On the Way to Understanding the Time Phenomenon: the Constructions of Time in Natural Science. Part 1. Interdisciplinary Time Studies. Singapore, New Jersey, London, Hong Kong: World Scientific. 1995. Pp. 193-201.
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TIME STRUCTURE OF THE WORLD

V. M. Sarychev

Time is most closely linked to changes. In describing processes, developing on small time intervals, in the differential equation language, changes are set proportional to time (linear approximation). This makes it possible to reverse the relation and set time proportional to changes. Then, time acts as an equivalent of any changes just like money acts as an equivalent of any commodity. Hence, a Leibniz statement (1956) that time without commodities is a purely ideal possibility is the case in point. In the classical physics paradigm, involving the Newtonian concept of time, the variability and constancy are necessarily absolutized. The permanent entities - material points, etc. - are by themselves extra time, and the variations are reduced to purely quantitative (motion in space).

However the world, as we know it beyond the classical physics paradigm, is both variable and static or stable, manifold and unique, amorphous and manifesting itself in qualitatively distinct forms. (Suffice it to recall the Earth, biosphere, organism species, social forms, human being, languages, etc.). This means that the world is too complex to allow a unique, unambiguous logically consistent description. It would also be appropriate here to cite the dualism of particle-wave, Bohr's relativity principle. But the macrocosm is as complex as microcosm.

Is it possible to describe such a diverse world without giving up the unambiguity and logical consistency of description? We believe the description to be feasible, and will state our approach to the solution of this problem.

The fundamental idea of this approach boils down to splitting the reality into maximal finite homogeneous domains enabling an unambiguous, logically consistent description of this reality, different in different domains. To put it another way, instead of an integral picture of the world, we will have to do with a variety of different pictures. This is the price for having an unambiguous, logically consistent description of reality. The traditional Newtonian time and space would not do here. To make up for it, the fragmentation is possible in "spaces" of durations and extensions. Here, we shall focus on duration "spaces" only. As for the extension "spaces" and relationships thereof, we shall deal with them in later publications.

It follows from the aforesaid that the solution of the mentioned problem would place demand on a paradigm differing from the Newtonian concept of time, hence, from that of classical physics. (Naturally, the case in point is the development of a paradigm complementary to the classical physics paradigm, not replacing it.)

Time is associated not only with variability, but also with the being of qualitatively distinct forms of reality. We are interested in plastic evolving and reproducible forms. Unlike an abstract material point, any of such forms may not exist in a nonlasting point in time (e.g., see Whitehead (1969), Florensky (1988)). Its formation, evolution and manifestation of all its properties require a quite definite finite time. What is more, it would be wrong to speak about the existence of such form unless it is stable, reproducible in one and the same form over a considerably longer, than mentioned, time. Beyond some distinctly finite time this form is no longer reproducible in the same form, and comes to be variable (variability for the sake of preservation). Thus, the existence of any qualitatively distinct and stable form of being is limited to a finite range of time quantities - durations. It is worth noting that the point is not about the existence of the system over a running time interval - such form may exist for an extremely long time (the Earth, life on it) - but about the existence in a qualitatively distinct form that can be described in an unambiguous and logically consistent manner in terms of the frameworks of the range of durations not associated with any points in running time. The qualitative definiteness of the form in this range of durations may remain intact extremely long in the running time, but precisely as a qualitative definiteness rather than a specific form described with certain characteristic values.

Thus, it is the durations scale that will be treated as a time "space" in which reality decomposes into domains of unambiguous logically consistent description of its being, its behavior. To avoid confusion, we shall refer to this time as L-time, after Leibniz, in contrast to Newtonian N-time.

It is the range of durations, rather than duration, that will act as a variable here. In contrast to N-time, which is an independent variable, the range of durations is a variable selected by the researcher. It is noteworthy that the choice either provides or denies an opportunity for an unambiguous logically consistent description of reality. The problem is to set, proceeding from concrete reality studies, such finite durations that would allow a confident selection of the correct range of durations.

As for the Newtonian N-time, it is imitated by the running of the clock. As applied to L-time, the identification of duration ranges is possible with recorders. (We view these instruments just as abstract methodological tools.) Characteristics of such instruments are: (a) temporal inertia - duration against which the sliding average of the measured reality characteristic is defined, and (b) duration of observation, equal to the ratio of the length of tape, on which the instrument registers temporal development of the characteristic, to the speed of its motion. The time of instrument inertia is referred to as an atomic duration of observation, d, and the maximum length of observation as time horizon, D.

The atomic duration and the time horizon of observation determine the range of durations $(\mathrm{d};\mathrm{D})$ within which the reality behavior is observed. They act as filters relative to small- and large-scale changes in the reality characteristics. The boundaries d and D of the instrumentally identified range of durations are to some extent controllable, but finite in principle.

Apart from the aforementioned time characteristics of recorders, there is a need for yet another one, notably, threshold of response or measurement accuracy. The threshold or accuracy is controllable within certain limits but, in principle, are also finite. Thus, the recorders quantify the characteristic modifications and time as well as place an upper limit on the time value.

In the classical physics paradigm, serving as a reality description unit is a state or characteristic values in some point in time, having no duration. The approach we are dealing with uses as a unit of reality description a qualitatively definite form of its behavior over a range of durations. The simplest and most fundamental forms of such behavior are the constancy and variability of the reality characteristics.

Given a certain threshold of response or accuracy of measurement and time horizon of observation D, the alteration in reality characteristic X_j will either be fixed or not by the recorder. By reducing, in the former case, and increasing, in the latter case, the value of D one may find a boundary duration A_j such that the selection of $D < A_j$ yields constant X_j, and the selection of the atomic duration of observation $d = A_j$ yields variable X_j. Thus, for each X_j there is a finite duration A_j which separates the domains of its constancy and variability as qualitatively distinct forms of behavior.

A set of finite durations A_j for all characteristics $\{X_j\}$ can be ordered with respect to their values such that $A^{(i)} < A^{(i+1)}$ where i represents the level. Each duration $A^{(i)}$ can be put in correspondence with a subset of characteristics $\{X_l^{(i)}\}$ for which it is boundary. Thereby, we shall classify the characteristics with respect to their inertia.

In selecting $D < A^{(i)}$, characteristics $X_l^{(i)}$ are constant, and in selecting $d = A^{(i)}$ - variable. In selecting $d < A^{(i)} < D$, characteristics $X_l^{(i)}$ cannot be unambiguously defined as either constant or variable.

Consider now the joint behavior of characteristics of two levels of inertia: $X_k^{(i-1)}$ and $X_l^{(i-1)}$.

Upon choosing $D < A^{(i-1)}$, all characteristics $X_k^{(i-1)}$ and $X_l^{(i-1)}$ are constant. Upon choosing $d = A^{(i-1)}$ and $D < A^{(i)}$, characteristics $X_k^{(i-1)}$ are variable whereas $X_l^{(i-1)}$ - constant. If $d = A^{(i)}$ is chosen then $X_l^{(i)}$ are variable, and $X_k^{(i-1)}$ will be the mean with respect to durability $A^{(i)}$. Such mean values cannot, generally speaking, act as characteristics of reality for they are nonrepresentational, not governed by laws and do not follow them, cannot be meaningfully interpreted. And only in case the mean values are stable (constant) over a certain range of durations can they act as new characteristics of reality. Such stability is feasible in at least two cases.

First, the constancy of mean values may result from the process regularity on the average over some range of durations. Referred to as regular on the average is a process whose characteristic values over some duration $R^{(i)}$ are then reproduced over some appreciably longer duration. In particular, such properties are characteristic of regular cyclic processes.

Since all processes in a system are interrelated, it would be natural to assume that the process may retain its regularity for as long as characteristics $X_l^{(i)}$ of the next inertia level, i.e. within duration $A^{(i)}$, are constant.

The description of the process as regular (on the average) is possible for $d = R^{(i)}$ and $D \le A^{(i)}$. And, characteristics $X_k^{(i-1)}$ in detail describing the process, are replaced with new ones $X_k^{(i)}$, produced by sliding averaging of $A^{(i)}$ of the same duration. Then, all characteristics $X_k^{(i)}$ and $X_l^{(i)}$ are constant for $d = R^{(i)}$ and $D \le A^{(i)}$, and variable for $d = A^{(i)}$.

Let us now turn to the second case with possibly stable mean values of the characteristics. A dynamic description of system reality is limited due to the impossibility of accounting for the impact of a number of factors on the processes, as well as due to the instability of many processes. This results in a finite reality "memory" of its preceding states. Also, the dynamic description poorly fits the specific oscillatory (though not strictly periodic) processes running over extremely extended time intervals, and exhibiting relatively limited amplitudes of characteristic variation. This is precisely how processes run in long-living, highly organized systems.

Let $E^{(i-1)}$ be maximum duration rendering a dynamic description of reality behavior. Over more extended durations, the process of characteristic alteration may be considered stochastic. With statistical description of reality, time intervals can be treated as elements of a collection, and the characteristic values, matching up these time intervals, as attributes against which the elements are classified. The collection may be termed statistical only in case it is representative and qualitatively homogeneous. The qualitative homogeneity of a collection is achieved by limiting the time horizon to a duration on which the conditions, the process is running in, can be viewed as constant. In the considered case this holds $d \le A^{(i)}$ for. As for the collection representativeness, it must be achieved on a duration shorter than $A^{(i)}$. Denote this duration as $B^{(i)}$.

The statistical description of reality behavior is possible but only for $d = B^{(i)}$ and $D \le A^{(i)}$. Acting as characteristics in this case are $X_k^{(i)}$ - mean $X_k^{(i-1)}$ with respect to $B^{(i)}$, which results from the possibility of statistical description of reality over this range.

As was stated above, characteristics $X_l^{(i)}$ over this range of durations are also constant. For $D \le A^{(i)}$, both $X_k^{(i)}$ and $X_l^{(i)}$ become variable.

As for the system behavior for $E^{(i)} < D < B^{(i)}$, it cannot be defined as either dynamic or statistical. This is a chaos domain.

The form of $X_k^{(i)}$ and $X_l^{(i)}$ behavior is indistinguishable both over the ranges $\left(R^{(i)}; A^{(i)}\right)$ or $\left(B^{(i)}; A^{(i)}\right)$ and $\left(A^{(i)}; R^{(i+1)}\right)$ or $\left(A^{(i)}; E^{(i)}\right)$. As a result, the rapidly altering characteristics $X_k^{(i)}$ instantly follow the values of slowly varying characteristics $X_l^{(i)}$. Therefore, the relationship of fast and slow characteristics lends itself to description with algebraic equations containing no time. And the slow characteristic variations are described with differential equations containing time as an independent variable. When $X_l^{(i)}$ are constant, $X_k^{(i)}$ are constant too. But this constancy is continuously reproducible. And $X_1^{(i)}$ act as a stabilizing factor.

A survey of the joint behavior of characteristics of two levels of inertia is sufficient for defining the general behavior of characteristics of all levels over the range of durations of a random level of inertia i.

Over the range of durations $\left(R^{(i)};A^{(i)}\right)$ or $\left(B^{(i)};A^{(i)}\right)$ all characteristics with levels of inertia lower than i are replaced with $R^{(i)}$ or $B^{(i)}$ which are mean with respect to duration. They follow the values of the i-th level characteristics with no delay. Since the latter are constant over these ranges, all fast characteristics will also be constant.

Over the range of durations $\left(A^{(i)};R^{(i)}\right)$ or $\left(A^{(i)};E^{(i)}\right)$, characteristics of the i-th level of inertia become variable, and those of lower levels of inertia, mean with respect to duration $A^{(i)}$ constantly follow their alterations.

The reality behavior over the range $\left(R^{(i)};A^{(i)}\right)$ or $\left(B^{(i)};A^{(i)}\right)$ where all characteristics are constant, can be interpreted as the state of reality. We shall refer to these ranges of durations as S-ranges. As follows from the aforesaid, the state of reality is determined by two groups of characteristics: slow, inertial and fast, instantly following values of the former. Note that the second group of characteristics continuously reproduces this state. Duration $B^{(i)}$ can be interpreted as time of fast characteristics relaxation to the values of slow ones. The ratio of durations $A^{(i)} / R^{(i)}$ or $A^{(i)} / B^{(i)}$ can be considered a measure of stability of the i-th level of state.

The reality behavior over the ranges $\left(A^{(i)};R^{(i+1)}\right)$ or $\left(A^{(i)};E^{(i)}\right)$ where all characteristics up to the i-th level inclusive are variable, can be interpreted as a process. We shall refer to these ranges of durations as P-ranges. The ratio of durations $E^{(i)} / A^{(i)}$ can be treated as a measure of horizon "memory" of reality of its initial states. The ratio of durations $R^{(i)} / A^{(i)}$ can be treated as a value of a regular process development period.

On the scale of durations, S-ranges and P-ranges cyclically repeat from level to level. (We correlate the level of inertia with the range of durations between the lower bounds of the nearest S-ranges.) It should be noted that P-ranges and S-ranges either immediately follow one another, as in the case of regular processes, or separated by chaos ranges (C-ranges), given stochastic processes.

The state, the process and chaos act as fundamentally different forms of reality being, form of its representation, description. The state describes reality as common, whole, stable whereas the process - as manifold, variable.

The state is based on either statistical stability of the mean or a process, regular on the average. It is indistinguishable under any intermediate duration (the whole is equivalent to any of its part). The characteristics of state can, therefore, be averaged with respect to both minimal and maximal durations of S-range.

The process is a sequence of states. In this paper, the states are linked to finite durations. Also, in passing from state to state the characteristics vary over a finite value.

Thus, quantified are not only time, but also characteristic alterations. Duration $A^{(i)}$ acts as time required for manifestation of such finite variations in characteristics. This makes it possible to view the variations in characteristics, following the passage from state to state, not only as purely quantitative but also as qualitative.

Reality is simultaneously present in as many diverse states and involved in as many concurrently running diverse processes as many levels of inertia are available in it. The states and processes of one and neighbouring levels are closely connected with one another. The state can be interpreted as a process of uninterrupted formation, reproduction, in terms of behavior of fast characteristics, or as a latent process of variation of slow characteristics.

The state can be treated as a moment of process. It would be as correct to speak about any process resolution (directly or via an intermediate form of chaos) into a state of the other level, about the state constitution by a set of process moments.

In passing from one range of durations to the other, the forms of state and process go over into to another one. But within individual ranges they are distinctly separated. This is possible due to the quantification of durations and limitation of their maximum values within each range.

It is clear from the aforesaid that the structural element of reality, as applied to this approach, is the range of durations within which it can be described in an unambiguous, logically consistent manner. Serving as a frame of the entire structure are the boundaries of these ranges - a set of finite durations $\{U_n\}$.

Hencefore, we have broken down reality into domains allowing its unambiguous logically consistent description. Now we have to somehow match the decomposition with the conventionally identified systems. Accordingly, questions arise concerning the systems' boundaries, their structure, and hierarchies.

The reality decomposition into some fragments or systems must be carried out along the boundaries separating domains with different sets of finite durations U_n. Upon passing over the boundary, some U_n may vary while others stay intact.

It should be kept in mind that all layers of reality described by less inertial characteristics, involved in faster processes, are included in the layers described by more inertial characteristics involved in slower processes. The former are described by the appropriately averaged characteristics varying considerably slower than not averaged ones.

Yet another method of reality fragmentation is possible along the boundaries separating domains with different sets of characteristics within one and the same ranges of durations. Both fragmentation techniques produce a complex organization of reality.

In identifying any system, it is necessary to fix the minimal and maximal finite durations bounding it. Designate them as h and H, respectively. Clearly, H cannot exceed the system's age. As long as the system exists, it is "doomed" to evolution, to building up ever new layers and levels as its age increases. The choice if h and H are random to an extent, and in each case it must be done with regard to the system genesis, relationship of layers as well as the problems facing the researcher. If h and H fail to be fixed the system comes to be indefinite, which may result in confusion.

We may now turn to analyzing the newly introduced concept of L-time. We were unable to do that earlier because unlike the Newtonian N-time, irrelative to the world, L-time is an inherent characteristic of the world. It can, therefore, be studied only along with the respective ontology.

First, consider the scale of durations. It is as inhomogeneous as the reality that is characterized by L-time. The inhomogeneous scale of durations can be fragmented into homogeneous differing ranges of durations. Each of the ranges matches a possibly widest domain in which reality can be described unambiguously and in a logically consistent manner. Each range corresponds to one of the three qualitatively definite forms of reality behavior steadily following one another when moving from range to range. Matching these three forms of reality behavior are three different forms of L-time. Designate the forms by the same letters S, P, and C as the respective ranges of durations.

S-form of time is characteristic of S-ranges of durations, the respective states of reality. This is a common, homogeneous, immobile, continuously reproducible time.

P-form of time is characteristic of P-ranges, the respective processes. This is a manifold, homogeneous, mobile time. The time unit of measurement is duration $A^{(i)}$ - time required for the manifestation of alterations in the characteristics of reality of this level of inertia. $A^{(i)}$ can be interpreted as a time step. The value opposite to the time step - $1 / A^{(i)}$ - can be interpreted as time velocity of the given level of processes. The number of steps that can be counted on this level equals $E^{(i)} / A^{(i)}$. This is the measure of depth of reality "memory" of its initial states. It is important to note that the depth of "memory" is finite. The point, in effect, is about the finite duration of homogeneity of conditions in which the process develops.

As the duration extends beyond $E^{(i)}$, the homogeneity of these conditions is no longer there (C-form of time). Instead, a new statistical - homogeneity starts forming on durations close to $B^{(i)}$. This paves the way for the passage to new unified (units). This gives hope for an approach to solving the Rashevsky (1973) problem of escaping the natural series alternativeness.

In case of regular processes, the passage to new unified (units) is exercised without the reality losing "memory" of its initial state and no transition to C-form of time, i.e. timelessness occurs. The number of steps to such transition equals $R^{(i)} / A^{(i)}$.

Time in S-ranges of duration can be treated as a collection of simultaneous "now" of a system of different scales, different levels. A train of finite time elements in P-ranges of durations of all levels can be interpreted analogously. Embedded in each static moment "now" of any S-range are all the moments of the past time of P-range of a lower level (naturally, within the bounds of finite "memory"). However, they are not represented there individually but rather as some whole. Thus, the system remembers all of its past but not in detail. In passing from level to level, the system "forgets", in a stepwise manner, the details of its behavior in the past, its history. We may also say that the system "recalls its future", i.e. what of the past must repeat. "Memory of the future" is less concrete the larger the forecast horizon is.

The behavior of the system as a whole is either an invariable, static state, if its age falls in S-range of durations, or a dynamic historical process, if it falls in P-range, or chaotic, unpredictable if the system age falls in C-range of durations. A nonpredetermined historical evolution of a system may occur in periods when its age falls in P-ranges. The older the system, the more rarely it occurs, and the more stagnant it becomes on lower levels.

The system decomposition down to entities of lower levels of organization may result either in their "rejuvenation", provision of opportunities for their nonpredetermined evolution or to decay thereof.

The number of levels packed into a range of durations $(h;H)$, bounding the system, is a measure of its organization. Addition of new levels is, ordinarily, associated with the increasing lifetime of the system, i.e. extension of range $(h;H)$. The disappearance of any level within $(h;H)$ must, generally speaking, result in system's degradation and subsequent decay. This poses the greatest man-made hazard to environment.

Differential equations describe processes developing at a single level of inertia. The characteristics of slower processes are considered constant while those of faster processes can, in principle, be derived from the respective algebraic equations of state. Accordingly, the Newtonian N-time model can be used only on each P-level separately, but not on all, or even two, at a time.

The laws of nature are formulated in the differential equations language making use of the Newtonian model of time. Naturally, their formulation is similar at all levels of inertia. But each level will have its own time, for there will be intrinsic ultimately small and ultimately large quantities of time on each level allowing the description of reality in an unambiguous and logically consistent manner. The possibility of an infinite fragmentation and infinite growth of time is a little more abstract just as a natural series or numeric axis.

This approach was presented in the language of quantitative characteristics. But the approach itself, its concepts, principles, and results are also applicable in cases when reality is not described in quantitative terms. What is more, it can be immaterial as a matter of fact (culture, language, etc.).

How can the presented picture of the world be proved? In the first place, by successful utilization of the differential equation language for a separate description of different-level processes of quite various nature. Were the world not as multilayer and multilevel, as presented here, the separate description of processes would not have been possible. But much more essential is that otherwise the world could not be as we see it directly, without any paradigm "glasses".

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