6. Epistemological Foundations: Concepts of Time

Methods of time series analysis for complex systems which involve an objectively defined *Now* require a clear epistemological position. First, Rössler's "assignment conditions"[193] have to be defined: The observer who is to analyze a time series must first decide whether the internal strucutre of this time series is the result of the inherent pattern of an underlying process or a structure superimposed by the observer or the measuring chain or both. The phenomenological description of time series is invariably the result of our choice on where we set the interfacial cut between observer and the object under observation or that between the measuring chain and that object. Consequently, a concept of time is required which takes account of assignment conditions and the numerous levels of description in complex dynamic systems. The observer and experimenter will profit from a more differentiated, nested method of time series analysis by identifying levels of description, a nesting dimension to account for scaling patterns, and the concept of an objective *Now*.

6.1 Two Concepts: Modal and Relational Time Structures

In this paper, we assume that time exists, independent of empirical knowledge and observer. The structure of time is generally differentiated into two concepts. The first kind of temporal structure is the modal delineation of time, the notion of time passing from the past through the present into the future. Events appear to be, first, future, then present and eventually, past. The modal delineation of time contains the concept of the Now, the only window for the observer to access the world. The second kind of temporal structure is the relational delineation of time. Here, the concepts of earlier, later and between suffice for a complete description of a dynamical system. The relational concept of temporal structures is also referred to as the time of physics, t, as its earlier-later relations make time intervals comparable when being projected onto a mathematical continuum. As the Now has no counterpart in the relational delineation of time, the modal delineation is therefore attributed to the subjective domain.

These two concepts cannot be reduced to each other and no one-to-one mapping is possible: The concepts of earlier and later are semantically surpassed by those of past and future, as the past is remembered and the future anticipated. Furthermore, the Now of the modal concept of time has no analogue in the relational concept.

6.2 Husserl's attempt to reduce the concept of time to the modal delineation of time

The assumption that time is real and not a mere construction of our brains is a result of Husserl's unsuccessful attempt to reduce the concept of time to the modal delineation of time.

Husserl[194] intended to show that it was unnecessary to draw upon an objective "real" time to account for empirical knowledge of time. According to his approach, it is the subject itself which generates time by means of the following modes of empirical knowledge: retention, conciousness of the present, and protention. All retentions and protentions are represented in the consciousness of the present, where it seeks out past events in its fixed position only to reflect it, in a modified way, in the Now. In order to be able to host both retention and protention, Husserl's concept of the present is that of an extended Now.

The perception of a series of notes as a tune shows the necessity to assume concepts such as retention and protention in order to understand the individual's skill to recognize not only a series of isolated notes, but a tune [195]. Husserl defines notes as extended time objects (*Zeitobjekte*) which stand in a fixed relation to each other, so that even recollection cannot change this original order:

> "We refer to objects as *time objects in the special sense*, when they are not only units in time, but also contain temporal extension within themselves. When a musical note sounds, my objectivising apprehension may turn this musical note, which lasts and sounds, into an object. But it cannot do so with the duration of the musical note or the note in its duration. This note is, as such, a time object. The same is true for a tune, for any kind of change (...). Let us consider the example of a tune or an uninterrupted section of a tune. At first, this seems to be a simple matter: we hear the tune (...). While the first musical note sounds, the second comes, then the third, etc. Have we not to say: when the second note sounds, I hear it, but I no longer hear the first one anymore, etc? I do not, then, in truth, hear the tune, but only the individual present note. The fact that the section of the tune which has been played is objective to me, I owe - one is inclined to say - to recollection. And the fact that I do not, having reached the appropriate note, presume that that was all, I owe to anticipatory expectation (...).(The note) begins

> and stops, and its entire unity of duration, the unity of the entire process in which it starts and ends, 'shifts', after the ending, into an ever-more-remote past. In this receding motion, I still 'cling' to it, have it in a 'retention' and, as long as it lingers, it has its own temporality, it is the same, its duration is the same." [196]

According to Husserl, our consciousness not only perceives the time objects A and B (and, through the index of recollection, also A'and B'), but it also perceives succession:

> "This consciousness does indeed imply an A' and a B', but also a -'. Of course, this succession is not a third part, as if the way of writing the symbols consecutively indicated the succession. But still I can write down the following law:
> (A - B) = A' -' B'
> with the sense of: there exists a consciousness of the recollection of A and of B, but also a modified consciousness of 'A is succeeded by B'." [197]

Husserl's phenomenology of the inner consciousness of time failed to reduce the empirical knowledge of time to the modal concept of time for the following reason: The subject cannot generate time, as the concept of reflexion in the consciousness of the present already contains that of retention. Husserl's idea of a sucession of time objects already presupposed a real time structure. And if the modal concept of time does not suffice to generate time, time must be assumed to be real in the sense that it exists without an observer.

It is, in principle, inconceivable to regard empirical knowledge of time as something subjectively generated, without assuming a futher level of generation, which itself, again, generates the time in which our consciousness of time works.

As a result, empirical knowledge of time has to fall back onto a real temporal structure, which exists independent of the observer, to avoid slipping into an infinite regress.

Even though the subject cannot generate time, an important lesson may be learned from Husserl's approach: The nested arrangement of time objects which are nested by means of the act of recollection or perception during the extended Now makes sense today in nonlinear time series analysis as well as in cognitive studies.

Even though one may gather from Husserl’s approach that the subject does not generate time, it may nevertheless be in a position to structure it. In fact, his concepts of retention and protention, as well as the nested arrangement of various levels of description prompted the first reflections on a fractal structure of time with nested levels of description.

6.3 Bergson's concept of the Now

Bergson's concept of duration as a non-divisible whole dismisses ideas of divisible units of the continuum as a means of comparing and measuring events by projecting them onto the mathematical continuum:

> "Let us therefore rather imagine the image of an infinitely small elastic band, contracted, if it were possible, into a mathematical point. We slowly start stretching it, so that the point turns into a line which grows continuously. Let us focus our attention not on the line qua line, but onto the action of pulling it. Notice that this action is indivisible, given that it would, were an interruption to be inserted, become two actions instead of one and that each of these actions is then the indivisible one in question. We can then say that it is not the moving action itself which is ever divisible, but the static line, which the action leaves under it as a trail in space."[198]

The Bergsonian concept of the Now does not accept any juxtapositions or successions within the non-divisible whole of the duration, but does contain past and future:

> "The internal duration is the continuous life of a recollection which extends the past into the present, so that the present may clearly contain the perpetually expanding image of the past.....Without this continuing existence of the past in the present, there would be no duration, only the existence of the moment." [199]

Based on the foregoing considerations, the term duration and Now are, in this paper, used in Husserl's sense, insofar as they comprise the properties of an extended present which displays deep nestings of protentions and retentions. The predicate of Husserl's extended present is ascribed to events which have the potential to form "during-relations". The terms *time condensation* and *Prime* [200] introduced later in this paper are based on the Bergsonian concept of duration: a *Now* which implies the past *and* is, at the same time, indivisible.

6.4 The *Now* as a PSC, a TNC, and a δ_i-interval combining past and future

In this context, Timashev et al introduce a new definition of the *Now* which comprises, apart from the present moment, the past as well as the future, that which has happened and that which potentially exists. The new approach rests on the assumption that the evolution of a system can be described, for each level of description, as the succession of a series of adjacent δ_i-intervals. For a dynamic variable V(t) with scaling behaviour over long periods of time, a hypothesis may be formulated that, for every i^{th} level of description, there is a set of short δ_i-intervals which contains the essential information about the evolution of V(t). This means that not all points on the time axis but only a set of discrete points suffices to describe the dynamic behaviour of such a scaling system. In addition, the intervals between these δ_i-intervals also contain this essential information about the behaviour of V(t), as these intervals are not "empty" but contain information which is inherent in the nested, smaller δ_{i+1}-intervals. As the same information is found on various nested levels of description, correlations can be described by means of a set of parameters. These are the passport parameters introduced in Chapters 4 and 5.

The evolution of a system from one δ_i-interval to the adjacent one, which covers a period on the same level of description, must also be describable as a change in the spatio-energetic states of the system, with V(t) undergoing irregular changes in its evolution. If irreversibility emerges with such measurable spatio-energetic changes within the δ_i-intervals, the intervals in-between, which are "empty" on the i^{th} level, may be defined as *Now*. This concept of Nowness implies and connects the past intervals and the future ones within one *Now*. One may idealize these δ_i-intervals and contract them to the extension of a point of zero duration, but still carrying the essential information about the system's dynamics. This means the evolution of V(t) in these points is either real or potential, as it may refer to the system's past, present or future evolution. The main conclusions to be drawn from Timashev's definition of the *Now* are that even a single point may be enough to describe the entire evolution of a system and that the Now is an extention of time which hosts information about events which have already passed as well as information about the future evolution of the system. This concept of the *Now* holds the potential to decribe the dynamic evolution of a system exceeding the *Now* of the observer and experimenter, as it contains, and therefore combines, past and future.

Analogously, the approach via the Theory of Fractal Time suggests that the various levels of description in a scaling system may be correlated by defining the structure recurring on all levels as the PSC (Prime Structure Constant), which contains the structure of the Prime but covers intervals of differing lengths on the various levels of description. Here, too, the interval may be condensed to point-size, by means of condensation, but still contain all essential information about the system's evolution. This smallest interval is the Prime, a structure which has no nesting potential itself, but is nested in a scaling cascade of self-similar temporal structures defining the various levels of description. The Prime contains all information about the scaling system and manifests itself as a TNC (Temporal Natural Constraint) in the sense that it cannot be divided into smaller intervals. It is an "atom of time" - indivisible in the Bergsonian sense and, although derived via a different approach (the Theory of Fractal Time), epistemologically the same as Timashev's idealized δ_i-intervals, in which the *Now* also contains the entire information about the system. A TNC defines a limit to a system's temporal structurability and manifests itself as an interval (although this interval may be condensed to a point) containing the structures of the past and the future. Both Timashev's and Vrobel's concepts of the *Now* may be defined as indivisible in the Bergsonian sense and as *Zeitobjekte* as defined by Husserl in his phenomenological account of time.

6.5 A Temporal Fractal Interface: Nested Detector Readings

All quantities introduced so far need to be measured at a specific point in time by a specific apparatus with specific properties. The choice of detector determines the outcome of the measurement. Two types of observer (be they detectors or human beings) are conceivable, and they register the incoming signals in a very different manner:

1. A non-fractal observer (or a non-nested detector) perceives (registers) reality by treating the individual LODs individually, in an unnested way: Here, the Prime structure of varying Δt_{length} on the individual LODs manifests itself as "bent", i.e. condensed or dilated with respect to (a kind of absolute) time.

2. A fractal observer (or a nested detector) perceives (registers) reality through a nested interface, on several LODs simultaneously, i.e. through condensation[201]: Here, on the individual LODs, the Prime structure of constant Δt_{length} manifests itself as a time structure which is "bent" with respect to the constant.

In this light, TNCs act as a limitation of the observer's potential to generate and observe temporal nestings and, therefore, as a constraint on the "structurability" of the world. Consequently, setting the structure of the Prime as a constant results (for the fractal observer or detector) in the manifestation of time as being "bent" with respect to the Prime Structure Constant (PSC).

Three types of detectors are conceivable, each of which registers a given temporal structure X in a very different way, which, again, leads to very different measuring results. Let us assume that a time series consisting of three superimposed structures on 3 LODs is measured by three different detectors A, B and C. The following results are to be anticipated:

> **Detector A is a non-nested simultaneous detector of temporal structures.** It registers all 3 levels separately, it does not recognize the self-similar nesting structure and processes each level separately, i.e., it measures the temporal structure in the units t_1, t_2 and t_3. This method results in the detector registering uncorrelated sequences.
>
> **Detector B is a nested simultaneous detector of temporal structures.** It registers all 3 temporal structures on LOD1, LOD2 and LOD3 superimposed, it recognizes the self-similar nesting structure, measures the temporal structure simultaneously in the units t_1, t_2 and t_3, but processes each level separately.This method results in the detector registering pink noise.
>
> **Detector C is a nested simultaneous detector of temporal structures with simultaneous processing capacity.** It registers all 3 levels superimposed, it recognizes the self-similar nesting structure and processes all levels simultaneously, i.e. it "locks in", measuring the temporal structure simultaneously in the units t_1, t_2 and t_3 ($\Delta t_1 = \Delta t_2 = \Delta t_3$) and sets the Prime structure as a constant. This method results in the detector registering not pink noise but reality as seen through a fractal temporal interface with simultaneous processing capacity.[202]

Detector A is a conventional apparatus which does not require further explanation. Detector B is reminiscent of wavelet analysis, where the reading of ever-decreasing intervals leads to an ever-increasing differentiation of levels. This makes wavelet analysis a suitable tool for detecting self-similarity. Detector B manages this task too, but is capable, in addition, of reading incoming signals simultaneously, as a superimposed structure. In wavelet analysis, the detector reads level after level, however, not simultaneously. The question of how to generate a detector of type C , however, requires a more detailed answer. Here, a possible algorithm for generating such a detector (for 3 LODs):

Step 1:	Read LOD1, LOD 2 and LOD3 simultaneously.
Step 2:	Compare LOD1 with LOD2 until a self-similar nesting is detected.
Step 3:	If a self-similar nesting is detected, "lock in", i.e., start entrainment search for LOD1, LOD 2 and LOD3 on the basis of the scaling factor s relating LOD1 and LOD2.
Step 4:	Set the PSC as a constant so that $\Delta t_1 = \Delta t_2 = \Delta t_3$.
Step 5:	Display readings.
Step 6:	Compare readings with those of Detector B.
Step 7:	Determine the readings of Detector B as a function of the readings of Detector C. [203]

Detector C now displays a measuring which reveals the distortion function (the function which distorts readings for, and produces pink noise for, Detector B). This "nested detector reading" is a new phenomenological method for the analysis of complex dynamic systems.

NDR goes a step further than wavelet analysis and detectors of type B: In the condensation scenario, which is generated by Detector C, all intervals of varying sizes, which the PSC covers at one point or another, are made congruent and superimposed, leading to a distortion of the individual axes. For the time being, we are unable to show Detector C's participation in condensation, as we are looking at the system from an outside perspective. Unless Detector C is our brain, is inside our brains, or connected to our brains in such a way that we can disentangle all noise induced by the connection itself, we will not be able to catch a glimpse of such a distorted, timeless universe, which has no extension in the direction of Δt_{length}, but measures only nestings which extend in the direction of Δt_{depth}. This new approach requires further study and will be discussed elsewhere.[204]

6.6 The Phenomenological Approach

The phenomenological approach recognizes that there is no neutral way to approach reality. An inherent intentionality must always be accepted as a prerequisite for generating reality. Therefore, this approach is not primarily concerned with the epistemological status of underlying processes, as it accepts that the observer has no access to the "thing in itself", as Kant put it. Instead, it studies only the interface between the observer and the rest of the world. The observer's entire world is an "interface reality"[205], therefore his field of study is limited to structures as they appear on his interface. The phenomenological approach, however, accepts that it is futile to discuss whether these structures are part of the observer, the measuring chain or the rest of the world, and is therefore only concerned with those structures themselves.

Although both of the present authors follow the phenomenological approach to attempt an interpretation concerning Nature's underlying logic and essence, it is, of course, tempting and, in the scientific endeavour, to take the next logical step. Therefore, we also present suggestions and hypotheses which exceed the phenomenological approach, in that they hint at ways to reveal Nature's internal logic and possible ways for an observer to access this underlying level.

6.7 Plato Revisited

There have been numerous attempts to bridge the quantum world and the classical world, including general relativity, and to describe how non-algorithmic elements of the quantum level are catapulted up to the macroscopic level of our consciousness. A recent proposal by Rössler, based on Everett's "Many Worlds" interpretation, is a promising turnabout.[206]

Roger Penrose's approach[207] seeks to develop a physics of the mind, in which human consciousness provides the pivot between the physical, time-asymmetrical world of algorithms and Plato's timeless world of ideas. Contact with Plato's world of mathematical ideas occurs, according to Penrose, in a non-temporal manner, i.e. no time passes "during" this contact. This process, which he calls insight, is non-algorithmic. The connection of our consciousness to the "real" physical world of algorithms, in which time must pass whenever information is transmitted, is time-asymmetrical. Penrose illustrates this idea of distinguishing non-temporal and time-asymmetrical worlds through an example in which he describes the experience of insight:

> "An extreme example (...) is Mozart's ability to 'seize as a glance' (*sic*) an entire musical composition 'though it may be long'. One must assume, from Mozart's description, that this 'glance' contains the essentials of the entire composition, yet that the actual external time-span, in ordinary physical terms, of this conscious act of perception, could be in no way comparable with the time that the composition would take to perform." [208]

Another musical example quoted by Penrose, to whom he attributes such time-encompassing vision, is the composer J.S. Bach. The experience described below can only be undergone if, on the one hand, the composer has organized his tune in such a way that the character of the entire composition may be anticipated in even the tiniest elements and, on the other hand, the listener is experienced enough, i.e. has acquired enough LODs to be able to perceive and anticipate these structures.

> "Listen to the quadruple fugue in the final part of J.S. Bach's Art of Fugue. No-one with a feeling for Bach's music can help being moved as the composition stops after ten minutes of performance, just after the third theme enters. The composition as a whole still seems somehow to be 'there', but now it has faded from us in an instant. Bach died before he was able to complete the work, and his musical score simply stops at that point, with no written indication as to how he intended to continue. Yet it starts with such an assurance and total mastery that one cannot imagine that Bach did not hold the essentials of the entire composition in his head at the time. (...) Like Mozart, he must have been able to conceive the work in its entirety, with the intricate complication and artistry that fugal writing demands, all conjured up together. Yet, the temporal quality of such music is one of its essential ingredients. How is it that music can remain music if it is not being performed in 'real time'?" [209]

Penrose seeks a new quantum theory CQG (Correct Quantum Gravity) which might bridge the gap between a timeless platonic world and human experience of processes in an extended time. Penrose shows that, in the so-called R-part [210] of quantum theory, a non-algorithmic element may be found, which is to be catapulted to the macroscopic level (in order to deduce the arrow of time which is always present on the macroscopic level). According to Penrose, non-algorithmic elements are also non-temporal elements, since there is involved no computation, which is bound to take place in time, i.e. covers an interval Δt_{length}.

To illustrate the necessity of assuming a non-temporal realm reminiscent of Plato's, let us examine another musical example. Musical examples provide excellent candidates for fractal descriptions, since numerous studies on the topic of scale-invariance in music are already available. [211] Let us therefore assume that the basic structure of a fractal consists of the sequence of musical notes F, A, C, F or, respectively, E, D, C. In Figure 77, several nestings of this structure can be found:

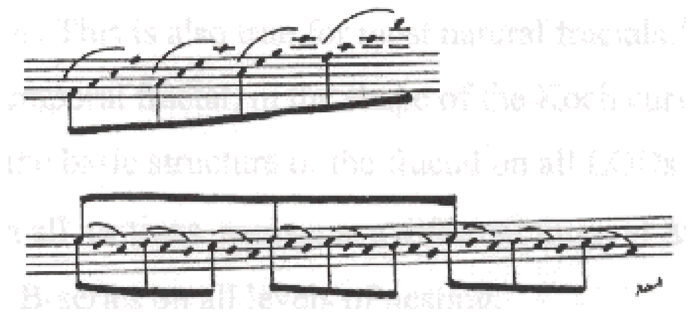

Figure 77: Several nested layers [212]

> "Musical events can be understood as occurring in numerous simultaneous layers, some brief and some lengthy. Self-similarity occurs between macroscopic patterns and the shorter patterns that comprise them. The simplest examples are created by a technique called melodic sequence, where a short sequence of notes with a particular pitch contour is several times repeated to create a longer sequence of short sequences. Each repetition of the basic sequence is displaced to a new pitch level; the contour of the macro-sequence is created by a pattern of displacements that replicates the contour of the basic sequence. Replications may be nested several layers deep..." [213]

The correlation of long and short structures in a nested scale-invariant composition allows the listener to anticipate the character of the entire composition when listening to only a short section of the composition. If this short section is from the middle of the entire composition, it is possible to catch a "glumpse" (the audio-analogue of "catching a glimpse") of parts of the composition already played as well as of those yet-to-be played. In terms of the modal concept of time, one learns about past and future structures via an extended but not divisible present which hosts the basic structure of the fractal it is embedded in. Scale-invariances in compositions are bound by an upper and a lower limit to the nestings. This is also true for most natural fractals [214]. Picture an infinitely nested temporal fractal, in the shape of the Koch curve, for example, and you will find the basic structure of the fractal on all LODs. This structure, which is present in all nestings, measures a different interval Δt_{length} for each LOD on all levels of nesting for each relational time series.

The structure of a fractal may be defined by the appropriate time series interval it covers. In the case of the Koch curve, though, the structure corresponds to varying intervals of Δt_{length}, depending on the LOD in question. In order to give a LOD-independent definition of the structure, i.e. neither in terms of its length, nor in terms of its earlier-later relations, concepts are required which allow a description of the structure without implying the idea of an extension. Such concepts can be found in Plato's world of ideas: timelessness, unextendedness, indivisibility.

A "fractal analogy" to Plato's world of ideas, which combines temporal extended structures with non-temporal idealized ones, such as the Prime, requires the assumption of a non-temporal V-series. The V-series is the set of structures which are non-temporal (i.e. not implying any duration in Δt_{length}), unmodifiable and inaccessible. The structures of the V-series exist in (duration-implying) relational time series as structured intervals of Δt_{length}.

We have already introduced the notion of a Prime as a temporal natural constraint. Here, we shall try to enrich this concept by declaring it an epistemological necessity. The need to assume a non-temporal (i.e. implying no duration) V-series results from the lack of a sector to which that last nested structure of a fractal with nesting potential can be appropriately attributed. Elements of this sector (which hosts the last nested structure of a fractal) must exhibit some characteristics of both the relational time series, which consists of extended elements, and the V-series, whose elements are not extended in time. In order to define such an interim-sector (between relational time series and the V-series), one must assume the existence of a V-series, since some of the characteristics of V-series elements define this interim-sector. The elements of this interim-sector are the idealized entities we have defined as Primes (the last and smallest structure of a self-similar nesting which is non-temporal and indivisible, since it has no nesting potential).

Philosophically defined, a Prime is a nested self-similar structure of a relational time series. It is the most deeply nested structure which has no nesting potential, as a result of which it cannot generate Δt_{depth}. It is indivisible in the Bergsonian sense. The Prime structure constant (PSC) exhibits extension in Δt_{length} and exists independent of the observer. These are properties of elements of relational time series. But these elements are also defined by their nesting potential, which enables them to generate Δt_{depth}. The Prime cannot do this, as it has no nesting potential. Without this potential, no further differentiation within the Prime interval can be made. This indivisibility in the Bergsonian sense is a property of the V-series. But although V-series elements have other properties the Prime does not share, such as non-temporality (i.e. implying no duration), the V-series is not identical with Plato's world of ideas: Plato's ideas are eternal, Primes and V-series elements are non-temporal.[215] Non-temporality denotes a status of inability to generate Δt_{depth}. Since Δt_{depth} is a prerequisite for the possible existence of Δt_{length}, $\Delta t_{depth} = 0$ suffices as a defintion of non-temporality.

The Prime of a fractal may be accessed via the scale-invariant structure of relational time series by means of condensation. This presupposes that the same structure exists on all LODs of the time series and that the structure of the Prime may be set as a constant, in order to put all LODs into a relation to each other. We assume that, within a nesting of Koch curve structures, the PSC on LOD 1 corresponds to Husserl's concept of the present, which is extended through retentional nestings and experienced by the subject. This structure implies duration - it occupies a certain interval Δt_{length} of a certain LOD of the time series. In Figure 78a , the structure of the Koch curve occupies the entire interval of LOD 1. Having set the PSC of the Koch curve as a constant, this interval corresponds to Δt_{length} on LOD 2, Δt_{length} at LOD 3, etc., with, Δt_{length} contracting with every additional nesting, until, on LOD ∞, Δt_{length} approaches 0 (see Figure 78b).

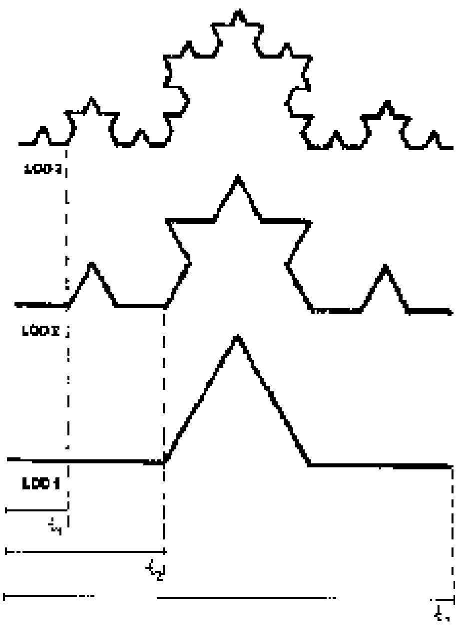
Figure 78 a

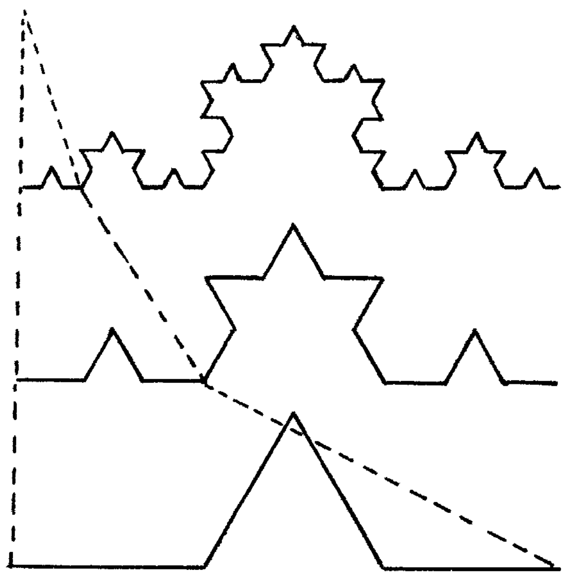
Figure 78b

The Prime exhibits properties of both the relational time series and the V-series: Indivisible structures are not elements of the relational time series (which comprises elements with temporal extension in Δt_{length} and nesting potential), but these structures on the last LODs are, however, congruent to their corresponding time series structures - they are, in a sense, derivatives of the latter. To conclude, the Primes "live" on the last LOD and they are essentially non-temporal, i.e., they do not imply duration. Such non-temporality is a property of V-series elements, which comprise non-temporal, indivisible, unmodifiable, ideal structures. We therefore have to assume the existence of a V-series to accommodate Primes.

In terms of epistemology, there are, of course, differences between the V-series and Plato's world of ideas, as they have been derived in a very different context. For reasons of transparency, however, it is didactically reasonable to illustrate the internal relations between the modal time series, the relational time series and the V-series by means of the image of the

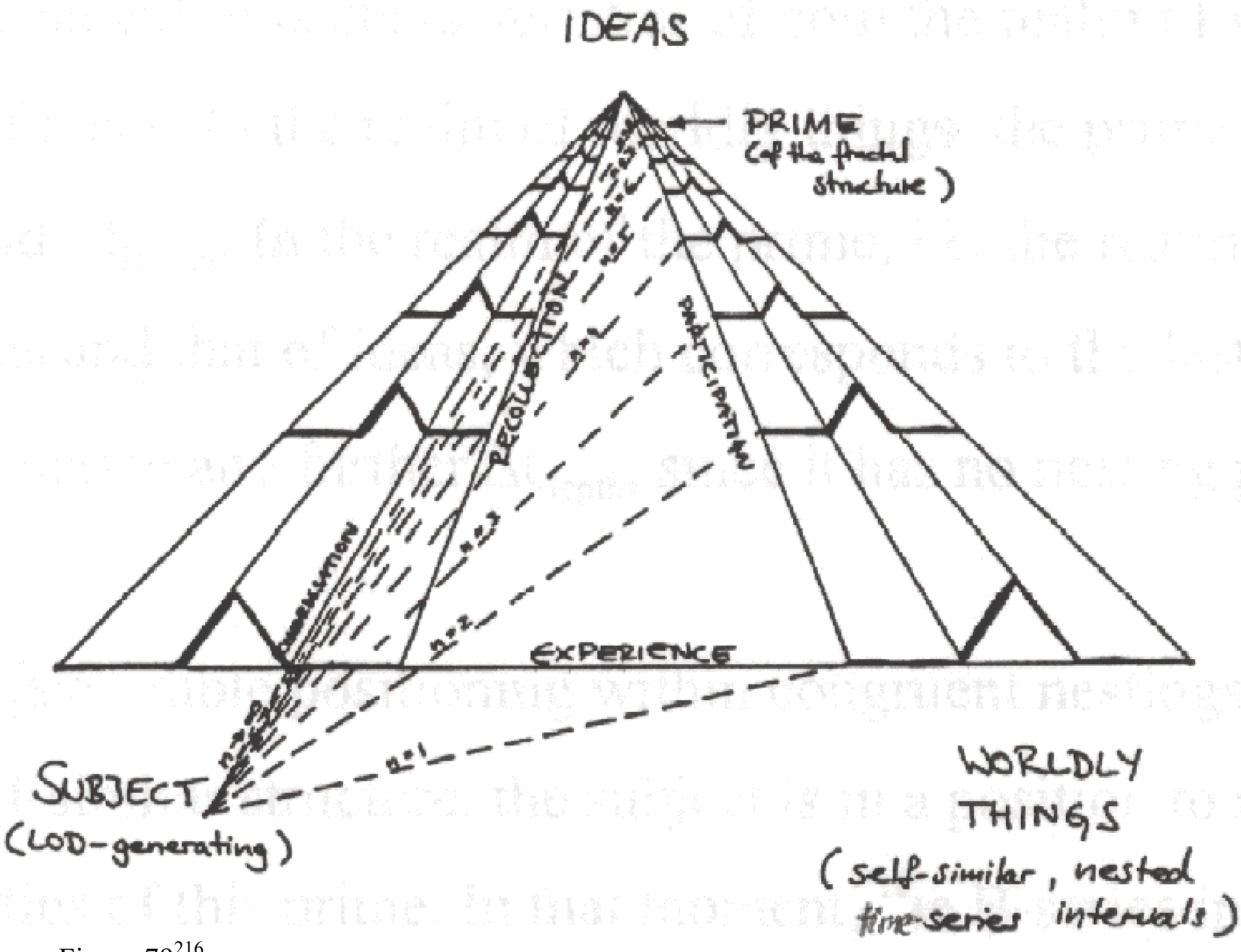

Figure 79[216]

Platonic Triangle as portrayed in Figure 79: Each of Plato's three realms of idea, worldly things and subject corresponds to (at least) one time series. The V-series, inaccessible to us, correlates to the realm of ideas. The relational time series, whose structures are extended and exist independent of any observer, describes the temporal order of the realm of worldly things and therefore correlates to that realm. The modal time series, which hosts the Now and is observer-dependent, i.e. based on indexicals such as past, present and future, describes the temporal relations of the indexical realm of the subject and therefore correlates to that realm.

The relation between the modal time series and the Prime, first via the relational time series, which comprises self-similar structures with extension in Δt_{depth} and Δt_{length}, is established through condensation (cf. Chapter 3.3). With every nesting, the length of Δt_{length} contracts further and further, until there is direct contact between the modal time series and the Prime. In terms of Plato's Triangle, the realm of the subject can make contact with the realm of ideas, indirectly via the Prime, through condensation: the first step is taken through experience via the realm of worldly things, and the second step is taken, on the last LOD, via the Prime.

The original Platonian concept connected with the triangle carries various connotations which do not directly correspond to the fractal time model. For example, the condensation link correlates, in the fractal model, with a recollection link analogous to the anamnesis link in Plato's Triangle (see Figure 79). The terms 'recollection' and 'anamnesis' are not identical, though, as 'recollection' does not imply characteristics such as the cleansing of the soul from the encrustation of bodily cares and interests, as the Platonic term 'anamnesis' does. Recollection in the fractal model serves as a step by step approach of the subject - via the Now of the modal time series - towards the realm of ideas. This occurs through experience via the realm of worldly things, whose internal relations are described by the relational time series. Nature's participation in the ideas, relates, in the fractal model, exclusively to a structural equality: the Prime of the fractal exhibits characteristics of both the realm of worldly things and the realm of ideas. In the realm of worldly things, the Prime occupies a certain Δt_{depth} and Δt_{length}. In the realm of the Prime, i.e. the realm between that of worldly things and that of ideas, which corresponds to the last nesting, the Prime cannot generate any further Δt_{depth}, since it has no nesting potential.

If the conditions for a condensation scenario are met (cf. Chapter 3.3 on condensation), the observer may, through positioning himself within congruent nestings, i.e. in the Prime of the self-similar structure, recognize the V-series properties of this Prime. In that moment, the relational time series in its function as a connecting link between the modal time series and the V-series properties is released: the contact between subject and Prime is non-temporal (or, in Penrose's terms, non-algorithmic). In this position, the observer may catch a glimpse of the larger structure embedding the present, by, metaphorically speaking, looking into the opposite direction to the V-series: there, the Prime of the present is embedded in larger intervals of the same basic structure. This glimpse is rendered possible through the congruence of the Prime structure on all LODs. This intuition which comprises the past as well as the present and the future, corresponds to Penrose's concept of insight [217]. In the fractal model, this moment of intuition corresponds to the καιρος , the key moment in which the future may be influenced.

As we have pointed out, natural fractals exhibit an upper and a lower boundary, so the nesting level ∞ will practically not be accessible. Even a limited scale-invariant nesting, however, suffices to allow us to catch a glimpse of the structure embedding our particular present. Such scale-invariant nestings may be generated artificially, through fractal compositions, for example[218]. Other scale-invariant nestings are probably structured through and by ourselves. As human beings with more or less extended bodies, we are subject to temporal structures steered by our metabolism, hormone regulation, etc. Many of these processes exhibit scale-invariances [219].

There have been other attempts to reconcile temporality with non-temporality, one of which is Leibniz' concept of the monad. The virtual presence of temporal structures in non-temporal ones (Primes) is reminiscent of the concept of the monad, which mirrors the universe and, in a virtual sense, already comprises a temporal structure:

> "As 'repraesentatio mundi', the world is present in it not just spatially but also temporally. Just as every spatially formed organism finds its corresponding representation in the monad, so does every temporal series." [220]

Apart from the 'momentaneum', Leibniz does not attribute any reality to time. To him, it is an ordering principle which relates only to the world of phenomena: time is the order in which what is incompatible is real [221]:

> "Even what is mutually incompatible is still reflected by the monad in a unified way. This reflection does not occur according to the ordering principle of time; the relation of the monad to the unfolded time series, i.e. to the 'empirical time series', corresponds to the relation of the unity of time to the continuous succession of its modes." [222]

Despite apparent similarities in the two concepts, the relation between monad and empirical time and the relation between Prime and relational time series are fundamentally different.

The most significant difference lies in the status of these concepts. The difference between Leibniz' concepts of monad and time is analogous to the difference between substance and phenomenon [223]. By contrast, the fractal model allows an arbitrarily close approach of a B-series structure towards its Prime. Even if an approach such as this is executed only in part, it allows the arbitrary dilation of a present nested in a self-similar structure by making nesting LODs accessible through condensation.

6.8 The Arrow of Time

One of the fundamental questions in the natural sciences is how to reconcile reversible equations of dynamics with irreversible natural processes. The latter introduce the arrow of time associated with macroscopic perspectives, an anisotropy which cannot be derived from reversible classical mechanics. Attempts to associate the second law with the arrow of time are not helpful, as the second law is *descriptive* in essence and cannot *explain* the generation of the arrow of time.

As any process may be described on various, rather arbitrarily chosen levels of description (LODs), a fractal approach may help to answer the question as to whether the arrow of time is already contained in the most deeply embedded LOD or emerges somewhere on the way.

Boltzmann considered the most deeply embedded LOD as reversible and without temporal direction. He attempted to derive the arrow of time from a reversible world by identifying the arrow of time with an increase in the probability of a state. The idea was to define the state of thermal equilibrium as the most probable state and present the first statistical description of entropy. But although Boltzmann's statistical approach portrayed the arrow of time in a revolutionary new way, his model did not *derive* the arrow of time, as Prigogine and Stengers point out:

> "... probability *presupposes* a direction of time and therefore cannot be used to derive the arrow of time."[4]

Prigogine and Stenger insist that irreversibility exists either on all levels or on none, i.e. that the arrow of time is already inherent in the most deeply embedded LOD. They conclude that the arrow of time emerges as a result of an instability inherent in dynamical systems. This instability results in an unpredictability of the behaviour of deterministic dynamical systems.

This unpredictability is the result of a sensitive dependence on initial conditions, which generate not an individual trajectory but regions which comprise alternative potential developments.

> “Arbitrarily small differences in initial conditions are amplified. As a result we can no longer perform the transition from ensembles in phase space to individual trajectories. The description in terms of ensembles has to be taken as the starting point. Statistical concepts are no longer merely an approximation with respect to some ‘objective truth’. When faced with these unstable systems, Laplace’s demon is just as powerless as we.“[6]

According to Prigogine and Stengers, we would have to overcome an infinite entropy barrier to reverse time. Their most deeply embedded LOD already contains the arrow of time while Boltzmann's does not. The question as to where the arrow of time "pops up" between the apparent micro-reversibility and macro-irreversibilty cannot be answered if posed in this general way. The differentiation required to tackle this issue is a fractal perspective and a clear defintion of the extension and relation of the system to be observed.

A fractal description prompts two basic questions: 1.Which units should be chosen to define the LODs? and 2. Which LODs should be defined as the inner and outer nestings, i.e. where should the inner and outer borderlines of the system to be described be situated?[224]

As the arrow of time which is associated with an increase in entropy is a *mucro*[13] phenomenon, an omnipresent direction generator, a fractal perspective raises the question as to whether ΔS is LOD-dependent, i.e. whether it is a quantity which may refer to subsystems. This question challenges the dogma that, in total, entropy increases, if this "total" refers to something we refer to as "the entire universe".

A thought experiment by Vrobel[225], which pictures a universe consisting entirely of hot water bottles and ice cubes illustrates these considerations. Our model universe is arranged in the following way:

> "An ice cube is situated in the middle of each hot water bottle, and each hot water bottle is situated in the middle of an ice cube. (Let us assume the rubber of the hot water bottle to be infinitely thin.) Imagine a universe consisting entirely of such nested ice cubes and hot water bottles. If one tried to measure the differences in entropy $\Delta S = S2 - S1$ for the various sections of this universe (where the values for S1 and S2 are to be taken as freeze- frames), one would measure a decrease in entropy for the water of a hot water bottle (without taking into account the ice cube contained), since the much larger surrounding ice cube cools down the water

> in the hot water bottle. Vice versa, ΔS is positive for the systems 'ice cubes' (without taking into account the hot water bottles contained), since the embedding hot water bottles melt the ice cubes, i.e. entropy increases. Depending on what section of this hot-water-bottle-ice-cube-universe one chooses to observe (and this observation should have an extension of not more than a glimpse), entropy either increases or decreases. How can we say that, in total, entropy increases, if we cannot specify the extension of ΔS when we talk about the hot-water-bottle-ice-cube-universe? After all, we do not know whether it is finite. And if it is finite, how can we know whether the outer embedding layer is a hot water bottle or an ice cube? Given two freeze-frames of our hot-water-bottle-ice-cube-universe, the entropy total will either be positive or negative, depending on the sections chosen."[226]

It is, of course, the observer position which will determine the outcome of any experiment carried out to determine a direction of time. The observer would be situated in a subsystem of this universe, either in a hot water bottle or in an ice cube. If the observer is situated in an ice cube, he will obtain results which will differ drastically from those registered by an observer situated in a hot water bottle. Each observer would thus generate his own private arrow of time. If we now imagine such an observer’s internal structure as resembling a section of the hot-water-bottle-ice-cube-universe, this fractal description of a nested universe turns ΔS into a LOD-dependent quantity, determinable for subsystems by chosing the number of nestings taken into account and the observer position.

If these private arrows of time are observed from an outside position, i.e. from an observer position which allows the observation of several nested LODs, how could this observer detect a nesting of arrows of time of differing directions? He may require a nested detector, such as those introduced in Chapter 3.4. The fact that we are generally not aware of conflicting arrows of time may be the result of a selection effect:

> "In order to detect something, one requires a detector. If one wished to detect several LODs of a nested structure simultaneously, one needs simultaneous nested detectors. If one wishes to detect a nesting of X arrows of time of differing directions, one needs detectors in the form of antennae on X numbers of LODs. These antennae could emerge as a result of learning, of generating new LODs. Nested antennae could be grown through learning on different LODs. (...) It is conceivable that these antennae have been at our disposal for a long time but have been suppressed as a result of a selection process: negative feedback on certain LODs puts us off - rather than living with an apparent inner conflict, we tend to align all our arrows of time, which may point into all sorts of directions, with the all-embracing entropy-arrow."[227]

To observe the entire universe, a nested detector would require as many nestings as this universe has. This is, of course, not a practical suggestion. It is however, a step towards a more differentiated way of posing questions to Nature. The final step, to actually take the perpsective of a nested detector of type C, remains a challenge to be met.

An approach by Timashev et al suggests that it is impossible to build an absolute thermostat, as, when we analyze heat fluxes, any thermostat must be considered as a dynamic system with inherent rearrangements of its structurally non-equilibrium subsystems[228]. Therefore, the measuring chain has to be taken into account when we describe the evolution of a system. This implies that we have to account for the fluxes of energy and entropy between the thermostat and the environment, in addition to the equations which describe the evolution of the system under study:

> "The necessity to account for the structural rearrangements in the thermostat during the evolution of a system leads to an uncontrolled increase in the number of degrees of freedom of the combined system and to a complication of the dynamics of each individual generalized coordinate because of an increase in the number of factors that act on it. These circumstances substantially complicate the search for adequate expressions for the operator of the evolution of the system as a whole; at the same time, they result in irrevesibility even at the level of a single trajectory. Thus, it is possible to state that, during the evolution of a dissipative nonlinear subsystem, reversibility certainly cannot be realized in real time, and the evolution should proceed in accordance with the second law of thermodynamics."[229]

Moreover, equilibrium flicker noise may be reagrded as an indicator of irreversibility:

> "The observation of equilibrium flicker noise in solids, which reflects the dynamics of the redistribution of structural or elastic energy in the matrix, a process accompanied by local rearrangements of its structurally non-equlibrium fragments, suggests that the relaxation flows of energy and entropy in structurally non-equilibrium nonlinear systems manifest themselves through sequences of overshoots in the dynamic variables rather than through the Poisson sequence of small-amplitude and temperature-dependent fluctuations (white noise). This means that flicker noise can be considered an indicator of the time arrow. The analysis performed is based on the assumption that the thermostat ideally sustains a desired temperature and exchange through heat fluxes only with the subsystem under study. Obviously, this is not the case. An actual thermostat inevitably interacts with the environment..."[230]

As the actual act of measuring has a duration in time, the microscopic states cannot be reagrded as invariable during this measurement. This includes equilibrium flicker noise, which is an indicator of correlations in the subsystems:

> "This means that such an instrument cannot be used as a reference in order to unambiguously determine the dynamics of transition in the quantum subsystem. Flicker noise macroscopic fluctuations in the classical device can be considered as 'hidden parameters', whose objective existence is sometimes discussed in connection with the problem of indeterminism in quantum physics."[231]

Timashev et al suggest that FNS may be used to quantitatively describe the dynamics of macroscopic fluctuations which are generated in the measuring device. The aim would be to substitute the Copenhagen interpretation (the principle of complementarity) or the acknowledgement of hidden parameters by a quantitative analysis of flicker noise fluctuations.

7. Conclusion: Fingerprints and Blueprints

Self-similarity in time series indicates a universality in pattern formation, which appears to be an underlying principle, as the same recurring structures can be observed in very different kinds of systems. Both self-organized critical systems and equilibrium continuous phase transitions leave fingerprints of universal power-law scaling.

The question as to whether there is a blueprint underlying these complex dynamic systems requires a differentiated answer. On the macro-level, there is no all-embracing blueprint which steers and controls pattern formation. On the micro-level, however, self-organization is at work, generating macro-structures which cannot be predicted from the micro-level dynamics. As Ball points out,

> "Nature commonly weaves its tapestry by self-organization, employing no master plan or blueprint but instead simple, local interactions between its component parts - be they grains of sand, diffusing molecules or living cells."[232]

Whatever the mechanism of generation, these patterns exist and indicate a relationship between systems which seem to share no other common features. In general, however, universal patterns cannot be made out at first sight but require further analysis:

> "The universal patterns and forms of noise-dominated systems are commonly 'hidden' - they become apparent only in 'mathematical space'. (...) ...the most robust feature of disordered fractals (...) is their power-law scaling behaviour, which reveals a fractional exponent that tells us much about the similarity or otherwise of structures that bear no *particular* visible features in common."[233]

There are, however, structures which are accessible to us, albeit indirectly. Just as the passport parameters are determined only via an FNS analysis, the PSC must be deduced from superimposed detectors' readings.

Symmetry always seems to indicate a further level of description in relation to which this symmetry ceases to exist. In this monograph, we dealt with symmetry in the shape of self-similarity and the constants which emerged in its wake. And new constants entail a new relativity, which may, hopefully, be exploited in a sensible way.

To conclude, natural constraints such as the Prime are a gift because they define LODs and, at the same time, indicate and demarcate limits to the number of LODs at our disposal. This enables us to study these LODs - in particular, their internal relations. Although these constraints may not be here to stay, we may be in a position to modify our scale-invariant nesting cascades in such a way that we can either create new LODs or initiate a condensation. It is conceivable that TNCs are selection effects: Being able to define a limited temporal inertial system within which communication may be practised without too many distortions caused by time condensation or dilation is certainly an evolutionary advantage. At the same time, TNCs reveal our own shortcomings and limitations, as TNCs set a limit to "structurability" of time by the observer.

With regard to the FNS method, the presented results reveal shortcomings and limits of existing non-linear approaches to the analysis of chaotic time series. In particular, the fact that calculating the Kolmogorov entropy, which may be determined as the rate of loss of information, a mix of information of all "colours" takes place. In the FNS approach, the description of the dynamics a priori is not reduced to representations of the classic deterministic chaos theory introducing the strange attractor in a multi-dimensional phase space. Instead, representations of discrete random dynamics are required[234]. FNS may be considered a phenomenological basis for a new "science of complexity", one which puts us in a position to hold a rewarding new dialogue with Nature.

Sound science is founded upon a metaphysical essence, axioms we have come to accept as a basis of *normal science* in the Kuhnian sense. Even though we may not have access to the thing in itself, as Kant has shown, we nevertheless, for very pragmatic reasons, tend to construct a metaphysical picture, in order to create a basis for our scientific models. Newtonian mechanics presupposes the dimensionless material point and the inertial system; quantum mechanics assumes Bohr levels. Once the scientific community has accepted and adopted these metaphysical foundations, a very sound science may be based on them, a science which allows us to make precise predictions, as Schrödinger and Heisenberg have shown. The metaphysical picture we have presented here is intended to provide a basis for a Science of Complexity. Up to now, we have been preparing this basis by trying to interpret and to understand the information hidden in chaotic experimental series.

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[193] O.E. Rössler: *Endophysics.* World Scientific, Singapore1998.
[194] E. Husserl: *Vorlesungen zur Phänomenologie des inneren Zeitbewußtseins.* Niemeyer, Tübigen 1980 (1928),

[195] E. Husserl: *Vorlesungen zur Phänomenologie des inneren Zeitbewußtseins.* Niemeyer, Tübigen 1980 (1928).
[196] E. Husserl: *Vorlesungen zur Phänomenologie des inneren Zeitbewußtseins.* Niemeyer, Tübigen 1980 (1928), p. 384ff (my translation).
[197] E. Husserl: *Vorlesungen zur Phänomenologie des inneren Zeitbewußtseins.* Niemeyer, Tübigen 1980 (1928), p. 402 (my translation).
[198] H. Bergson: *Einführung in die Metaphysik*. Diederichs, Jena 1909, p. 8.
[199] H. Bergson: *Einführung in die Metaphysik*. Diederichs, Jena 1909, p. 27f.
[200] At this point, it will suffice to understand the term *Prime* as a structure which exhibits properties of both B-series elements and so-called V-series elements (i.e. the internal structures of the latter), which are non-temporal and non-modifiable.
[201] S. Vrobel: "Ice Cubes And Hot Water Bottles". In: *Nonlinear Studies,* **Vol. 5**, No. 2 1998 pp.153-163.
[202] S. Vrobel: "How to Make Nature Blush: On the Construction of a Fractal Temporal Interface" in: D.S. Broomhead, E.A. Luchinskaya, P.V.E. McClintock (eds.), *Stochastics and Chaotic Dynamics in the Lakes*, American Institute of Physics, Melville, NY, USA, 2000, pp 557-562.
[203] S. Vrobel: "How to Make Nature Blush: On the Construction of a Fractal Temporal Interface" in: D.S. Broomhead, E.A. Luchinskaya, P.V.E. McClintock (eds.), *Stochastics and Chaotic Dynamics in the Lakes*, American Institute of Physics, Melville, NY, USA, 2000, pp 557-562.
[204] "Fractal Time and Nested Detectors", *Proceedings of the First IMA Conference on "Fractal Geometry: Mathematical Techniques, Algorithms and Applications",* De Montfort University, Leicester UK, 2000 (in press).
[205] The concept of "interface reality" was developed by O.E. Rössler to describe the endophysical view of the world. Cf.: O.E. Rössler: "Intra-observer Chaos: Hidden Root of Quantum Mechanics?" in: M.S. Naschie/O.E. Rössler/I. Prigogine: *Quantum Mechanics, Diffusion and Chaotic Fractals.* Pergamon. Elsevier Science, Oxford 1995, pp 105-111. O.E. Rössler: *Endophysics*. World Scientific, Singapore 1998.
[206] O.E. Rössler: Steady-State Theory: 4new apects in: *Chaos, Solitons & Fractals*, 1996.
[207] R. Penrose: *The Emperors New Mind*. Vintage, London 1989.
[208] R. Penrose: *The Emperors New Mind*. Vintage, London 1989, p. 575.
[209] R. Penrose: *The Emperors New Mind*. Vintage, London 1989, p. 576.
[210] According to Penrose, the R-part of quantum theory (the part corresponding to the wave function collapse, i.e. for those cases in which a measurement takes place) is time-asymmetrical, in contrast to the U-part (the part which may be described by the Schrödinger-equation, i.e. for those cases in which no measurement takes place). The arrow of time does appear if one describes the quantum world from a classical LOD, i.e. if one carries out a measurement.
[211] Cf. in particular: R.F. Voss "Fractal Music", in: Peitgen, H.-O., D. Saupe (Eds.): *The Science of Fractal Images.* Springer, London 1988 and K.J. Hsü : "Fractal Geometry of Music: From Bird Songs to Bach" in: Crilly, A.J., R.A. Earnshaw, H. Jones (Eds.): *Applications of Fractals and Chaos*. Springer, New York 1993.
[212] G. Mayer-Kress et al: "Musical Structures in Data from Chaotic Attractors" in: *Chaos, Musik, Kunst* (Eds.): Chaos-Gruppe München 1993, p. 13.
[213] G. Mayer-Kress et al: "Musical Structures in Data from Chaotic Attractors" in: *Chaos, Musik, Kunst* (Eds.): Chaos-Gruppe München 1993, pp. 12/13.
[214] Cf. F. Cramer: *Chaos und Ordnung*. DVA, Stuttgart 1988.
[215] Plato considers time as 'the moving image of eternity' and the forms as eternal. For the fractal concept of time, non-temporality is defined as $\Delta t_{depth} = 0$.

[216] S. Vrobel, *Fractal time*. The Institute for Advanced Interdiciplinary Research, Houston, TX, 1998.
[217] Penrose's explanation of *insight* varies considerably from this fractal approach. Cf. Penrose 1989.
[218] Such a fractal concert (composed by Peter Neubäcker - see biblography) was performed at the Annual Symposion of the Munich Chaos Group on 13.11.1993.
[219] Cf. L.F. Olsen et al: *Chaos in Biological Systems*. Plenum Press (NATO ASI Series) London 1987.
[220] E. Rudolph: "Entelechie, Individuum und Zeit bei Leibniz" in: C.F. v. Weizsäcker, E. Rudolph (Eds.): *Zeit und Logik bei Leibniz.* Klett-Cotta, Stuttgart 1989,, p. 121 (my translation).
[221] Cf. G. Böhme: *Zeit und Zahl. Studien zur Zeittheorie bei Platon, Aristoteles, Leibniz und Kant.* Frankfurt 1974, p.251.
[222] E. Rudolph: "Entelechie, Individuum und Zeit bei Leibniz" in: C.F. v. Weizsäcker, E. Rudolph (Eds.): *Zeit und Logik bei Leibniz.* Klett-Cotta, Stuttgart 1989, pp. 121f. (my translation).
[223] E. Rudolph: "Entelechie, Individuum und Zeit bei Leibniz" in: C.F. v. Weizsäcker, E. Rudolph (Eds.): *Zeit und Logik bei Leibniz.* Klett-Cotta, Stuttgart 1989, p.122.
[4] I. Prigogine and I. Stengers, *Order Out of Chaos*. Fontana, London, 1984, p. 259.
[6] I. Prigogine and I. Stengers. *Order Out of Chaos*. Fontana, London, 1984, pp. 270-71.
[224] S. Vrobel: “Ice Cubes And Hot Water Bottles“. In: *Nonlinear Studies,* **Vol. 5**, No. 2 1998 pp.153-163.
[13] *mucro* means “referring to, or considering, the entire universe“.
[225] S. Vrobel: “Ice Cubes And Hot Water Bottles“. In: *Nonlinear Studies,* **Vol. 5**, No. 2 1998 pp.153-163.
[226] S. Vrobel: “Ice Cubes And Hot Water Bottles“. In: *Nonlinear Studies,* **Vol. 5**, No. 2 1998 pp.153-163.
[227] S. Vrobel: “Ice Cubes And Hot Water Bottles“. In: *Nonlinear Studies,* **Vol. 5**, No. 2 1998 pp.153-163.
[228] S. Timashev et al: "A New Dilaogue with Nautre: A Law of Evolution of Natural Systems." in: *Russian Jouranl of Physical Chamistry*. Vol. 74, No.1, pp.11-23, 2000.
[229] S. Timashev et al: "A New Dilaogue with Nautre: A Law of Evolution of Natural Systems." in: *Russian Jouranl of Physical Chamistry*. Vol. 74, No.1, pp.11-23, 2000.
[230] S. Timashev et al: "A New Dilaogue with Nautre: A Law of Evolution of Natural Systems." in: *Russian Jouranl of Physical Chamistry*. Vol. 74, No.1, pp.11-23, 2000.
[231] S. Timashev et al: "A New Dilaogue with Nautre: A Law of Evolution of Natural Systems." in: *Russian Jouranl of Physical Chamistry*. Vol. 74, No.1, pp.11-23, 2000.
[232] Ball, Philip, *‚The Self-Made Tapestry*. Oxford University Press, Oxford 1999.
[233] Ball, Philip, *The Self-Made Tapestry*. Oxford University Press, Oxford 1999, p.266.
[234] *http: // www.sdu.dk/tvf/statdem/Events/Chaos/chaos.html*