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Entropy and evolution

(November 11, 2012. Updated: January 26, 2013)

A system openess is the *required* condition of its *progressive* evolution; it means that the regular input and otput *energy* flows exist. Also, the input *entropy* flow has to be less than the ouput one. However, this condition is sufficient *only to support* an obtained level of remoteness from the thermal equilibrium state, while it is needed something yet to *complicate* the system ordering. Namely, a rule of choice must exist in the system phase space that enables a set of *stable* points or domains and disables other points and domains. When the both conditions present, a progressive evolution really occurs and leads to a structural changes and a new rules of choice appearance. I consider below two fundamental examples of such systems: 1) whole Universe, and 2) Earth.

So, a *material* system evolution is based on Nature's Laws. However, these Laws are *objective ones*, but they aren't *material*, i.e. they cannot be attribted by time-space parameters and cannot transport the energy and momentum. The such Laws existence forces us to suppose that an *other* level of the Reality exists which has to be (in a sense) an *external* one relative to our Universe.

Introduction

There exist two principal trends in our Universe: the first one consists in the entropy (and chaos) rise anywhere, while the second one leads to the ordered structures creation. One can see this on Earth (including the human activity phenomena). Also, all the Universe is clearly an example of the system that regularly moves avay from the "heat death" state. So far the physicists usually imagine our Universe as an *isolated* system, so the energy and matter cannot leave it and come into it. Because of that one deduces the Second Law of Thermodynamics that quite contradicts to the real Universe evolution.

However, one often states that the Universe cannot be considered as an isolated system due to the gravitation effects, and this may explain a complicately ordered structures and processes existence that clearly contradicts to the Second Law. Unfortunately, this statement is rather "a carpet under which one sweeps up a trash" (as Feynmann said), it explains noting and cannot help us to understand the evolution origin.

How the Universe entropy does change?

Wee need in the entropy trend picture to understand the Universe evolution hystory. I believe that one has to recognize the evident fact: *the Universe entropy decreases (not increases*) with cosmic time. The problem remains "only" how one can theoretically explain it.

Since 1993 I develop a new cosmological model that differs from the standard one, see **[Shulman, 2011]**. In this new model our Universe represents the black hole (as I know, Jh. A. Wheeler was one of pioneers of such the idea, see **[Smolin, 1994]**), which *irrevercibly* expands due to the matter and energy absorption from an external 4D World. The time course itself is just the Universe radius increment that refers the events chronology like a tree growth rings.

So, in the proposed model at least a *regular input energy flow* into the Universe is accounted. However, the model also provides the opposite process: the energy *elimination*. It seems to be *impossible* due to black hole definition. However, there exist the *internal* black holes in our Universe. Some decades ago the astrophysicists reval that

there are supermassive black hole inside of the galaxy cores. The total entropy of these supermassive black holes is 20 orders larger than all the rest of the Universe, see **[Egan and Lineweaver, 2009]**. Their surface (event horizon) temperature is practically equal to zero, i.e. is less than the average Universe temperature. Hence, they are the perfect heat absorbers. Accounting all that we can believe that "the rest" of the Universe is thermodinamically *open* system, not isolated one.

Why may we suppose that the *output* entropy flow from our Unoverse is *larger* than the input one into it? The each internal black hole entropy is proportional to its freedom degree number, i.e. to its dimensionless surface area (the number of 2D cells having plankian size). If our Universe is the black hole in an *external 4D World*, then its entropy should be equal to the number of *3D* plankian cells. Hence, the our Universe entropy *increasing* with time will be proportional to the 3^{th} power of its size, while entropy decreasing will be be proportional to the 2^{th} power of an internal black hole average size. However, it is possible that the blac hole *amount* also increases with time; for example, if it is proportinal to the Universe current volume, then total entropy *decreasing* rate will be *positive*.

So, we can suppose that our Universe (without all internal black holes) progressive evolution is due to a transit flows of the negative entropy.

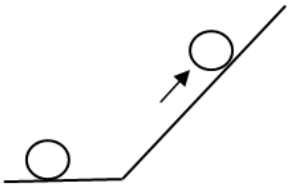
The isolated and open system evolution

The energy redistribution during interactions can lead to a systems evolution. Corresponding the intensity and type of interactions to a current statistical system state we can describe evolution using positive and/or negative feedback mechanisms that just define this evolution.

For example, let an isolated system be consist in two subsystems, where each of them initially is in the thermal equilibrium state and is specified by an own temperature. *If* both subsystems have a *positive* heat capacity, *then* a subsystem having the higher temperature will send the heat to the system having the lower one, and the temperatures will tend to be equal. One can say that the total system is regulated by a *negative* feedback that stabilizes its state and maximizes its entropy. Contrary, *if* both subsystems have a *negative* heat capacity (for example, stars whose temperature *increases* with energy emission), *then* a *positive* feedback emerges in such the system, so a system deviation from equilibrium leads to a further deviation growth. Because a temperature cannot rise up to infinity due to energy limitation the system stabilisation is probably the most general case (Le Chatelier's principle), i.e. it generally tends to the equilibrium state ("heat death").

Another case is an *open* system that is included as intermediate part between an energy source and an absorber. The energy coming into our system from an *external* source creates in it a local energy gradients, i.e. deviates it from the thermal equilibrium state. If an effective energy elimination was absent, then emerging relaxation flows returned our system to the equilibrium, however, if such the energy elimination is present, then it can assure the conservation and even increasing of the remoteness from the equilibrium state.

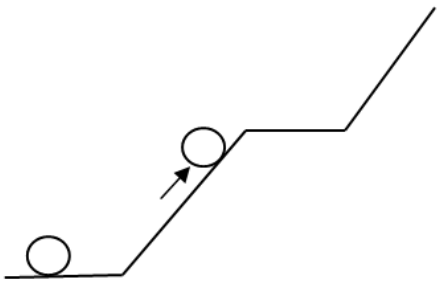
Let us consider how a regular negative entropy assures the remoteness from the equilibrium state. We can compare the system position in the phase space at the equilibrium with a ball disposed at the bottom of a mount (miminimal energy, maximal entropy).



If the ball is regularly pushed by an external power (as the flash points out) and the average energy is large enough, then it starts to ascend onto “energetic” mount while the system potential enegy will increase and its entropy will decrease. Of course, a type (accidental or systematic) and irreversibility of the ascending depend on the energy inflow parameters.

So, the regular yielding of the negative entropy solves the problem of the open system remoteness from the “heat death” and statistical homogeneity state. But is it enough to increase the *ordering* level of the matter structure?

In the above figure there exist a linear connection between a potential energy increment and its entropy decrement, and evolutions turns out to be reversible. If the accumulated system energy decreases, then evolution inverses. However, for ordered systems a *stable* states exist, so the system resists to any deviation from them. When the potential energy changes, the entropy of such the system changes essentially by a *nonlinear* way due to creation of a feedback contours. A simple illustration is shown below where there is only *one* intermediate stable state (the bar). The states stability can be in general obtained using a numerous feedback contours.



The considered situation shows that the main assumption – “all microstates have a priori the *equal* probabilities” – turns out to be *incorrect*. Because of that a numerical estimate of some very important *macrostate* turns out to be *incorrect* too. This statement will be considered below with two fundamental examples: the Universe evolution and Earth’s one.

The Universe evolution

Our Universe evolution is, of course, connected with its structure complication, elementary paricle, atoms, and molecules creation. The more and more heavy chemical elements appeared consequently. A very intersting description of cosmogenesis one can find in a numerous literature (see, for example, the famous bestseller **[Weinberg, 1976]**). But now another thing is important for us. *Why* did it occur what is did? Precisely saying, could it occur something another including some kind of chaos, with minimal ordering (even far from the equilibrium state)?

This question is not so senseless as one may think. It turns out that many nature laws and our Universe features seem to be *fitted* excluisively fine in order the lattest were

just such as it is. “The observed values of the dimensionless constants such as the fine-structure governing the four fundamental interactions are balanced as if fine-tuned to permit the formation of commonly found matter and subsequently the emergence of life. A slight increase in the strong nuclear force would bind the dineutron and the diproton, and nuclear fusion would have converted all hydrogen in the early universe to helium. Water, as well as sufficiently long-lived stable stars, both essential for the emergence of life as we know it, would not exist. More generally, small changes in the relative strengths of the four fundamental interactions can greatly affect the universe's age, structure, and capacity for life.” (see **[Wikipedia])** There exist also many other similar facts.

This problem is investigated since 20th century, the attempt to its solution was named “Antropic principle”. One of its formulations states that there exists a set of universes (a multiverse), but only in such universe as our one there are observers who can observe it.

As I believe, this explanation is not satisfactory. In fact, we have to consider a more fundamental things than even such the “fine tunning”. For example, let us calculate a probability for some amount of elementary particles to be aggregated into *absolutely identical* atomes and molecules. If we were depart from the Second Law of Thermodynamics only, then this probability were negligible. The more, before the atoms appeared in the early Universe, why had we to believe that the same chemical substances will be consequently born in the very distant Universe regions and occupy the cells of the periodic table (yet not “existing”)? Only now we know the remarkable laws of Quantum Mechanics that determine such the facts. Hence, the nature’s laws provide also several positive feedbacs that *select* some stable structures and forbid another ones, not only negative feedbacs.

So, what happens? Our open system (Universe) regularly gets the energy from outside. Due to this the energy gradients in the system constantly increase, and the resources of energy are accumulated (for example, in the stars and galaxy cores)[1]. During this process “the representation point” in phase space moves away from an initial position. This way contains some “special” points and domains where a non-trival *selection rules* act. These rules action sharply changes “prior probabilities” that could be found without corresponding rules knowing.

The Earth evolution

In the proposed model our Universe is thermodynamically *open* system, a transit energy flow “blows” on it. The very similar model is held for the system of lower level: the Sun energy (the visible light photons having small entropy) comes onto Earth and then reemits into Space in the form of infrared thermal photons having large entropy. Beside the Sun surface temperature attempts 6000 degrees Celsius, while the Space temperature is near to zero. Because of that a giant *negative* entropy flow passes trough Earth, see **[Penrose, 1989]**. So, the Sun is very powerful source of “negaentropy” (and structural information[2]) for us.

[1] The system internal energy change is formed by two components. The first one is the *heat change*, and the second one is the *work change*. The first component corresponds with disordered (chaotic) energy of an individual freedom degrees while the second one corresponds to their *correlated* energy. The famous author of **[Brillouin, 1961]** wrote that *a system which is able to produce a mechanical work (or a work due to electrical forces existence) has to be considered as a negaentropy source. A spiral spring, a lifted weight, and a charged battery can be considered as such the system.*

[2] As I found, the total capacity of the informational channel from Sun to Earth is near 10^{26} bit/s. This corresponds to (more than) 10^{7} J/s, or 10^{26} eV/s (note, the total Sun radiation power is 20 orders larger).

Note, a large supply of the potential energy and highly ordered matter is accumulated on Earth (for example, oil, etc.). Of course, this model is true in general for any system “star – planet”.

The same progressive evolution schema (like Universe evolution) works again. It led to the Life creation on Earth (as we know, the photosynthesis is its important condition). Schrodinger **[Schrodinger, 1955]** stated that the negative entropy inflow into a living organism is *required* for it life. The regular energy recharge is transformed to the useful work increment (and partially to the unused heat) that services the organism and supports its state far from the equilibrium. But this is a *possibility* only! However, what about of the *sufficience* condition?

It is well known that some trivial calculations give an insignificant “prior” life appearance probability. For example, in the **[Koonin, 2012]** such the probability is estimated as 10^{-1018}. The famous evolutionist Eugene V. Koonin says that the Antropic Principle and the infinite Multiverse’s concept could explain this. However, I propose another approach: for the life appearance we need practically the same thing that for the periodic table realization. A special *selection rules* together with a regular energy and negaentropy inflow should exist that *interdict* a numerous amount of meaningless combinations. Contrary, these rules *select* the combinations that really exist.

Practically, this idea is not a new one. It is consistent with the important concept of the modern biology which was stated by Berg, Meyen, Lubitshev, Vavilov, and other famous scientists. We do not yet know these rules, however, there exist many indirect proofs in biology (for example, the Vavilov’s homologous series law is similar to the Mendeleev’s periodic table).

The social system evolution

We still do not how Life was appeared on Earth and what namely living (pre)organisms were the first ones. The new types of communities emerge on the several stages of the terrestrial life, and the same general laws act: the regular flow of the negative entropy and new non-linear rules of phase states selection. In fact, Sun continues to send the photons to Earth; the food chains become longer and more complicated, and at each new development level a new ordered communities appear (from cellular colonies up to UN) in which an individual existence turns out to be less preferable than collective one due to the functions differentiation, for example – the specialization of labor between people.

We know the human community evolution history quite better than the terrestrial life history. Finally, complicate communitн of human communities emergeы, not only simplest communities. The links and communications between people and communities develop non-linearly that assures the input resource (energy) use efficiency and depth rise. The structure and evolution dynamics of communities become more and more complicate. During its development the humanity acquires knowledge (as we can see, its *informational resource increases exponentially*) and by such the way controls the more power energy sources. It seems that a next stage is inevitable: we will leave Earth and new cosmic civilizations will appear.

On Nature’s Laws

As we saw, the evolution processes are connected with the nature laws existence, which are investigated by the science. Of course, such the laws really exist (for example, Coulomb’s law or Newton’s ones). However, the question “WHAT are the nature’s law?”

seems to be rather philosophical problem that the scientific one. For example, from where does electron knows what the behavior should it demonstrate? Why all the electrons are described by the same laws? How the nature's laws are incorporated into the Universe?

On the one hand, it is clear that the nature's laws *are not material*, they are eternal and unchangeable, they have not some spatial or temporal extent (size), they do not correspond with some energy or momentum. So, do we in general can ask such the questions, taking into account that, say, physics describes a material systems only.

On the other hand, our mind may try to answer these questions. We do not state that the following is the *real* case. However, we can *consider* several models that will prompt to us how it *could* be realized in order to deduce several useful conclusions. For example, let us imagine a supercomputer executing many calculations. In such the model the data sets will be an analog of "matter", while data transformations will correspond to "processes" that consequently form the data set one from another. In our model the "Causality principle" will be held because applying the same procedure (starting the same process) B to the same data set D1 we *always* will get the same data set D2.

In the model the *philosophical* question "*Why*?" can be easily transformed to the *technical* one "*How does it work*?" The answer is simple: the processor (or processor group) of our supercomputer that represents *the meta-reality* relative to "a matter" and "processes" in the internal working space (*memory* in the *meta-reality* language) in perfect case works always by the same manner (relative to every data transformation). The processes in the *reality cannot in principle* have an influence on the processor work in *the meta-reality*. Analogously, a material structures and processes of our Universe cannot (as it seems) have an influence on the nature's laws that act in it.

Our Universe space and time features also can be deduced from the conditions given in *meta-reality*. For example, the dimension 3 of the space can be connected with the memory organization as 3D vector. The space closity can be provided using cyclic index: x[n+k]=x[k]. The elementary space structure is determined by the memory cells structure, etc.

So, the nature's laws that do not depend on spatial and temporal relations in our Universe rather can represent the *meta-reality* components and admit some model description in the corresponding frame. The more, the possibility itself to use such the *concepts* in the science (in order to material system behavior describe) points out (as I believe) onto meta-reality existence. Hence, a meta-reality simulation becomes the scientific subject, not exclusively subject of philosophical speculations.

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