TIME
Physical and Eternal

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One cannot progress very far in answering the questions concerning reality without considering the riddle of time. Time may be the most enigmatic of all metaphysical and physical problems, and it must be resolved in order to understand reality.

It seems that time is a *fundamental variable* in reality. There is no law of physics which does not require the concept of time for its formulation, but needless to say, there is no unanimously accepted definition of time. The humble purpose of this paper concerning *two* variables of time is to provide a step toward a meaningful definition of time.

Time as metaphysical problem

Two opposite views of time have been clashing from the dawn of Western thinking. Heraclitus (ca.540-480 B.C.) thought that the basic feature of reality is "becoming," that is, time is a "flux" or perpetual change. As such, time is something *physical*: measurable, countable, and computable, that is, *a posteriori*. Parmenides (ca. 515-445 B.C.), in turn, thought there is no change in the universe, because the permanent forms of reality are motionless and mathematical. The universe is timeless and hence, it is something *eternal*: immeasurable, uncountable, and incomputable, that is, *a priori.*

Western metaphysicians have mainly argued in favor of Heraclitus. There have been three paradigmatic topics concerning time in philosophical enquiry: change, causation, and modality. [1]

Time as change. It is commonly accepted that only time, not space, is the variable of change. The genuine change involves temporal variation in the properties of things, when time "passes." Time is the changing *process*, where the future is

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1 See f. ex. *The Philosophy of Time*, ed. Robin Le Poidevin and Murray MacBeath (New York: Oxford University Press, 1993) and Atso A. Eerikäinen, *Two Dimensions of Time. The Dimensional Thinking of Karl Heim. An ontological Solution to the Problems of Science, Philosophy, and Theology* (Frankfurt am Main: Peter Lang, 2003), next abbreviated: *TDT*.

becoming the present, and the present is changing into the past. It is just the change that goes on in the event while it is occurring. A presentness of an event is its happening, as opposed to its having happened or being about to happen. The present is a factual point in the flux of time or a number of motions, which separates and unifies the past and the future, or earlier and later, as Aristotle (384-322 BC) thought. It follows from the *ontological* difference between the past and the future that the past expands in the flux of time: more facts are added to the totality of facts.

J.M.E. McTaggart showed in his famous paper concerning the unreality of time the movement of time consists in the fact that later and later terms pass into the present, or that the present passes to later and later terms. In other words, the so-called "B series" of time is sliding along a fixed "A series" of time, or A series of time is sliding along a fixed B series of time. In the first case, time presents itself as a moment from the future to the past. In the second case, time presents itself as a moment from earlier to later. The events seem to come out of the future, while we ourselves move towards the future. B series of time runs *backwards*, whereas A series of time runs *forwards*, that is, the future has been, the present is, and the past will be, and *vice versa.* [2]

Time as causal relation. The main point in the causal theories of time is that time, as a temporal becoming, is asymmetric, deterministic, and continuous. If *A* causes or is among the causes of *B*, then *B* does not cause or is not among the causes of *A*, and *A* is sufficient cause for effect *B*. The *asymmetry* of time entails that time has a direction because causation has a direction. Asymmetric time is the variable of causality. The direction of asymmetric time means also that the so-called "time travel" is impossible, as already Hume (1711-1776) proposed. Especially, if the present is ontologically privileged or time is unreal, there is nothing for the time-traveler to visit.

Yet within physical time, we cannot affect the past, because it is *determined.* Any statement about the past has a determined truth-value. The future, instead, is not yet determined. There is no present fact about whether *A* will exist tomorrow, so anything we do or happens now can make a difference for the future. If there is no ontological difference between the present and the future, then future-tense statements must have a determined truth-value. Hence, the rejection of temporal becoming means a rejection of indeterminism, that is, free will.

The flux of time seems to be *continuous.* The changing things in time exist continuously. Kant (1724-1804) proposed in his principle of contradiction that a

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[2] J.M.E. McTaggart, "The Unreality of Time" in *Mind, 17/1908*:457-474.

thing cannot be itself and something else simultaneously. If one state exists, the other cannot exist simultaneously. One cannot be both existing and non-existing, or neither existing nor non-existing simultaneously. Reality is a continuity of the temporal states.

Time as modal relation. Finally, time can be described in modal terms. "Necessarily *p*" means that *p* is true in all possible worlds, and "possibly *p*" means that *p* is true at least in some world. The future is just a set of possible worlds, so the flux of time is the passage from the possible to the necessary. However, if causality is the mechanism by which we have knowledge of temporal relations, then there is some epistemological motivation for a non-modal causal theory of time.

One might ask why it is necessary to base causal relations on the possibility between events and not the *actual* temporal relations between them. It is only because time somehow exists between two events that there is the possibility of change between those events. Yet, there are some topological difficulties between time and modality. Is the structure of time *necessary* or *contingent*? Aristotle argued in favor of necessity, but Hume in favor of contingency. Hume also thought that time is merely composed by *discrete* instants, and hence, it cannot be continuous.

The followers of Parmenides have argued in favor of unchanging, unreal, and/or non-existing time. For instance, McTaggart thought that impressions of temporality are mere human inventions. Because time cannot change in time, there is no time existing independently. Temporal relationists believe that time is only the *measure* of change or motion. Time does not change, and its existence depends on motion, as Aristotle thought. As such, time is a *scalar* quantity.

Leibniz (1646-1716), in turn, thought that temporal relations can be logically analyzed as *timeless* properties of individual monads. Time is *unreal* but not empty. It is regarded as a possibility of the temporal location. Kant, in turn, located time into the mind as a pure *form a priori* of sensible intuition or reason. As such, time has no physical status. Whereas Euclidean space is the formal *a priori* condition of outer experiences, time is the formal *a priori* condition of appearances. If this subjective condition of sensibility were removed, time would be nothing at all. Thus, space and time are given *a priori*, whereas everything that is given in them is *a posteriori*.

Time as physical problem

In classical mechanics (CM) of Newton (1642-1724), time is *absolute*, true, and mathematical, which of itself and from its own nature, flows without relation to anything external. Material bodies move through Euclidean space along predictable paths, subject to forces that accelerate them in accordance with strict mathematical laws. The universe is a gigantic clock-like mechanism, predictable in every detail by universal and absolute time. Time is simply there, and nothing can affect it. Newtonian time is absolute *calculus*: the precise and continuous succession of the present moments.

Newton's conception of absolute time was rejected 150 years later by Einstein's (1879-1955) flexible time. Time became Riemann's non-Euclidean "metric" *space* or at least an inseparable part of it. Euclidean and "phenomenalistic" SR needs observers and their time depending on how they are moving, whereas non-Euclidean and "realistic" GR does not need any observers. Strictly speaking, Einstein's GR does not describe time but *gravity*, which has some important implications concerning time. On the one hand, gravity is not a mysterious mechanical force operating at a distance but a warping of space-time by the mass and energy on it. On the other hand, it is an acceleration that depends on the curvature of space-time. So to say, mass tells space-time how to curve, and space-time tells mass how to move. [3]

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[3] According to Riemann's (1826-1866) concept of "metric space," it is possible to think of n-dimensional non-Euclidean spaces, and that every space includes an infinite number of internally different spaces. These differ from each other only in curvature. The curvature of two-dimensional Euclidean space is 0, and therefore the parallel-axiom is valid in it. In Riemannian spaces, the curvature is constant and positive. This kind of space is "elliptic;" for example, the surface of a ball, in which parallel lines cannot be drawn through a point outside a given line. All lines always cross each other, and the sum of angles in triangle is always bigger than 180°. Instead, in spaces of Lobatchevski and Bolyai, the curvature is constant, but negative. This kind of space is "hyperbolic," in which more than one parallel line can be drawn through a point outside a given line, and the sum of angles in a triangle is always smaller than 180°. All these spaces are mathematically equally true. The concept of the three-dimensional non-Euclidean space nullified the mathematical twilight, which had been characteristic for all attempts to solve the problem of space in physics. See Eerikäinen, "Space-problem from Newton to Quantum mechanics," in TDT, pp. 52-57. – According to Gary Vezzoli, *Physical Consequences of a Momenta-Transfering Particle Theory of Induced Gravity and New Measurements Indicating Variation from Inverse Square Law at Length Scale of .1 mm: Statistical Time Properties of Gravitational Interaction and Analysis Thereof,* however, the reason why Riemannian space is more suitable to understanding nature and the universe, and analyzing it, is not because of any inherent improvement over Euclidean or Cartesian space, but because of the nature of gravity and gravitons which "force" mass to move through space in a curved, non-

In fact, Einstein's space-time as a Riemannian field is simply there, like Newtonian absolute time, but as relative, because it depends on motion of mass and energy on it. Because, it seems that the *velocity* of gravitons is equal with the velocity of light, as Einstein predicted, both elastic and especially inelastic *interaction* of gravitons and mass particles causes the bending effect on light passing through space near a large and massive body. So, it would be that just gravity or both the gravitational *pushing* and the electromagnetic *pulling* is the field of space-time. [4]

Einstein's GR imply that the universe and physical time must have a *beginning*, and they may have an end. Causality determines that physical time must have an irreversible direction. The laws of thermodynamics verify the law of causality. The second law of thermodynamics determines that every closed system tends toward a state of total disorder. Entropy measures the degree of disorder, which always increases with time. If there is no beginning of the universe, it would be in a state of complete disorder by now, and everything would be at the same temperature. [5]

GR implies that physical time is also *warping*. Because a gravitational field is associated with warping time, it tells how much time is dilated at each point in space. An infinite time warp could occur in the so-called "black hole," from where light would not be able to escape because of the infinite density of that space-time singularity. The event horizon of the space-time singularity is the boundary to physical time itself. It is possible that a singularity, the so-called "Big bang," was once the spontaneous origin of physical time, and the so-called "black hole" singularities and/or "Big crunch" might be the end of physical time. [6]

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straight-line fashion. Such does not imply that space is curvilinear or warped, nor does it imply that space-time is so geometrized. See *http://arxiv.org/abs/physics/0104018*.

4 See Davies, *About Time,* pp. 16-17, 29-33, 40-44, 51-55, 279-283, Richard P. Feynman, *Six not-so-easy Pieces*, pp. 93-109, Stephen Hawking and Roger Penrose, *The Nature of Space and Time* (Princeton, NJ: Princeton University Press, 1996). -Based on the work at the University of Missouri and at the National Astronomical Laboratory in Charlottesville, studying the eclipsing of the deep space quasar Jo842+1835 during the period 7-9 September 2002, particle physicist Gary Vezzoli informed me he feels confident that *the speed of gravity is the same as the speed of light*, as Einstein predicted this decades ago.

5 Stephen Hawking, "The Beginning of Time" in: *http://www.hawking.org.uk/lectures/lindex.html.*

6 Davies, *About Time*, pp. 33-35, 106-125, 131-132.

Instead, in *Quantum mechanics* (QM), time is not the Einsteinian relativistic one but it is Newtonian absolute time, and its geometry is Euclidean. QM describes phenomena according to a special time coordinate, that is, the state $f(t)$ of a system follows Schrödinger's equation:

> $df/dt(t) + iHf(t) = 0, f(0) = g$, where H is Hamiltonian, g the initial state, and t is time of the system.

At the quantum level of reality, there is, however, a basic limit that introduces an irreducible fuzziness to the notions of speed, rate, and time: Werner Heisenberg's (1901-1976) *uncertainty principle*. The size of the wave function at a point gives the probability that the particle will be found at that point, and the rate at which the wave function changes from point to point gives the probability of different velocities. One can have a wave function that is sharply peaked at a point. This corresponds to a state in which there is a little uncertainty in the position of the particle. However, the wave function varies rapidly. It means that there is a lot of uncertainty in the velocity. Similarly, a long chain of waves has a large uncertainty in position, but a small uncertainty in velocity. One can have a well defined position or a well defined velocity but not both at the same time. This would seem to make complete determinism impossible. If one cannot accurately define both the positions and the velocities of particles at one time, how can one predict what they will be in the future? Even if time is absolute Newtonian clock-time in QM, there is no absolute clock in QM, because all physical clocks are subject to quantum uncertainty. Hence, also time itself may be subject to quantum effects, if Heisenberg's principle is valid. [7]

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[7] Davies, *About Time*, pp. 90-92. Einstein did no believe that there is any uncertainty in the universe. According to Stanley L. Jaki, *Means to Message. A Treatise on Truth* (Grand Rapids, MI: William B. Eerdmans Publishing Co, 1999), pp. 102-105, the uncertainty principle is an obscure notion. It leads to fuzzy conclusions. According to the uncertainty principle, (1) *causality* does not hold in QM. However, the so-called "Big bang" was a quantum mechanical singularity. Hence, there is no causality in the universe. (2) Reality is *discontinuous*. An interaction that cannot be measured exactly, cannot take place exactly. But because the "measurement" is an operation and the "taking place" is an ontological occurrence, the conclusion is an elementary mistake in logic. (3) The uncertainty principle can be written: $\Delta mc^2 > \hbar/\Delta t$, where m is mass, c the constant velocity of light, $\hbar$ is Planck constant, and t is time. Because c and $\hbar$ are constants, the factor in evaluating the total uncertainty is only Δm. If there is no causality in QM, the causality defect becomes a true mass defect in the interaction. If we want to ascertain time t of a particle emission from an atom, we cannot avoid concluding that in the emission, we have on hand an amount of mass which is missing without a cause.

What is Now?

Einstein was seriously worried about the question: "What is now"? He concluded that the "now" has no physical status, and hence, it was a metaphysical question that lies beyond scientific physics.[8] Instead, Sir Arthur Stanley Eddington (1882-1944) thought that our impression of "becoming" is so powerful and central to our experience that it must correspond to something in the objective world. He thought: "If I grasp the notion of existence because I myself exist, I grasp the notion of becoming because *I myself become*. It is the innermost Ego of all which is and becomes. It seems that we experience time in two distinct ways: *externally* through the senses and *internally* within the mind."[9]

Although Plato (c. 428-347 BC) was obviously the first discoverer of "self" (soul, mind) in Western thinking[10], it was Aristotle who first put the mind into the center of changing reality. For him time was a measure of change, and as such, a number of motions in connection with earlier and later. There is no time without motion, and there is no present without the mind who realizes it.[11] In this sense, Einstein's SR is only a novel variation of Aristotle's metaphysics.

But what is the now? Could it be (1) something physical: changing, measurable, countable, and computable; or (2) something eternal: unchanging, immeasurable, uncountable, and incomputable; or (3) something physical and eternal simultaneously? There are some novel theories based on (1), such as "Local time" of Hitoshi Kitada (LT), and theories, based on (2): for example, time as a pure form *a priori* of intuition in Kant's transcendental idealism and a Par-

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[8] Einstein confessed to Rudolf Carnap (1891-1970) that "What is now worries me seriously", that "there is something essential about the now," but what ever it was, it is "just outside the realm of science." See *The Philosophy of Rudolf Carnap*, ed. P.A. Schilpp (La Salle, IL: Library of Living Philosophers, 1963), p. 37.

[9] A.S. Eddington, *The Nature of the Physical World* (Cambridge: Cambridge University Press, 1929), p. 97.

[10] In Eastern thinking, it was Gautama Buddha (563?-483? BC) who discovered the innermost ego, and since his time, Eastern philosophy and practice have been focused on the mind and introspection. Especially in metaphysics of Japanese Zen-Buddhism, the mind is seen as "absolutely inconsistent self-identity." See f.ex. James W. Heising's anthology *Philosophers of Nothingness. An Essay on the Kyoto School* (Honolulu: University of Hawaii Press, 2001).

[11] See Aristotle, *Physics,* IV: 10-14.

menidian theory of immeasurable time-capsules by Julian Barbour, [12] and at least a prominent theory based on (3): the relative now of secondary becoming or *process* (G) and the absolute now of primary becoming or *transition* (W) of Karl Heim's dimensional theory (HDT) proposed a half century ago.

Local time (LT)

According to a Japanese mathematician and metaphysician, Hitoshi Kitada at the University of Tokyo, as far as we are able to know, the microscopic phenomena follow precisely QM. Because the universe is assumed to have begun from an infinitesimally small point within the so-called singularity of "Big bang," we have to apply QM to this initial singularity. However, because the macroscopic universe generated by the singularity follows GR in classical approximation, we need the *relativistic* QM. How it is possible to construct relativistic QM, that is, a quantum theory of gravity has been the main puzzle of physics since Einstein.

According to Kitada, it seems that there are two problems behind the unification of GR and QM: (1) the conflict between their different kinds of geometries, and (2) the conception of time. In order to resolve the geometrical conflict and to define time properly, Kitada introduces his theory of "local time" (LT). [13]

As was noticed above, QM is constructed on Euclidean geometry. Therefore, there is a special time coordinate defined without any ambiguity, according to which physical phenomena must be described. Instead, because GR is constructed on non-Euclidean Riemannian geometry, there is a large arbitrariness of choosing space-time coordinates in GR. Because the physical laws are covariant under the transformations between coordinates, any one of them is equivalent in describing physical phenomena. These two notions are obviously incompatible. The resolution of the problem is attempted by using two opposite methods in quantization.

The so-called "canonical quantization" is an attempt to preserve the framework of QM by choosing *beforehand* a special time coordinate for the quantization, but as a result, the covariance is lost. Conversely, the so-called "non-canonical

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[12] In this paper, we do not analyze neither Kant's nor Barbour's conception of time. See a detailed analysis of Kant's ideas and their flaws in *TDT*, pp. 23-32, and 105-111, and Barbour's ideas and their flaws in *TDT*, p. 138.

[13] See Hitoshi Kitada, *Locality and the Universe 2002. Time XI* (http://www.kitada.com/), and his other papers about time.

quantization," starts without any special time coordinates. QM is generalized in order to make it covariant with respect to the change of coordinates by defining *afterwards* a special time coordinate in order to recover the quantum mechanical description. In both of these two methods of quantization, it is presupposed that a special time coordinate exists independently in order to make the description of quantum mechanical phenomena effective. Thus, we are back to the question: "What is the definition of time?"

The local systems of Kitada's theory are inner systems equipped with Euclidean geometry and QM associated to each point on the Riemannian manifold of GR. Thus, Kitada adopts Euclidean geometry for QM as an *inner* space and Riemannian geometry for GR as an *outer* space. Time recaptures its meaning as a "local time" inside each local system, defined as a measure of quantum mechanical motion inside the local system. In other words, time is defined as a notion associated with a system that can accommodate clocks, which have actual sizes. [14]

All attempts to unify GR and QM have failed, not only for reasons of their different kinds of geometries, but because time is presupposed to *exist* as an independent or external entity separated from the minds reading it on a clock. Time does not appear without measuring it by a clock. Time is a movement of the hands of the clock, and it does not have an *a priori* existence that measures motion. Just the motion of hands of an analogue clock or just the change of figures of a digital clock measures time. The definition of "local time" is based on this observation, and it is defined as a local notion effective only in each local system.

As such, *time is equivalent to the quantum mechanical evolution of a local system*. Since clocks are proper to each local system, and local systems are mutually *independent* concerning the association among the coordinates of these systems, one can impose relativistic change of coordinates among them. The change of coordinates gives a relationship between those local systems which yields relativistic quantum mechanical Hamiltonian, explaining the actual observations. Thus, LT is created by the minds of the observers, and does not demand continuous and external "global time" effective throughout the universe.

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[14] See Hitoshi Kitada, *A possible Solution of the non-existence of Time*, (http://arxiv.org/PS_cache/gr-qc/pdf/9910/9910081.pdf)

LT arises from the *stationary* nature of the universe.[15] The "stationary" of the total universe, that is \$\Phi$, means mathematically an *eigenstate* of a total Hamiltonian H. This, in turn, means that the universe \$\Phi$ as the *existence* itself is *timeless*, and as such it cannot be explained in terms of duration of physical time.

The axioms of LT are the following:

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.

$$H_{total}\,\Phi = \Lambda\Phi, \text{ for some non-positive real number } \Lambda \leq 0.$$

In fact, the eigenstate does not contain any reference to time, as can be seen from its definition. However, this definition does not argue that the entire universe \$\Phi$ is any frozen instant, which sempiternally lasts forever without a beginning and an end. Instead, the universe \$\Phi$ as the totality of *existence* has the infinite *freedom* inside itself as an internal motion of finite and local systems.[16]

Axiom 2. The local system is of *finite* nature, having its own origins of position x and momentum p, independent of the other's origins and inside worlds. However, the inside world of a finite local system is of *infinite* nature.

The local system oscillates in itself, because the stationary nature of the entire universe assures the oscillation of the locality.

Axiom 3. The oscillating nature of the local system caused by the stationary nature of the universe is expressed by $exp\ (-2\pi itH/h)$, which is known in QM as the evolution operator of the local system. It is the *local clock* of the system, and so, t is *local time* of the system.[17]

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[15] The quantum mechanical concept "stationary" does not mean motionless, as usually is understood. For example, you can say a hydrogen atom is stationary when it is stable and forms an atom. But inside it, electrons are moving around the nucleus.

[16] See "Local Time and the Unification of Physics Part I. Local Time," by Hitoshi Kitada and Lancelot R. Fletcher in *Apeiron*, Vol.3, No.2, April 1996, pp.38-45. Kitada and Fletcher based on Spinoza's idea of eternal substance (*natura naturans*), which is "exhaustive potentiality exhaustively actualizing itself." See also Rainer Zimmermann, "Spinoza in Context. A Holistic Approach in Modern Terms" and the comments to it of Juhani Pietarinen, "Spinoza and Modern Physics" in *Infinity, Causality and Determinism. Cosmological Enterprises and their Preconditions*, ed. Eeva Martikainen (Frankfurt am Main: Peter Lang, 2002), pp. 165-192.

[17] Kitada proves the equation of a local Hamiltonian by using a Fourier transform of a function. Sine and cosine components are summarized to the exponential function *exp (-ixp)*, which is an eigenfunction of the negative Laplacian. See the detailed mathematical

The infinite *inside* world of our local systems is quantum mechanical, and it obeys Schrödinger's equation. Instead, the finite *outside* world of our local systems obeys the general principle of relativity and the principle of equivalence.

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

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 concern the distortion of our view confronting the finite outside world, whereas the axioms 1-3 concern the infinite inside world, which is independently conceived as its own. The oscillation of the local systems is due to the intrinsic "internal" cause, whereas the distortion of our view toward the outside is due to observational "external" cause.

The internal and external aspects are mutually independent from each other, because the internal coordinate system of a local system is a relative one within the local system and it does not have any relationship with the external coordinates. Therefore, the inside of a local system is free, that is, indeterministic, but when it confronts the outside, it is determined to see the curved universe. Thus, LT is made and experienced by the self-centered observers and "located" inside the *minds* as "now time." [18]

Physical and eternal time of Heim's dimensional theory (HDT)

A German theologian Karl Heim (1874-1958) defined time *ontologically*, without any mathematics, although he was worked with Georg Cantor in Halle, because theories based on mathematics are either inconsistent or incomplete, as Gödel had proved. Heim's dimensional theory was based mainly on Kant's transcendental idealism, Schelling's (1775-1854) ideal-realism, Heidegger's existentialism, Einstein's SR and GR, and QM. [19] As such, it (HDT) is simply a *realistic* version of Kant's transcendental idealism.

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procedure and formulations in Kitada, *Locality and the Universe* 2002. *Time XI* (http://www.kitada.com/)

18 It seems that "local systems" of Kitada are quite similar with the windowless "monads" of Leibniz. For Leibniz, as itself unreal time was regarded as a possibility of the temporal location.

19 See details concerning the philosophical background of Heim's dimensional theory *TDT*, pp. 23-50.

The basic idea behind HDT and LT is similar. There are *two variables of time* inseparable from each other: physical and eternal or timeless. Based on this idea, from the view-point of metaphysics, it is possible to combine two opposite stances toward reality, namely phenomenalism (idealism) and physicalism (realism). From the view-point of physics, the idea allows unification two incompatible conception of time, namely Newtonian absolute (idealistic) and Einsteinian relative (realistic) time. Thus, HDT as a combination of two variables of time unifies *ontologically* GR and QM.

In entire reality, there are limitless or infinite *objectifiable* spaces (*Räume*), which can be defined as *well-founded sets*. The objectifiable *consciousness-spaces* of my-, your-, and their combination, our-space construct the objectifiable, physical aspect of reality: G-reality (*Geworden*). In other words, there is *an* objective reality constructed by "many worlds." [20] This objective G-reality is *relative*, physical time. [21] It is impossible to talk about time in general, but only time of individual observers: "my-time" of my-space, "your-time" of your-space or "our-time" of our-space depending on how we are moving through space-time.

Physical time as temporality is the variable of the measurable, countable, and computable change. It is an ever-changing process. The future of possibility and potentiality is becoming the present of actuality, and the presence is changing into the past of necessity. The relative flux of time as a "secondary becoming" or a *process* is an irreversible sequence of successive present moments (t_1, t_2… t_n). Thus, physical time does not start at t_0, but at t_1, because physical time can be infinitely long or infinitely short but *never zero*, that is, $G > 0$. It means that we can observe only the *past* of time. The events we observe lie on what is called our past light cone.

Like "clock-time" of SR and GR, "physical time" of HDT is relative *space* or at least inseparable from Riemannian metric space and gravity in it. The crucial difference between Einstein's and Heim's thinking was the question concerning

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20 HDT is very similar with MWI (many worlds interpretation of QM). See f.ex.. Lev Vaidman, "On Schizophrenic Experiences of the Neutron or Why We Should Believe in the Many-Worlds Interpretation of Quantum Theory" at: http://lanl.arxiv.org/abs/quant-ph/?9609006.

21 Heim argued that time is "relative space" in his first publication *Psychologismus oder Antipsychologismus* (Berlin: C.A. Schwetschke und Sohn, 1902). He also argued that time must be "two-dimensional." In my dissertation, *Time and Polarity. The Dimensional Thinking of Karl Heim* (Helsinki: Yliopistopaino, 2000) published as an internet version at: http://ethesis.helsinki.fi/julkaisut/teo/syste/vk/eerikainen/, and in my book *TDT*, I have reinterpreted and rethought Heim's ideas of his dimensional theory as a novel theory of physical and eternal time.

the now. The "now" was, for Einstein, the mysterious question beyond physics. He was right, but because he did not want to answer this crucial question, his conception of time was insufficient. According to Heim, this "mysterious something" is W-reality, which as non-objectifiable and eternal time is beyond scientifical inquiries, as Einstein clearly understood.

Thus, there are also limitless or infinite *non-objectifiable* spaces, which are incomputable, and hence, they cannot be defined as any kinds of sets. The non-objectifiable *mind-spaces* of I-, You-, and their combination, We-space construct the eternal aspect of reality: W-reality (*Werden*). It is the *absolute* "now": *nunc aeternum,* that is, W = 0. W-reality is the pure non-objectifiable, emerging, and energetic state within G-reality. Heim argued that W-reality does not include only human minds but also non-objectifiable "minds" of the whole biosphere and the material world. For example, the core of electron seems to be such a mental property. In other words, eternal W-reality is *panpsychic*.

Eternal time is the variable of the "primary becoming" or *transition*. It is a certain "imaginary *zero*-point," where the "secondary becoming" or process appears into existence. In other words, "not yet become" *potential* reality becomes "already become," that is, logically necessary *actual* reality. Entire reality is a dynamic *interaction* and an information exchange of physical and eternal time. Eternal W-reality of the minds or knowing, willing and evaluating subjects (I-, You-, and We-space) is the perspectival and energetic center of physical G-reality (my-, your-, and our-space) of the objects. Eternal time is absolutely simultaneous with all moments of physical time, as St. Thomas Aquinas (1225-1274) thought. Or in other words, at its deeper level, reality is a sort of "super hologram," in which the past, present, and future exist simultaneously, as for instance, David Bohm has proposed. [22]

Even if spaces are limitless, there are boundaries within and between spaces. The *boundary of contents* prevails within a space. If the number of dimensions in a space is *n*, then the number of dimensions in the boundary of contents is *n-1*. Instead, the *dimensional boundary* is the constant *velocity of light* = *c* between spaces of W- and G-realities. It means that within a black hole, from where light cannot escape, or within the singularity of Big bang, G-reality of physical time merges into W-reality of eternal time, and hence, W + G = 0.

Except the boundaries, there prevails also the *polarity*, that is, the *absolute simultaneity* between W- and G-realities and their spaces. The law of double polarity: *A<>B<>AB* (indifference condition), as Schelling defined it, is neither a causal

[22] David Pratt, "David Bohm and the Implicate Order" in http://www.theosophy-nw.org/theosnw/science/prat-boh.htm.

(cause-effect) nor logical (premise-conclusion) relationship but is obvious immediately. Since Aristotle, philosophers have concluded that if there is no entity that is purely "in itself" and "through itself" (*AB*), then there is no secondary and dependent thing imaginable, and all actuality as a whole dissolves into illusion. The polarity implies that there is no physical time without eternal time, and no eternal time without physical time. *The polarity holds physical and eternal time together*. In other words, reality is not dualistic but monistic totality combined by objectifiable and non-objectifiable aspects of reality. Practically, the polarity means, for instance, that "here" and "there" is absolutely simultaneous in eternal time of I-space but relative in physical time of my-space. I can be "here" and "there" simultaneously in eternal now of I-space (the mind) but not in physical now of my-space.

Thus, eternal time is bound in certain *locations* in physical time, which can be described by using Boolean algebra.[23] Eternal time is like the *Boolean duration* between two measurable "clock-ticks" of clocks. The Boolean non-numerical, *uncountable* duration and the *countable* duration in physical time are always in the *polar* relationship: $(\oplus)\ 1<\oplus>2<\oplus>3\ldots<\oplus>n\ (\oplus) \geq 0$.

Because eternal time exists *within* physical time, *time as a dynamical unity of physical and eternal must be a continuum.* Hence, Heisenberg's uncertainty principle is not valid. Thus, the enigmatic questions of St. Augustine (354-430): "How can we measure time actual only in the present time, where there is no duration?" and of McTaggart's: "How can time change in time?" receive their novel answer.

We can conclude that the definition of time would be:

$$\boldsymbol{G+W \geq 0}, \text{ and } \boldsymbol{G \times W = 0}$$

(G is physical time and W is eternal time).

The ontological HDT can be illustrated as a polar *interaction* and an *information exchange*:

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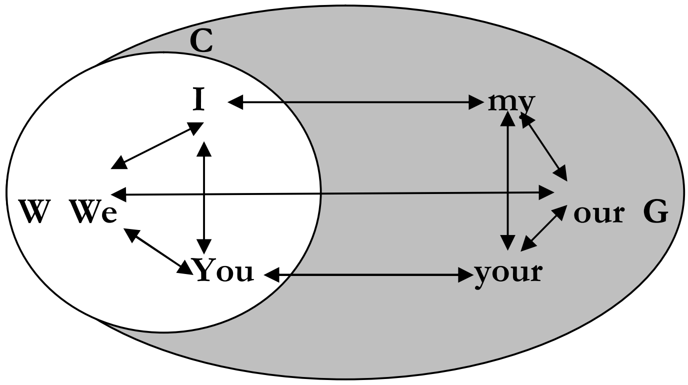
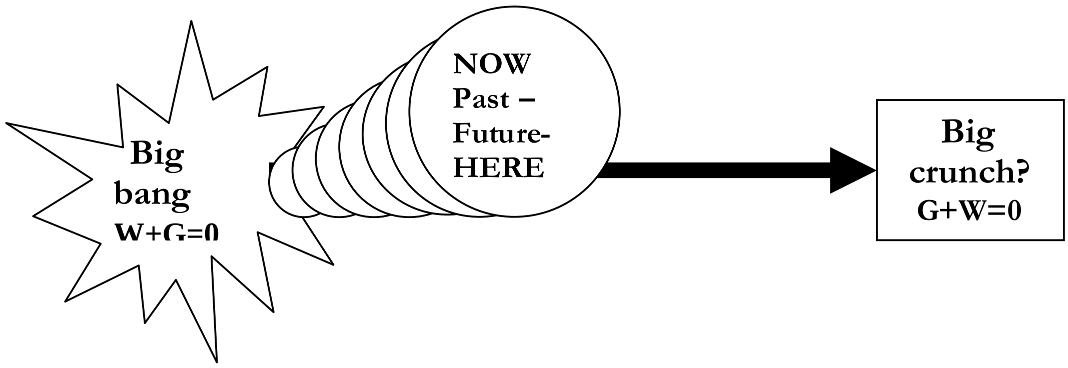
[23] Reality can be described mathematically, but reality is not constructed or created by mathematics, which is only a human metaphysical intervention toward reality, and as such an intelligent but incomplete approximation of existing reality.



All polar spaces are limitless or infinite. The dimensional boundary = the velocity of light c (circle) prevails between W- and G-realities.

Polarity = ⟷ G-reality = ● W-reality = ○

The *process* of physical time and the *transition* of eternal time can be illustrated as following:



The linear asymmetric "arrow" of relative and *physical time-process* starts from the Big bang singularity (W+G= 0), and it may end in the Big crunch singularity (G+W = 0). Absolute, vertical, and *eternal time-transition* is present in every moments of linear or horizontal physical time, and so, entire reality is a dynamic interaction of events and an information exchange of physical and eternal time. In physical time, all changes are *successive*, but in eternal time, all happens *at once*.

Thus, time is physical and eternal. Time is in eternity, and eternity is in time.