

Time and cosmological Metabolism

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A link between cosmological Time and Variability concept basing on metabolic processes is considered.

Nihil est sine ratione
(Nothing is without a reason)

Leibniz

1. Variability and Metabolism

The works of A.P. Levich (see, for example, [Levich, 1988, 1995]) contain an investigation of possibility to build fundamental representation on Time using generalized link between variability and metabolism for arbitrary type systems. Particularly, the author says about biological systems.

For example, a live cell plays the role of elementary object in embryology, its variability is due to cell's division, and specific unit of biological Time in this case is equal to the interval between division events. General process for multicellular organism consists in growth, where new cells appear and existing cells are replaced or disappear.

A population represents an elementary object in ecology, its variability is associated with individual birth and death events. One measures the age of population in ecology, ethnography, and genetics using the number of generations. General process for a population consists in its outnumber. Change of species represents a general process in an ecological community, and change of living organism associations in Earth's biosphere is called as "evolution process".

For some evolving object Levich proposes to identify the general process concept with Time's course and to use an amount of varying elements as measure of variability. In fact, he says on the object's age – for example, oxygen's quantity that an animal consumes since "first" to "last" sigh may be used as a measure of physiologic age of the organism. At this he notes possible irregularity of such Time, since its intervals measured by two different general process clocks may do not agree.

Levich proposes to call as "parametric" the time that is measured by "clock" of some general process and to treat that Time as an image of varying objects while one maps it into a linearly ordered metric set. He also notes that any varying systems consume some resource. The last is specified by a set of system numerical parameters, which: 1) necessarily accompany system variability; 2) increase monotonically with the system time, and hence 3) can be used to parametrize the variations. The "consumed" resource amount defines so called "*metabolic time*" of the system.

He also states that the solving of problems of the Time course and irreversibility leads to the World representation as open and complicating one. Thus, our Universe appears to be open too.

The Time course is also specified by so called "Time arrow", i.e., by its direction. For example, the cosmological Time arrow is associated with the Universe expanding, the thermodynamic one is associated with Second Law, the biological one is associated with the living organism evolution, the psychological one is associated with an individual Time perception. All these arrows have to agree between them.

For example, E. Schrödinger in his famous work [Schrödinger, 1955] notes that a living organism evolves (biological Time arrow) as an *open* system consuming the

negative entropy that appears due to energy flow from Sun, i.e. accordingly with thermodynamics laws (thermodynamic Time arrow). So, the metabolic processes turn out to be associated with the negative entropy flows.

As S. Hawking notes [**Hawking, 1988**], the psicological Time arrow is agree with thermodynamic one too, since mind's work metabolism (as device to record an information to a memory) is necessarily related with energy consumption (in particlary, to cool it). The Time course direction in which mind or computer remembers the past turns out to be the same as this one of the disorder increasing.

2. Black Holes and parametric Time

There exist some astrophysical objects for which all foresaid has non-trivial meaning. These objects are Black Holes (BH). They can increase their mass due to matter consuming from environment and/or lose mass due to Hawking radiation ("quantum evaporation"). As it is known, a size of non-rotating and electrically neutral BH is proportional to its mass.

One can describe BH's evolution by introducing parametric Time that is by definition equal to its radius divided by velocity of light. As result, a solution of Einstein-Friedmann equations appears that corresponds to proposed mass increasing (see [**Shulman, 2009a**]). Note, this parametric Time turns out in principle to be the same inside and on the outside of BH. So, the considered BH represents some kind of expanding universe, and its expanding is due immediately to mass increasing coming from the outside. An elementary particle is seeming to play the role of clock in any point of BH, because this particle's *energy* can be associated with the ratio of the BH's *age* to the paricle's *de Brolie wave period*.

The "external" world together with the event horizon play for considered BH the same role that Sun and Space play for Earth. The matter and energy flow coming to BH should be necessarily associateted with its entropy decreasing. One could see some contradiction here. Indeed, when one considers BH from the "external" point of view (outside from BH), the BH's entropy is accepted to be proportional to its event horizon surface area, so it increases (not decreases) with its mass increasing. However, this contradiction is the seeming one. When we consider some external mass, part of which will be consumed by BH, we need add the entropy of remained part of mass to the BH's entropy (that is determined by the event horizon surface). One can say that this "external" entropy of BH supports the validity of Generalized Second Law of Thermodynamics (introduced by J. Bekenstein). In the system "Sun – Earth – Space" entropy is transported from Sun to Earth and then is dissipated into Space. Differently, in the system "BH's environment – event horizon – BH's internal volume" the entropy is coming to the event horizon as from BH's environment as well from BH's internal volume. Because of that the increasing of "external entropy" (event horizon entropy), and the decreasing of the "internal BH's entropy" as well do not contradict to the thermodynamics as a partial increment due to the solar heat does not contradicts to its total decrement. So, the "internal" BH's entropy decreases (as in open system) [**Shulman, 2009b**].

Furthermore, inside of such BH some "daughter" BHs can appear. They may be formed due to a collapse at different points of time accordingly the maternal universe "clock" and have in general different expansion rate, particularly – accelerated or decelerated one. So, their own scale of parametric time can differ from maternal universe point of view. Note, if an internal BH expands with acceleration, it have to become one day equal to the maternal universe and absorb it.

3. Evolution of Universe as consequence of energy and matter consumption from outside

The picture that internal observer can see inside BH is very similar to our expanding Universe picture. The rejection to consider Universe as closed system allows us to solve successfully the most of known cosmological problems: horizon's problem, cosmological constant's problem, relict cosmic radiation anisotropy's problem, etc. [Shulman, 2007].

A number of fundamental facts can be explained by this way. Such things become to be evident:

- physical meaning of “Big Bang” as initial event of gravitational collapse in some Super-Universe,
- treating of the Universe expansion as immediate consequence of a continuous (in own parametric Time) absorption of external matter and energy¹,
- radical difference between the real Universe's thermodynamic state and the equilibrium one.

We noted above the fact of three Time arrow consistency – biological one (evolution direction), thermodynamic one, and psychological one. Note, thermodynamic Time arrow was considered as basic Time arrow. Now we can see that cosmological Time arrow in our Universe is due to the existing of Super-Universe and validity in it the general laws of Thermodynamics. Thus, these thermodynamic laws support energy and negative entropy flows coming to our Universe that leads to the continuous differentiation of its structure and deviation from the equilibrium state during 13,7 billions years of parametric Time.

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¹ From this we can deduce that in an evaporating (decreasing) quantum BH Time should be directed oppositely.