentalism only as something akin to the left half of the brain hemisphere. The spiritual aspect of science is also there and is raising its head now when LHC is at the verge of not only new particles but entirely new branches of physics. I believe that mathematics and physics will eventually transform to a general theory of consciousness and that the challenge to understand conscious experience will become a powerful source of inspiration in both disciplines.

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