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THE ACCUMULATION OF CHANGE DEPENDING ON THE TIME FACTOR

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Abstract. Each phenomenon contains variable components, which are conservative. Because of their conservation, they accumulate. Present phenomena contain constituents of phenomena, belonging to the past which form the present and the future, and their dependence on time is an exponential one – $S = S_0 e^{t-t_p}$ (S is a variable component, t_p is a moment in the past). We assume that before and after $t_0 = t - t_p = 0$ the change pertains to phenomena of one type. The dependency is for each defined phenomenon of one and the same type (for its characteristics). The concrete aspect of the change S will depend on the type of the phenomenon. We show in our study how in some cosmological phenomena, the exponential dependence on time is present. The processes of radioactive disintegration of atomic nuclei, are also phenomena of this type. We present the real phenomena as a sum of exponents. Each phenomenon originates, develops and is destroyed. In reality most phenomena are formed as a composition of exponential dependencies of the change (of its characteristics).

We start from the idea that both a constant and a variable component are present in unity in every phenomenon. In that unity change keeps itself constant, accumulating from the past into the present and the future. In this connection we shall consider what possibilities exist for the development of the phenomena.

Starting from the assumptions that constantly existing variable components are present in every phenomenon and that change is preserved in each such phenomenon we reach the conclusion that the change of each phenomenon contains that of all previous phenomena. Therefore we shall examine the changes of concrete consecutive phenomena under the condition that no other phenomena (both simultaneous, as well as non-simultaneous) exist.

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Let's assume there exists phenomenon P_n having a limited duration, containing (comprising) as one whole phenomenon, several consecutive phenomena P_1', $P'_{2'}$ ...P'_n (Fig. 1).

The change of each of these phenomena, however, keeps itself constant, it does not vanish as a qualitative and quantitative determination.

If the phenomenon P_n includes all phenomena preceding P'_n it follows that the change of P_n will comprise the component of change of each phenomenon starting from P_n i.e., it will contain its own change naturally, plus another change participating in the formation of P'_n. If we denote the change of phenomenon P_n with S_n, the change of phenomenon P_n' with S'_n, we can express the above stated thus:

$$(1)\quad S_n' = S_{n-1} + (-S_{n-1} + S_n)$$

Hence, due to this accumulation and preservation, the following equation will be valid:

$$(2)\quad S_n' = S_n$$

If we proceed from correlation (2) and presume that phenomenon P_i with a change of S_i occurs in an interval of time (o, t_i), whereas phenomenon P_i' with a change of S_i', in an interval (t_{i-1}, t_i) then for change S_i we shall have a correlation of:

$$(3)\quad S_i'(t_i - t_{i-1}) = S_i(t_i - 0)$$

This means that the change of a concrete phenomenon, existing at a definite time-interval, includes the change of the phenomena prior to it (see Fig. 1). Therefore, the correlation (3) can be laid down as:

$$(4)\quad S_n'(t_n - t_{n-1}) = S_n(t_n - 0) \quad \text{or} \quad S'(\Delta t) = S(t)$$

For $t_{n-1} \rightarrow t_n$ we shall have $\Delta t \rightarrow 0$ and $S'(\Delta t) = S'(dt)$. Hence, bearing in mind correlation (4) we can write down:

$$(5)\quad S'(dt) = S(t)$$

But the change S_n of P_n is formed by the changes of the phenomena it comprises (see Fig. 1), so we can put down:

$$(6)\quad S = S_n(t) = S_1'(t_1 - t_0) + S_2'(t_2 - t_1) + \ldots .. + S_n'(t_n - t_{n-1})$$

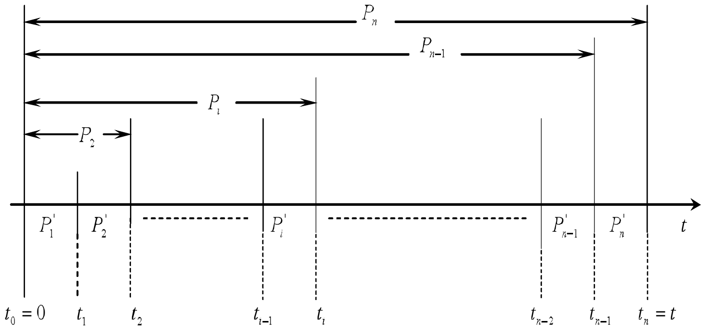

Fig.1: „The big change” of phenomenon P_n is composed of the changes of phenomena $P_1', P_2', \ldots, P_n'$, while each of them contains the change of previous phenomena.

Proceeding from correlations (3), (4) and (6) for $S_n(t)$ and $S'_n(t-t_{n-1})$ we shall obtain

$$(7)\ S'_n(t-t_{n-1}) = S(t) = \sum_{i=0}^{n} S'_i(t_i - t_{i-1}) = \sum_{i=0}^{n} S_i(t_i - 0)$$

Respectively for unspecified small intervals of time at $t_i - t_{i-1} \rightarrow 0$ and in conformity with (5) we shall have the integral formula:

$$(8)\ S'_n(dt) = S(t) = \int_{t_0}^{t_n} S'_t\, dt = \int_{t_0}^{t_n} S_t\, dt$$

So the change S'_i of phenomenon P_i' comprises the change pertaining to the preceding phenomena (that are included in one whole phenomenon – P_n).

In this case each of the phenomena $P_{1,}$ .....P_k comprises each of the preceding phenomena plus those following them, namely, phenomenon P_2' following phenomenon P_1 (respectively phenomenon P_1' as well), phenomenon P_3' following phenomenon P_2 (respectively P_2' too), and so on.

When stating that a certain phenomenon contains the change of previous phenomena contained within it, plus some other change, this includes

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the change of the infinite number of phenomena preceding it. Since this is a change, it forms a concrete phenomenon of the present, which is different (variable), in relation to the preceding phenomena. We can say that the present is formed from the past. It is an existence of all past phenomena. This is brought about by the accumulation of change expressed respectively in relations (3), (6), (7) and (8).

The ideas, and conclusions we have set forth express not only the preservation of the phenomena but, likewise, the accumulation of their constituents (components). It can be stated that time bears fruit by means of the accumulation of new phenomena. There exists not only a preservation of the components of the phenomena, but also a change – a „birth" of new phenomena by means of accumulation, in the course of time, of previously existing phenomena with their respective components.

If we regard $\int Sdt|_{t_0}$ from correlation (8) as some initial change, present in all subsequent (following t_0) phenomena, i.e., consider it as a constant value $S_0 = const(t)$, then the expression for S_t acquires the aspect:

$$S_t = \int S_t \, dt \,|_t - S_0$$

– This equation complies only with the exponential function for which

$$\frac{df}{dt} = f' = f. \quad \text{Hence: } S_t = C_0 e^t$$

For $t_0 = 0$ we obtain $C_0 = S_0$, which gives us the right to write down, for the change S_t, the expression:

$$(9)\ S = S_0 e^t$$

The concrete aspect of the change S will depend on the type of the phenomenon. The determination of S_0 will, of course, depend also on the concrete phenomenon.

It must be noted that in general the change S should by no means be connected with any concrete type of change. The deliberations, regarding the preservation and accumulation of change in phenomena, refer to all types of phenomena on a plane of utmost generality, so that they are valid for their variable components at any macro – and micro – level. The change S should not necessarily be considered as velocity, acceleration, energy and so on.

It is possible that these characteristics are present within the change, but we shall not concern ourselves with one-valued answers with regard to the concrete forms of this presence.

On the basis of the assertions expressed so far, we can consider, for instance, that, owing to the accumulating change $S = S_0e^t$ in the course of billions of years, the existing material formations have been formed – the different fields (gravitational, electro-magnetic etc), the stable (longevity) elementary particles (electrons, protons etc.) atoms, molecules, as well as macro-objects, such as planets, stars, galaxies, etc.

I. Accumulation of change from past to present phenomena

When deliberating on the change S_0 in a manner analogous to that by which we deduced a correlation (9) for the change S, and hence for the change that had existed prior to a concrete moment t_0, we can now put down $S_0 = S_pe^t$. This correlation is valid for the time preceding the moment t_0, i.e. for $t < t_0$.

If we suppose that $t_0 = 0$, then for $t < 0$ respectively we get $S_0 = S_pe^{-|t|}$, where S_p is some initial change in a past (prior to t_0) time-interval which is analogous to S_0 as relating to S . If we assume that $|t| = t$ then for the change S_0, before the zero, moment we can write down:

(10) $S_0 = S_pe^{-t}$

We consider that before and after moment t_0 the change pertains to concrete phenomena of one type. Although variable, they are all of one and the same kind. If in correlation (10) we fix a given past moment t_p, prior to t_0, where a definite type of phenomenon has existed, then substituting the change S_0 in correlation (9) we get:

(11) $S = S_pe^{t-t_p}$

It is evident that if the time t, begins to grow upward from zero, then in a large time-interval t_p the difference $t - t_p$ will be less than zero, and respectively $e^{t-t_p} < 1$. Therefore, regarding common phenomena, accessible in the duration of human observation, the time factor t will increase, but the difference $t - t_p$ will approach zero rather slowly. While this difference is negative, the values, which are connected with the change

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S, will change slowly depending on the time *t*, and they shall not increase rapidly. However, when $t - t_p$ begins to increase upwards from zero, for a short time the change *S* of the concrete phenomenon will begin to grow rapidly according to the relation (11) and, the values with which it is connected will also change rapidly. Attention should be called to the fact that t_p is a past moment at which a concrete type of phenomenon began to exist, and whose extension (of the same type) continues to exist at present, i.e., after the moment $t_0 = 0$.

When the change *S* of the phenomenon starts to increase very strongly with time, many of the characteristics in which it participates likewise vary strongly. The change at a certain moment becomes so great, and the characteristics change to such an extent, that they no longer correspond to the definite type of phenomenon, but to phenomena of another, new kind. In this way in the development of the phenomena, from a given moment onward, a qualitative leap is brought about. The evolution occurs in the following way: generation at a moment $-t_p$, further existence up to the moment $t_0 = 0$, after which the characteristics of the phenomenon (determining it as a phenomenon of this type) are greatly changed (destroyed) from this moment onward. So after the moment t_0, the change $S \sim e^t$ begins to grow abruptly and brings about the destruction of the definite phenomenon in its particular aspect. Naturally, the phenomenon does not disappear, it simply changes into a new type of phenomenon, which is born, develops and „dies" by virtue of the same regularity as the preceding one, from whose „death" it has emerged. This new phenomenon will be destroyed, in the course of time, and will give rise to another, which also will develop in an analogous way, will give birth to a new phenomenon, and so on.

It is evident, that the time of the existence of a concrete type of phenomenon (the time period during which it is born, develops and dies) depends on the value of the past moment t_p. The magnitude of this past time, by its presence in the expression $S = S_p\, e^{\,t\text{-}tp}$, actually determines the velocity of development of the phenomenon. In its content the value of the time moment t_p is related to the duration of existence of the preceding phenomenon, which after its destruction has given birth to the „new" phenomenon with a change of $S = S_p\, e^{\,t\text{-}tp}$.

From the above stated we can draw the conclusion that phenomena having a greater duration (respectively a larger interval t_p of existence), are more steady and less liable to change, since they reach the condition where $t\text{-}t_p = 0$ more slowly, from which state onward the characteristics of the

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phenomena change more rapidly. This is because the moment t_p, at which they arose, is more remotely in the past. Such stable phenomena are, for instance, the existence, over the course of billions of years, of the stable elementary particles, such as protons, electrons, photons, which will continue to exist long into the future. This longevity however does not mean eternity. A moment will come, when for a certain proton (or electron) the values in which the expression e^{t-t_p} is present, will change abruptly and the respective „stable" particle shall be destroyed. The planets, rotating around the stars, the stars themselves, the galaxies and other cosmological objects are also long-lasting, but not eternal. They arise from some kind of preceding phenomena, evolve and die by the force of the described regularity, owing to the accumulation of change over millions of years (the variable component). Certain interactions in concrete phenomena can be contained in correlations (11). As to where (in which object) and how the deduced correlations are manifested in nature, we shall not offer any concrete, one-valued interpretations. We will consider some examples of the manifestation of the change present in the concrete phenomena in compliance with the correlations mentioned. In the field of cosmological phenomena there are many examples of the birth, evolution and death of cosmic objects.

II. Change in spatial moment

If an object *B* moves in relation to another object *A*, in each „moment" (interval of time) there will exist a definite phenomenon consisting of objects *A* and *B* (unchanged, i.e. identical to those of the previous „moments") and a space (distance) between them.

The change of each phenomenon, of this type, in relation to the preceding one, can be expressed by the change of the distance between the objects and/or the change of the direction, when the straight line connecting the two objects changes, and in the concrete moment does not coincide with that of the preceding one. Hence, the space between objects *A* and *B* expressed by their straight line distance changes, and respectively, the integral change for a time interval $\Delta t = t - t_0$ is the sum of the change in each of the segments connecting object *A* to object *B*.

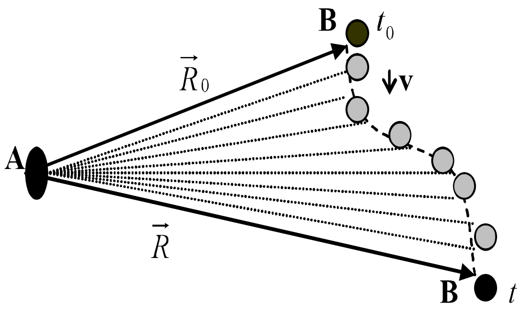

Fig. 2: The space between objects *A* and *B* changes and the integral change for a time interval t-t_0 -is the sum of the change in the segments connecting object *A* to object *B*.

So we shall investigate the change of the space in the phenomenon „movement of object *B* in relation to object *A*". Let us assume that the velocity of object *B* in relation to object *A* at a certain „moment" has the value $|V|$. As stated, we shall deal with the change of the distance in a straight line (in magnitude and direction) between object *A* and *B* at a concrete „moment" (interval of time) in relation to the same distance in the preceding moments. Therefore, if we study the variable phenomenon for a fixed time interval, the change for that interval will be the sum of the changes in each „moment" (see Fig. 2). This summary alteration (change) can be expressed by means of a certain area, which can be expressed by the integral:

(12) $\int_{t_0}^{t} R.Vdt$, where $R.Vdt$ is the summary change of the space at a concrete „moment" (arbitrarily small time interval)

On the other hand, we arrived at the conclusion that the change *S* pertaining to a given phenomenon, existing at a fixed „moment" (time interval) contains the change of the phenomena existing in the preceding „moments" (intervals of time). In conformity with this, proceeding from correlations (9) and (12), regarding the change *S* of the phenomenon at a concrete „moment", we can put down:

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(13) $S = S_0 e^t = \int_{t_0}^{t} R.V dt$, where $R = |\vec{R}|$ and $V = |\vec{V}|$

In this case *S* constitutes the change of the phenomenon (phenomena) that had existed till the moment *t*. This is the change of the entire phenomenon, consisting of consecutive variable phenomena, where the position of the two objects varies, i.e. they „disappear" from one place and „appear" in another, as the space around them changes.

Correlation (13) is an integral equation whose solution is:

(14) $R \cdot V = S_0 e^t \Rightarrow V = \frac{S_0 e^t}{R}$

That gives to us the speed value of object B towards object A in dependence on the time and distance R between the two objects.

Respectively the value of acceleration of object B to object A will be in the following dependence of distance and time:

(15) $a = \dot{V} = \frac{S_0 e^t}{R}\left(1 - \frac{S_0 e^t}{R}\right)$,
respectively for $t = t - t_p$ $a = \frac{S_0 e^{t-t_p}}{R} - \frac{S_0^2 e^{2(t-t_p)}}{R^2}$

This means that when $t << t_p$ for a great time period is valid $e^{t-t_p} << 1$ (and $e^{t-t_p} \approx const$), and respectively $a \sim \frac{1}{R^2}$.

We investigated the change of three objects: *A*, *B* and space. The result obtained should not necessarily be connected with a concrete type of object – macro-bodies or micro-particles interacting in a gravitational, electromagnetic or nuclear mode.

III. Accumulation and development in cosmologic phenomena

The object of our study is to show how in some cosmological phenomena, an exponential dependence of the accumulating change in relation to time is present. Proceeding from the equations of Einstein, H. Bondi and T.

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Gold (Weinberg 1972, p. 491), who propose the stationary cosmological model, according to which the cosmological scale factor $R(t)$ changes with the time according to a law $\frac{\dot{R}}{R} = H$, where H is the constant of Hubble.

Hence, $R(t) = R(t_0)\ e^{H(t-t_0)}$.

For the change in the volume of the expanding (contracting) universe in the course of time is obtained the dependence (Ibid., 497):

$$V(t) = \frac{4p}{H^3} \cdot \left[H(t - t_0) + 2e^{H(t-t_0)} - \frac{1}{2} e^{2H(t-t_0)} - \frac{3}{2} \right].$$

It is evident that the change in certain characteristics of this grandiose cosmological phenomenon is exponentially dependent on time. This shows that the change in some components of the phenomenon itself is subordinate to the deduced correlation (11), expressing its accumulation in the course of time.

The idea of the expanding Universe (a model of a non-stationary Metagalaxy), by means of which the red shift is explained, presupposes that the velocity of movement apart between the galaxies depends on the distance r between them, according to the law: (Пикельнер, 1976, p. 118).

$$V = \frac{dr}{dt} = H.r\ .$$

It is valid for the change of distance between each of two galaxy systems. If the constant H of Hubble is independent of the time, the distance r will change according to the law:

$$r = r_0 e^{Ht}$$

Hence the velocity will depend on time according to the exponential law $V = \dot{r} = r_0 e^{Ht}$. So, the change and all its characteristics (velocity, acceleration, energy) present in this phenomenon will be subjected to the exponential law for accumulation (9).

The cosmological models, comprising a phenomena forming the evolution of the Universe confirm the dependencies (9) and (11) of the change with relation to time. Such a model is that of W. de Sitter (Lang 1974, p. 317). According to it the radius R of the space curvature of the Universe changes in time by the exponential law, ensuing from the correlation $\frac{\dot{R}}{R} = H$, where H is the constant of Hubble. For this change of the radius we get $R = e^{Ht}$, respectively for the velocity $\dot{R} = \frac{dR}{dt}$ $\dot{R} = \frac{dR}{dt}$ we get

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$\dot{R} = e^{Ht}$, which is consistent with the deduced correlation that $S = S_0 e^{t-t_p}$, because $H \sim 10^{-10}$ years and this respectively requires a large time interval for the evolution of the phenomenon. For the variation of radius R of the space curvature of the Universe this time interval should be of the sequence H^{-1}, i.e. of a sequence of 10^{+10} years.

There exist other phenomena, confirming the exponential dependence of their change on the time factor. In the case of gravitational collapse, for instance, the following dependence of the change of the density of matter r on time is presupposed: $\frac{\Delta r}{r} = Ce^{st/l}$, where C, S and | are values independent of time.

The initial process of gravitational collapse flows in such a way that when coming close to the center of a star, the speed of the matter quickly increases, tending towards the speed of light. The radiation of the collapsing star, in correspondence with definite conclusions of the General Theory of Relativity, is realized according to the law $I = I_0 \cdot e^{-\frac{1}{t_0} \cdot t}$. Thus, in the final stage of the evolution of the star an exponential dependence becomes obvious – a fact showing that, deep in itself, the phenomenon contains a variable component (respectively characteristics), which is changing in accordance with an exponential law of the type $S \sim e^{t}$. The phenomena, in which this dependence is present in a more pure form, comprise a relatively small time interval wherein the processes are vigorous. These phenomena include only a part of the development of a cosmological object.

The adduced examples are from cosmological phenomena, in order to show the validity of our conclusions regarding the change of phenomena. In a small part of the phenomena, however, these inferences (correlations) are present in an evident aspect. The rapid change of a given phenomenon presupposes a swift change of its corresponding variation, leading to the more tangible comprehension of its exponential dependence on time. Phenomena of this type are, for instance, the processes of radioactive disintegration of atomic nuclei. In this process the number of non-disintegrated atoms at a concrete moment is $N^{t} = N_0 e^{-1\,t}$ (Born 1969, p. 47). Hence, the relation of the number of disintegrated atoms to that of the non-disintegrated nuclei, expressing a variation of the phenomenon, will be dependant on time by the exponential law $\frac{N_0 - N_t}{N_t} = e^{tl} - 1$.

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IV. The real phenomena as a sum of exponents

It should be noted that there exist a number of natural phenomena, in which the exponential dependence of the change (certain characteristics of it) on time is visibly lacking, as it is different than deduced correlations (9) and (11). The reason for this non-conformity lies in the fact that we do not account for all objects or processes with the respective characteristics (at a macro- and micro-level) of the change related to them. We do not account for all phenomena of the past and present with the change belonging to them. It would be extremely difficult to take all this into consideration, because the world is infinite, both in macro- and micro-level space, as well as in time.

The dependence of the accumulating change on time, for a definite phenomenon (respectively for its characteristics) in its pure, exponential form is rarely encountered, since most phenomena are not one-valued, i.e. they are not the result of accumulated change only of one and the same type of phenomenon. In most cases, when a certain phenomenon originates (from another phenomenon preceding it), it is influenced by other phenomena as well.

These phenomena, existing simultaneously with the given one are of a qualitatively different type and respectively have other elements and characteristics. So to the variable component of the existing phenomenon is added their change as well. In this way, a concrete phenomenon, existing at a certain moment (interval) is formed from several types of phenomena (with definite constant and variable components and their respective characteristics), each one of which has begun its existence at a different preceding moment.

For each phenomenon (if it is in its pure form) the dependence of the change of any of its components (characteristics) on time according to relation (11) is considered to be an exponential function of the type:

$$S_i = S_p^i e^{t-t_p^i}$$

If there are several such phenomena, each with its own changes and respective characteristics, that have begun their existence and accumulation at different moments of time $t_p^1, t_p^2, \ldots, t_p^i \ldots$, i.e. then, for their changes, the correlations $S_1 = S_p^1 e^{t-t_p^1}, S_2 = S_p^2 e^{t-t_p^2}, \ldots, S_i = S_p^i e^{t-t_p^i}$ are valid. Then the phenomenon formed when adding up these changes will have a change

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(with the respective characteristics), depending on time as a function of the type:

(16) $$S = \sum_i S_p^i e^{t - t_p^i}$$

This summary change is a component in the newly formed real phenomenon and respectively, the dependence on time is present in its characteristics and in the laws pertaining to them as well. That is why the exponential dependence on time is seldom encountered in its pure form within the characteristics of the different types of phenomena in nature and society. The sum of the exponents gives a function of different kind, its concrete type depending on the number of the summary „purely exponential" phenomena, on the „initial" moments t_p^i, and on the initial change S_0^i as well.

Within phenomena displaying a purely exponential dependence of the change, its accumulation and development, on time, this leads to a strong increase after a certain moment, and respectively to the destruction of the phenomenon of this type (Fig. 3).

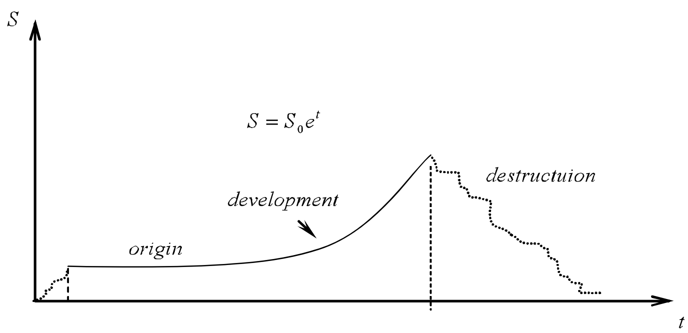

Fig. 3: The phenomenon which has an exponential dependence of the change originates, develops and is destroyed in certain „moment" (time-interval)

Each phenomenon originates, develops and is being destroyed. In reality however most phenomena are formed as a composition of exponentially dependent changes of phenomena. A rapid destruction of the phenomena does not occur, in nature and society, because besides the destruction there is a constant origination in different moments of qualitatively new phenomena. Since in correspondence with (16) the sum of exponents is not an exponent, in reality the phenomenon is not destroyed according to an exponential law in its pure form (Fig. 4). In this way its stability and its variability is built upon the instability of its constituent one-valued phenomena. This lies at the basis of the dialectical continuity between successive phenomena (the presence of a part of past phenomena in the present) and respectively of their development in a future.

As an illustration of the above, we can point out the solution of concrete differential equations, describing different dependencies between the characteristics of many physical phenomena. Under certain conditions they have solutions containing a sum of exponents.

For instance, the equations of the *n*-th order, of the type
$Y^{(n)} + P_1(t)\, Y^{(n-1)} + \ldots + P_n(t)Y = R(t)$ contain solutions of the type:
$Y = C_1 e^{r_1 t} + C_2 e^{r_2 t} + \ldots + C_n e^{r_n t}$

$$Y = e^{\alpha_1 t}(C_1 \cos \beta_1 t + C_2 \sin \beta_1 t) + e^{\alpha_2 t}(C_3 \cos \beta_2 t + C_4 \sin \beta_2 t) + \ldots$$
$$\ldots + e^{\alpha_n t}(C_{n-1} \cos \beta_{n-1} t + C_n \cos \beta_n t)$$

This equation (respectively the solutions comprised in it), describe dependencies in many phenomena, having repeating processes, connected with oscillations of different objects (respectively of their characteristics).

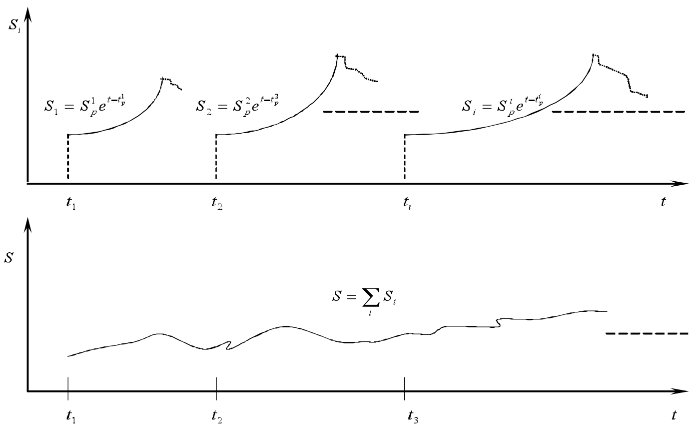

Fig. 4: The phenomenon, constituted as a sum of one-valued phenomena will have a summary change, consisting of the changes of those same

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phenomena. The kind of this change is obtained by the summing up of the exponents of their changes.

However, if the magnitude of the change in one of the summary phenomena is greater than that in the others then it is possible to „observe" in a comparatively pure form the origination, evolution and destruction of a given phenomenon. From the examples given above, such phenomena are nuclear disintegration and some cosmologic phenomena.

In society, the processes of generation, development and destruction of political, economic and ideological structures and systems, are also observed. Each nation, for instance, has a period of upsurge, summit of development, and then of decline.

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