

Locality and the Universe

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Abstract: I summarize our discussions on the time list (<http://groups.yahoo.com/group/time/>) in the first section and clarify the meaning of local time. Subsequently I discuss some relations with each of the major specific topics of our discussion.

0. Introduction.

In this talk, I try to summarize our discussions on the time list. What I state below does not cover all of the discussions, and many approaches that have been developed on the list are not included. This is due to the lack of my ability. I apologize that it is beyond my ability to consider all those attempts. So please hear the followings as my private view.

1. The Universe and locality.

My first recognition is that our very existence implies that something other than ourselves is a potential cause of such existence. Please recall that I myself did not expect to come here unless Ceta-Research recommended and promoted me to attend the conference. I have been completely disappointed with my situation, and I lost almost all hopes. But this invitation encouraged me and let me come here. So that I do not live without others' kind helps and encouragements, so I exist because others let me live. Whether we are the "brains-in-a-vat" or "real" existence, I have thus to conclude that we do not live by ourselves.

What makes us live, I call it the Universe. It can be called a vat that feeds us.

Because the Universe is the whole, we cannot know it nor grasp it by our hands unlike external objects. Thus it must be infinite. The Universe must, therefore, have the infinite degrees of freedom.

And as it is the whole unknowable to us, it is independent of our temporality and locality. Thus it must be eternal to us, so that it appears to us as a stationary whole, and we arrive at our first principle.

Axiom 1. The Universe is of infinite nature, and it is eternal. In other words, the wave function ϕ of the Universe satisfies with respect to the total Hamiltonian H_{total}

$$H_{total} \phi = \Lambda \phi$$

for some non-positive real number $\Lambda \leq 0$.

As beings that cannot grasp the whole, we are an existence of finite nature. We are so local that we cannot know the existence of the infinite Universe. So that we are self-centered.

Our coordinates start from our own origin, the self-centered origin of our local system. All things are measured with respect to this local origin.

Therefore we have our second principle.

Axiom 2. Our system is of finite nature, having its own origins of position x and momentum p , independent of others' origins and others' inside worlds.

By the fact that we tend to feel we are our own origin, we are always confronted with the outer world. The outside world pushes and pulls us in order for the whole Universe to be stationary and to be independent of any local variations. Between the self-affirmation and such “from-the-outside-negation” (in the sense that the disturbance or interaction from the outside works to us to negate our stable inward status), we are always inconsistent — inconsistent absolutely insofar as we live, so that we are the “absolute, inconsistent, self-identity” (“zettai-mujunteki-jiko-douitsu” due to Kitarou Nishida and subsequently due to Ronald Swan) in the sense that it recognizes itself in the circumstances that make us oscillate between the two poles; affirmation and negation.

Locality thus oscillates in itself by the very locality itself and axiom 1 in the sense that the stationary nature of the Universe assures the oscillation of the locality.

Oscillatory things are expressed as a sum of sine and cosine functions with suitable coefficients. More minute expression of oscillation is given by a Fourier transform of a function:

$$f(x) = (2\pi)^{-n/2} \int_{\mathbb{R}^n} e^{-ixp} g(p) dp,$$

n being the space dimension, $n \geq 1$.

Thus, these sine and cosine components are summarized to exponential function $\exp(-ixp)$, and it is an eigenfunction of the negative Laplacian $-\Delta = -\Delta_x = -\sum_{j=1}^n \frac{\partial^2}{\partial x_j^2}$. Therefore we have the third principle.

Axiom 3. The nature of locality is expressed by a local Hamiltonian

$$H = -\frac{1}{2m}\Delta + V$$

up to some perturbation V , that does not violate the oscillatory nature of local existence. Here m is the observed mass of the local system.

Thus a local existence (or local system) is oscillating as a sum or integral of eigenfunctions of H . In this sense, the locality or local system is a *stationary oscillating system*.

To express this oscillation explicitly in some “outer coordinate,” we force the locality or local system to oscillate along an “afterward-introduced” real-valued parameter t . The oscillation is then expressed by using the Hamiltonian H as follows:

$$\exp(-2\pi itH/\hbar).$$

This operator is known in QM (quantum mechanics) as the evolution operator of the local system. We call it the local clock of the system, and we call t the local time of the system.

Using our self-centered coordinates of our local system in axiom 2, that is, letting x be position coordinates and v be velocity coordinates inside the local system, we can prove that

$$\left(\frac{x}{t} - v\right) \exp(-itH/\hbar) \sim 0 \quad \text{as } t \rightarrow \pm\infty.$$

This means that the word “local clock” is appropriate for the operator $\exp(-itH/\hbar)$ and so is “local time” for the parameter t .

Once given the local time, the local system obeys Schrödinger equation

$$\left(\frac{\hbar}{i} \frac{d}{dt} + H\right) \exp(-itH/\hbar) = 0,$$

which shows that the internal world is of QM (quantum mechanical) nature.

The above introduction of local time t as an “outer coordinate” is nothing but a decomposition of our internal world (which is expressed by internal stationary oscillations; $\exp(-ixp)$, or more generally, eigenfunctions of H) into a *spiral* or an *endless screw* of Riemann sheets of exponential function e^z ($z \in \mathbb{C}$) or into the Riemann surface of e^z .

More specifically speaking, for each generalized eigenvalue $\lambda/m \in \sigma(H) (\subset \mathbb{R})^\dagger$ of H , we have on the energy shell $H = \lambda/m$ that $\exp(-itH/\hbar) = \exp(-it\lambda/(\hbar m)) = \exp(-2\pi it\lambda/(hm))$ decomposes the eigenspace with eigenvalue λ/m into the Riemann surface “space” (tentative concept) of $\exp(-2\pi\lambda z/(hm))$ ($z = it$) with parallel strips

$$(k-1)\frac{hm}{\lambda} < \text{Im}(z) = t < k\frac{hm}{\lambda} \quad (k = \dots, -2, -1, 0, 1, 2, \dots),$$

each of which is mapped onto the whole complex plane “space” with a cut along the positive real axis.

By seeing that the least component in the period 2π that gives a fundamental periodic structure of $\exp(-i\tau)$ is $\pi/2$ (which is also noticed by Frank Ploughman, one of Ceta-Research students), we can say that the fundamental quantum of time is $\frac{1}{4}$ in the case of $\exp(-2\pi it)$. Or, in the case of $\exp(-2\pi it\lambda/(hm))$, it is $\frac{1}{4} \frac{mh}{\lambda}$. We call this the “quantum of time” of our local system.

As for the validness of the name “quantum of time,” we see how it is related with the Planck time:

$$t_P = \sqrt{G\hbar/c^5} = 1.35125 \times 10^{-43} \text{ s},$$

where G is the gravitational constant. In fact, given Planck mass:

$$m = m_P = \sqrt{\hbar c/G} = 5.45604 \times 10^{-5} \text{ g},$$

our quantum of time yields by the correspondence $\lambda = m^2 c^2/2$ which holds when the observer is stationary with respect to our local system of mass m ([7]) that

$$\text{the quantum of time} = \frac{1}{4} \frac{2mh}{m^2 c^2} = \frac{1}{4} \frac{2h}{\sqrt{\hbar c/G} c^2} = \frac{1}{2} \sqrt{\hbar G/c^5} = \frac{1}{2} t_P,$$

which is a half of Planck time.

All up to now can be expressed on a Euclidean space \mathbb{R}^n .

We need not worry about any curvature as we consider ourselves with respect to our own coordinates.

But when we look at the outside world, our view will be distorted due to the finiteness of our ability. As equivalent existences as localities, we are all subject to the one and the same law of distortion.

Stating it in our coordinates, we have the fourth principle.

Axiom 4. General Principle of Relativity. Physical worlds or laws are the same for all local observers.

[†] $\sigma(H)$ is the set of spectra of H and includes continuous spectrum $\sigma_c(H)$ of H , and we here follow the identification in [7] that $H = \lambda/m$.

As a locality, we cannot distinguish between the actual force and the fictitious force, as far as the force is caused by the distortions that our confrontations to the outside world produce.

We have thus the fifth axiom.

Axiom 5. Principle of Equivalence. For any gravitational force, we can choose a coordinate system (as a function of time t) where the effect of gravitation vanishes.

Axioms 4 and 5 are concerned with the distortion of our view when we meet the outside, while axioms 1–3 are about the inside world which is independently conceived as its own. The oscillatory nature of local systems in axiom 3 is a consequence of the stationary nature of the Universe, so that the oscillation is due to the intrinsic “internal” cause, while the distortion of our view to the outside is due to observational “external” cause.

Those two aspects, the internal and the external aspects, are independent mutually, because the internal coordinate system of a local system is a relative one inside the local system and does not have any relation with the external coordinates. Therefore, when we are inside, we are free from the distortion, while when we are meeting the outside, we are in a state that we forget the inside for a while and see a curved world. Thus axioms 1–5 are consistent.

2. Related areas.

I state some remarks on related areas.

2.1 Observation as computation.

As QM systems, a local system evolves along its local time.

When making observation of the outside, the evolution operator $\exp(-itH/\hbar)$ expresses the observation activity of the local system.

This amounts to QM computation of observation as Stephen Paul King has been arguing on our celebrated time list.

2.2 Space dimension and Rhythm Based Time.

We started with a general dimension $n = 1, 2, 3, \dots$.

All arguments so far are valid with any dimension n , and we obtain QM (quantum mechanics) inside and GR (general relativity) outside.

The internal QM nature inside a local system, however, must be different from CM (classical mechanical) ones, in order for the oscillation to be able to express the absolute, inconsistent, self-identity, and not to be expressed as or reduced to a simple CM.

Then Kochen-Specker theorem implies $n \geq 3$.

On the other hand, the external GR space-time of observation have dimension $n + 1$.

For the external GR space-time to be rich enough (for humans), we should have dimension $n + 1 \leq 4$ for it to have the abundance of geometrical structures, in the sense that the dimensions higher than or equal to 5 can be treated by a common general algebraic method, while dimensions 3 and 4 cannot and require the special methods for each dimension.

Thus by the internal and external requirements, n must be 3.

Here appears Dr. Peter Beamish’s space dimension 3.

As we have discussed, inside a local system, its motion is described by the evolution operator or a local clock of the system:

$$\exp(-itH/\hbar).$$

This has a simple expression by axiom 3:

$$\exp(-itH/\hbar) = \int_{-\infty}^{\infty} e^{-it\lambda/(m\hbar)} dE_H(\lambda/m).$$

This is the exact expression of what we have discussed in relation to the decomposition of the eigenspace into the Riemann surface “space.” This means that the clock is abstractly equivalent to the cyclic motion

$$\exp(-it\lambda/(m\hbar))$$

on one-dimensional sphere S^1 .

In other words, the local clock is cyclic in an abstract form. This is Dr. Beamish’s

Rhythm Based Time or RBT.

This RBT is the basis for Rhythm Based Communication due to Dr. Beamish and Ceta-Research ([1], [2]), which constitutes a fundamental part of communication together with Signal Based Communication.

As we have seen, the fundamental quantum of time is $\frac{1}{4}\frac{m\hbar}{\lambda}$, which corresponds to the rotation with angle $\frac{\pi}{2}$ of the complex plane (of each Riemann sheet of $\exp(-2\pi z\lambda/(m\hbar))$, which sheet is the “Event Space Sphere or Spheroid” (essos) by Dr. Beamish and Ceta-Research) in positive or negative direction. Whether or not the “rotation” in this “Event Space Sphere or Spheroid” (essos) is by a force or psychological force, it is a fundamental component of Rhythm Based Communication as shown by Dr. Beamish and Ceta-Research in [1], [2].

2.3 Another axiom on observation.

We started from the internal observation of ourselves, and arrived at QM aspect inside and GR aspect outside.

These two aspects are inevitable for us, local existence, and are summarized to axioms 1–5. We can postulate another axiom, axiom 6 (see [3], [4], [5], [6]), on the more precise description of observation, which will be given more clarified description by bisimulation approach due to Stephen P. King. The consideration of observation is nothing but the investigation of the bisimulation as he has been discussing.

2.4 Momenta-transfer induced gravity.

We adopted GR principle for the external, observable world, so that GR view of gravity is reproduced.

However, from our structure of argument, we can combine our QM axioms 1–3 consistently with Dr. Gary Vezzoli’s model of momenta-transfer induced gravity in [8], so that our thought on gravitation would be deepened by the future observational data to include Dr. Vezzoli’s model of gravity.

There is a possibility also that his approach gives another unification based merely on quantum mechanical view.

3. Conclusion.

Summarizing, insofar as we stay inside our world, the outside world is independent of the internal world, and any classical view to outside could be incorporated into our framework, as far as it is consistent with axioms 1–3.

Thus we have a free framework of thought, and the more minute physics could be implemented with a broad freedom.

We conclude that we have in the above, just prepared a starting point

1) down to the more inside into our mind,

and

2) up to the more outside onto the external physics.

These two investigations will be deepened through the interactions with each other so that the work of mind with the external physical world will be clarified.

We expect that we will see and have fruitful advancements in further discussions.

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