Is this theory crazy enough to be true?
Niels Bohr

Information Relativity:
Times Stored in Spaces

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1. Introduction

It is rightfully mentioned in the announcement for this contest that "*The past century in fundamental physics has shown a steady progression away from thinking about physics, at its deepest level...* " . Let us recall that the last century started with deep insights into the nature of observation, measurement, and into the nature of relativity. Einstein has shown that the information we rely on, our observations of events in time and space depend on our choice of reference frame, i.e. on rulers and clocks as measurement tools. In General Relativity (GR) theory this concept of relativity was pushed further to include local events and local reference frames in space-time, making it possible to describe gravity as a sort of geometrical phenomenon. Founders of Quantum Mechanics (QM) then pushed the relativity of observation even further by demanding that observable physical events had to be relative not only to their reference frames, but to the choice and functioning of the measurement device itself.

This progressive movement of human theoretical thought towards more and more observation relativity could seemingly have been pushed even further in order to discover the principle that would unify these two fundamental theories, GR and QM. Einstein, until the end of his life actually believed that it would be some form of *relativity principle* – but history went in a different way. Instead of seeking deep physical connections between information, time and space, world physics turned to all kinds of formal approaches, of "quantization", trying to substitute pure mathematics for a real understanding of the nature of things. Recent advances in String theory, Loop Gravity, etc. have made the situation even worse by hiding this unfound principle under a huge pile of mathematical formalities.

Since both of the fundamental theories, GR and QM are, in fact, *observational mechanics,* i.e. theories on mechanical movement of physical matter in space-time, our search for the unification principle should be based on a deep analysis of the processes of the observation of events in space and time, deeper – and, following the logic of Niels Bohr, obviously, crazier than it has ever been done before.

2. *Something to think about. Observable facts and axioms.*

Here are some well-known facts and fundamental principles of modern physics that we too often

tend to “bypass” precisely because of their apparent “simplicity” and “familiarity”:

a. E*vents and quanta surrounding us in space only exist in the past. Not in the present, not in the future. In the past. One may say that space “lies” wholly in the past. Time, on the other hand, “goes” towards the future.*
b. *All quanta (elementary particles) of the same type are absolutely, fundamentally identical to each other, physically indistinguishable.*
c. *Under “Grand Grand Unification” of the future it is presumed that there will be just single type of fundamental quanta, so all quanta of this type will be identical. In this case, all of the Universe consist of absolutely identical quanta and therefore, the Universe is itself a quantum among these quanta .*
d. *Light speed, almost “by definition”, is the boundary between two realms: the time as the realm of change and the space as the realm of rest, of the absence of change.*
e. *Only time as universal change is directly observable and measurable. Space, as the fundamental opposite of change, as fundamental rest is not observable and presents itself in a fundamentally indirect way as a vast emptiness between the observable timely temporal events (quanta).*
f. *Event horizons and quantum uncertainty principle are both forms of boundaries that absolutely prevent the free flow of information.*
g. *“Elementary events”, the very fabric of space-time has a lot in common with “elementary particles”, quanta. The main difference is the “wave-particle duality” of quanta.*
h. *The anti-commutation rule for “quanta of matter”, fermions suspiciously resembles the ordering of events in causal time.*
i. *The path (histories) integral formulation in quantum mechanics effectively implies the idea that all space points are identical to one another (but points in time are not).*
j. *We have 3 “time tenses” past-present-future and 3 dimensions of space. Coincidence?*
k. *The fundamental concept of “energy” (“energy-momentum”) is extremely familiar to each end every physicist. So familiar, in fact, that nobody ever asks if there could be some kind of theoretical explanation of what this “energy” actually means. Is there a concept somehow “deeper” than the concept of “energy”?*

3. ***What IS information after all? Symmetry.***

Let us recall the famous Einstein's famous thought experiments on following the light wave and that of the free falling elevator. When looking at these experiments, which preceded the discovery of the so-called *special* and *general* relativity principles, it is easy to notice that both of them actually *nullify* or neutralize any observable changes when measured in particular frames of reference. In both cases such frames are rest-frames, where the frame is moving with the same velocity or the same (local) acceleration as the object under scrutiny itself. In Special Relativity (SR) theory this is the way that the observable effects of velocity are nullified and the same is true in General Relativity (GR) for the observable local effects of gravity.
Now, keeping in mind that in Quantum theory, the results of observation depend completely on the state of the measuring device, let us suggest a *hypothesis* that *there always exists such a device that can nullify or neutralize any observable effects of any given objective change measured by this device.* We must clearly understand that this hypothetical principle which may be called *observation relativity principle* [1] is in no way derived from quantum theory as such.

This is a totally new and independent physical principle, which can eventually become the GR and QM unification principle. We should also mention that new principle is neither global nor local as such. Locality, as well as other physical concepts like space-time, causality, dimensions, energy-momentum, etc. should be in one way or another *derived from the principle* itself.

We must be careful not to confuse ourselves: this *new principle directly implies the existence of physical processes going back in time*. As we see upon further thought, the very same principle allows us to apply such a reference frame/measuring device that will *neutralize or compensate any observable anti-time changes*, introducing *observable causality*.

Further, let us term this kind of *material* device *a subject,* meaning that one could take any human (or alien) person or even society as such a subject. The *class of subjects* includes, in fact, all other *material objects* that may physically *interact* with a particular *object*, therefore making *observation* of this object by the subjects possible. *Observation* in this case implies, of course, the mutual *change* of both subject and object caused by their *interaction*. We may go even further and consider this interaction a *fundamental dynamic physical symmetry* between object and subject. The symmetry transformation from object to subject and vice versa (interaction) we may call *observation.* Now the question is what is actually preserved in such a transformation, what remains the same between object and subject during this interaction? The answer is almost obvious: it is *information*. The preservation of information during the subject/object interaction is what we are used to calling *information transfer*. Of course, information is not only retrieved by the subject from the object but also goes back to the object. The same process may be interpreted as a subject acting on an object and getting feedback from it, as well. Physical interaction may create long chains of subject/object interactions where their corresponding roles are constantly interchanged, chains that provide actual information transfer from some distant objects of exploration to particular brains of theoretical physicists.

4. How does nature "store" and "process" information? Times rest in spaces.

Information and time are both about *observable change*. Therefore they both can be measured in bits, so where no change takes place, there is no time and no information. The process of getting information from the object and the subject acting on it as the process of active, "live" information is the process of objective change observed by certain experimental device – and via the subject/object chain - by a person exploiting the device. In general that kind of universal, objective, observable change may be called physical time.

Now, where are all of these changes, these bits of information stored? Take an unbiased look around and you will see it. The entire world, everything that we observe in the Universe rests in the past. Past times rest in space. But can space really be the storage of all of the information that ever was? The real meaning of the very existence of a fundamental speed (the speed of light) in nature may be simply to set a boundary between an "active" form of information, observed as "time" and a "passive" one, which we habitually call "space". Can it be so?

Let us look a little deeper. Where *time,* or universal *change* starts, its opposite, *timelessness* or "time vacancy" or *rest* definitely ends. And vice versa, where time-change ends, space (*rest)* begins. As physical intuition tells us, the *vacancy* "goes" in the opposite direction from the

direction of change. Meaning that time for the *vacancy* goes opposite to the time of *change*. The "time vector" for *timelessness* therefore points to the past, or in other words, space is "anti-time" or "time at rest". Information in the active form presents itself as time, and when it is in the passive, stored form – as space. *Times rest in spaces*.

How exactly may information be transformed from its active form into the passive? One way is to make a reference frame/measuring device or subject to "follow" precisely the exact changes of the object. The subject will, in essence, "go with the flow of time", staying indistinguishable from the object. According to our *observation relativity principle* it is always possible and will cause effective nullification or compensation of observable change. The compensating change of the device is the change of an object (named "subject"), but because it is a *compensating* change, it is opposite in "direction" to the change itself. In other words if the object is changing in one direction of time, the subject, to compensate this change causes an *observable change* into the opposite direction of *anti-time*. In this case, the subject is capable of retrieving the observable changes from one direction of time, but does not observe anything from the other direction or the *anti-time* order of events, being *at rest* with them. Hereby we come to *observable causality* as a phenomenon directly connected with the fundamental difference of time and space. Anti-time is not observable because it is space, it is rest, an opposite to change. It is extremely important that one can observe the causality only in the specific case when the *causal* reference frame that is chosen is based on space.

5. *How does understanding information helps us understand physics? Quantum as a time loop.*

Ok, "*times rest in spaces"*. Why plural, why "spaces"? Isn't there only one space, the one which we are in? And if so, isn't there only one time? Here we go.

First of all, if one wants to introduce numbers into the realm of information, one has to count in bits. And if any new change *is not really new*, i.e. it duplicates some other existing change, we cannot count on it. No real change means, by definition, no information, no bits. Or in other words, if some change is totally identical to some other change, there are not two changes, but there is only one single change. *Each change in time is unique*, different from others of its kind. *Duplicate change is plainly not observable*. Putting this in a somewhat *inverse way,* we may say that *no two times can be put into one*. We may notice also that the same does not apply to spaces because with no observable change (which is the "birth mark" of space as "emptiness"), there is no way to tell the difference between any pair of spaces. In other words, *any number of spaces may be easily put into one*. This fact also explains the absolute identity of the spaces confirming the correctness of the path integration technique (i.e. the fundamental equivalence of different paths in space).

Second, the dynamics of subject/object interaction consists, as we have seen, of information travel through the information transfer chain: observable changes/times are retrieved from the storage/spaces, processed and then stored in the form of spaces once again. Then the whole process continues recursively. Space, when taken as as a process of "passive" information, goes *back in time*, is anti-time, i.e. "*recalling*", retrieving changes *back* from memory. Therefore, each step of the information transfer, serves to confirm the existence of closed time loops of the

"time-anti-time" kind. Counting these loops gives us the count of changes and the count of spaces where these changes or *times* are stored.

If we decide to count not only times and spaces, but take into consideration the "internal structure" of any change, the fundamental fact that it starts, lasts and ends, meaning that a time loop has its past $\mathbf{e^0}$, present $\mathbf{e^1}$ and future e^2 (introducing therefore 3 anti-commutative dimensions in time, "time tenses"), we have to turn to somewhat more complicated mathematical entities, finite groups and quaternion representations [1,2,3].

Here are the subject/object symmetry transformations representing a quaternion basis for the information time process:

If we assume some natural denotations, such as:

From past to present: $\boldsymbol{(e^0,e^1) = i}$
From present to future: $\boldsymbol{(e^1,e^2) = j}$
From past to future: $\boldsymbol{(e^0,e^2) = k}$

And take some natural assumptions representing the count of the loops and the rule of transformations combination:

$$\boldsymbol{(e^n,e^n) = 1}$$

the anti-commutation rule here is obviously the result of the causal ordering of events:

$$\boldsymbol{(e^n,e^m) = -(e^m,e^n),\ n \neq m}$$

And the natural transformations combination rule:

$$\boldsymbol{(e^l,e^n)(e^n,e^m) = (e^l,e^m)}$$

we come to well-known quaternion algebra:

$$\boldsymbol{ijk = -1;\ ij = -ji = k;\ jk = -kj = i;\ i^2 = j^2 = k^2 = -1}$$

Here a quaternion may be represented as $\mathbf{Q_I} = a\mathbf{i} + b\mathbf{j} + c\mathbf{k} + d$, a,b,c,d – integers (whole cycle counts represent "coordinates").

Easy to see that exactly the same form of quaternion may represent the information storage process, or space: $\mathbf{Q_S} = a\mathbf{i} + b\mathbf{j} + c\mathbf{k} + d$, where imaginary units **i, j, k** obviously different from the previous "time-like" units, now represent information "input-store-output" entities and therefore correspond to 3 dimensions of space.

Both processes of time and space may be represented mathematically in one entity, the so-called

"bi-quaternion" or "complex quaternion" $\Psi = \mathbf{Q_T} + \gamma \mathbf{Q_S} = a\mathbf{i} + b\mathbf{j} + c\mathbf{k} + d$, where: a,b,c,d – are complex numbers (which, when one moves into field theory, may not be considered as just integers) and γ – is the new imaginary unit [1,2,3].

It may be shown that this simple process of storing, retrieving and processing information brings us to the bi-quaternion form of the Dirac equation [1,2,3]. *(The Dirac equation is derived there on the natural assumption that an infinitesimal coordinate shift as a minimal observable change is equivalent to "one bit", a single information process cycle.*) The equation describes the process of time going from past to present to future and the process of closing the loop in space (anti-time) storage, which we are more used to seeing as a quantum movement with a spin, a form of rotation in 3 dimensions . The complex quaternion Ψ represents here the transformation of the local space-time basis while the space-time process goes on.

6. Following the crazy path of information even further. Our micro-universe.

Now we have many identical loops in time (time-anti-time), all of them actually representing *one and the same* loop, but *in different moments of its own (proper) time*. This crazy thing must be repeated over and over again to be understood clearly: *Quanta, elementary particles-events of the same type, are actually one single quantum taken in one moment of our own time but in different moments of its own life*. This explains in clear terms exactly why it is that all elementary particles of the same type are absolutely identical. They are one. Many past time-moments of single quantum life are *observed as many quanta* positioned in different points of space. The famous phenomenon of *quantum entanglement* is the most obvious demonstration of this oneness.

It is extremely important to note that these times (changes) when examined as closed loops are *separated by spaces* which are not observable directly and therefore should be considered as barriers for information, event horizons. *Spaces are identical and indistinguishable from each other also, they are one.* This makes the observable space behavior of quanta *appear probabilistic.* This is a simplified view of quantum movement, which we discuss in a little more detail below.

Further, these quanta, which are associated with changes, are *observed as ordered in causal time.* That is why they obey the anti-commutation rules (The Pauli principle for fermions) and cannot be put into the same state. If they are in the same state, it means the that they are in the same moment of their own time, but their moments are clearly different (they may not be observable otherwise due to the nature of information).

Third, the *older the quantum is in its own time, the more influential it is*, the more changes it can cause in our present. This is the simple consequence of causality, illustrated vividly in numerous sci-fi stories describing time travel. The influence increases exponentially in time, representing, therefore, the well-known phenomenon of physical *energy* defined exactly as the potential to make changes. This exponential increase in influence leads directly to the well-known exponential Fermi-Dirac energy distribution for fermions [1].

On the other hand, of course, spaces may also be represented as loops in time, or as quanta. One

can make the choice between spaces count and times count by following one of the space-like directions (basis vectors) of the local basis quaternion Ψ. The obvious difference from the previous case here, is that spaces, as no-change entities (i.e. event horizons), cannot be distinguished from each other even by ordering (cannot be ordered) and therefore obey different type of statistics: the Bose-Einstein energy distribution for bosons [1].

Now we see that the "enumeration" of space-time points or, in other words, the process of "issuing" the numbers-coordinates to the events is done by counting the time loops in different directions of the local basis vectors (the bi-quaternion basis). This clearly resolves the old problem of quantum mechanics stated thus: is it about "real" physical space for one quantum or about a so-called configuration space, "phase space" for many quanta. Obviously we have no real difference here, because "many" quanta are actually a single quantum taken (observed) in different moments of its own (proper) time.

Therefore, we come to a situation where exactly how many quanta (or even only a single one) are taken into consideration becomes a question of choosing a simple reference frame (measuring device) for the observer. This looks like a clear approval of the approach currently taken in modern quantum theory (normalization condition for wave-function Ψ).

In the case of a single quantum instead of identical quanta with different energies, we get one quantum with different possible "states", which have different energies (different energy-momentum states, to be exact). The same is true when applied to different spaces (points in space) where the quantum can be observed ("located"). Different spaces are one, they simply cannot be distinguished by observation from each other, because, once again, where there is no observable change, there is no information. Elementary particles being "here or there" mean nothing except that "here" in no way can be distinguished from "there" and that's that.

The uncertainty principle clearly follows from the oneness of the quantum: the more we "squeeze" the time interval (the loop in time) of its observable existence, the more such intervals (loops) we find in its observable history, the more "old" in its own time, more energetic it becomes. The same is true about the pairing of space and momentum, being straight analog of the pairing of time and energy ("space representation").

The famous problem of "hidden" parameters in quantum mechanics (Bell inequalities, etc.) [5] gets a clear resolution too. Bell theorem directly demands causality [5], but in our case, the causality is only observed, but in reality we are dealing with quanta as loops in time. Thought experiments like John Wheeler's "delayed double slit experiment" get their clear explanation due to influence in time.

The most intriguing question still remains: what about the reality of such a crazy picture? How would our Universe look if all that is said here holds true? This Universe is not probabilistic in its nature, but it is, of course, probabilistic in observation. It looks like Everett's many-worlds interpretation [4] but in our case, all of these "worlds" are represented by quanta in our single Universe. Furthermore, the Universe looks more like a single Quantum, producing all of the other quanta with all of their energies and momentums by making copies of itself ("reflections of

itself in itself"). Large and small become relative. The Universe is outside and inside of us. We live in the Universe and consist of it. Reality becomes a kaleidoscopic fractal, where the very existence or observation of any object depends directly on its relation with other objects and, obviously, subjects. Time travel not only becomes possible, it is inevitable, it happens everywhere every single moment. In fact, as we have seen, time loops are the actual cause of the well-known physical phenomenon - *energy*. In other words, *"the world goes round" precisely because of quanta time travel*. And still it all remains the objective reality.

And therefore, as an objective reality, it has nothing to do with the Copenhagen interpretation, where quantum objects did not exist before they were observed. If this is true, then quantum mechanics will never be the same.

7. Space-time curvature equations. Time interaction and instantons.

Now, what can we say about quanta interaction in our picture? The driving force of all of this is, of course, *time as the universal change* process of generating objective events and their *observation* by other complex events. We choose these complex events to serve as our *reference system of events* and they therefore become subjective objects or *subjects*. All other physical interactions, based on quanta exchange interactions, including, by the way, even *observation as a form of interaction* are just different examples of only one, single fundamental basic interaction which one may call *time interaction*.

To understand clearly how this time interaction works, we must realize that the *exchange* of quanta is a form of change, i.e. it is a form of the process of time. In simple words, the generation of changes by fermions increases the volume of needed information storage (amount of physical spaces, space volume) therefore causing physical repelling between fermions. Quite contrary, *bosons are themselves the information storage*, they "destroy" observational changes by storing them, therefore causing observable physical attraction between bosons. These two forces of nature can be described also within the play of the energies and momentums of fermions and bosons, being generated or stored in the time process.

Mathematically this leads us to the localization of object-subject symmetry transformations described earlier and to the formulation of super-symmetrical gauge theory of time interaction. Such a theory should be a matter for future research and there is no doubt that it will bring us a lot of discoveries and surprises. One important thing to mention is that time interaction as we described it includes the Einstein gravity interaction as its inevitable companion on the grand scale. It follows from our very method in this particular approach, through the process of formulating the *observation relativity principle*.

On the subject of field equations: This matter is not covered in this short essay, but it may be shown that simple and *natural (in this approach)* symmetry considerations, like self-duality, lead us to the double-self-dual complex curvature tensor [1,2,3]. The main examples of time-spaces with such a tensor are very similar to the "empty space-time" solutions of Einstein's equations: the well-known space-time instantons [6] (Kerr and Schwarzschild metrics, for example) that are, by definition, finite-action solutions. We can say that such instantons describe the space-time structure of elementary events/quanta that are finite both in space and in time (cyclical). In other

words, according to this approach, such instanton solutions describe substantial back-and-forth-in-time events (quanta) with anti-time changes hidden behind their event horizons.

And now, once again, we should turn to the question of how all of this affects our picture of physical reality. Physical space-time broken into micro-pieces that are separated from each other by event horizons implies that enormous space-time curvatures and non-trivial topologies are almost everywhere, and *not on the scale of Planck's length, but on the scale of Planck's constant.* This is especially true in cases like standard quantum field theory, where we have always applied Minkowskian reference frames, assuming therefore that the space-time is flat. This case of "enforced space-time flatness" as it was shown in [1,2] makes the local coordinate basis non-integrable (non-holonomic), meaning that there is no way to expand local infinitesimal coordinate maps to finite ones in a deterministic way, with coordinates being dependent on the arbitrary ("subjective") path of integration. Finite coordinates therefore become random in nature and in the extreme case of event horizons, become totally unpredictable and probabilistic. This is exactly the picture that we have in standard quantum theory. The obvious difference here is that the probabilistic nature in our approach is in no way fundamental, it is just an *effect of observation*, caused by the specific choice of local reference frame/measuring device.

All of this brings us the intriguing question of whether "macro-quantum" reference frames exist such that will allow us to *go back in time* or do some other *crazy quantum things* like *being at two places at the same time*, *overcome impenetrable barriers*, etc. Following this particular approach *the answer is* ***definitely yes*** and such reference frames should be based on well-known macro-quantum systems such as Bose-Einstein condensates and the like [1]. It is interesting to note that pursuing these pretty deterministic goals in such cases does not contradict in any way the probabilistic conclusions of standard quantum theory. The reasons for this are quite interesting but cannot be discussed in this essay.

7. Conclusions.

All of what has been written in this essay tells us that the phrase "It from Bit *or* Bit from It" is a wrong dilemma. The truth, more likely lies in "It from Bit *and* Bit from It" which strictly follows the steps of our subject/object symmetry and fundamental time interaction. Times go back and forth and rest in spaces.

REFERENCES.

1. Koulikov V. (2009) Time Loops and the Unification of Quantum and Relativity Principles, Philica.com, Article Number 177
   Cached: http://exactingascension.com/TimeLoopsAndUnification.pdf
2. Koulikov V., Elkin S. (2005). Superoperators and the Theory of Informational Interaction. Proceed. Pract. Sci. Seminar on New Informational Technologies, 150- 193, MGIEM, Moscow
3. Koulikov V.(1980). Universe as Informational Superspace. Unpublished, Moscow
   Cached: http://exactingascension.com/UniverseAsInformationalSuperspace.pdf
4. Everett H. (1957). Review of Modern Physics, Vol. 29, pp.454-462
5. Bell J.S. (1964). Physics, Vol. 1, p.195
6. Petrov A.Z. (1966). New Methods in General Relativity, Moscow