RESONANCES

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Part two

Chapter IX.

Let's put things in order

We will begin with an alphabet A.
The set of all words (generalized or not) which can be generated by concatenation of its letters is infinite and is called $\mathcal{A}$(A) the free algebra generated by that alphabet A.
We chose a finite set of words we will call fundamantals and which will be considered to have given and unanimously accepted significances*. We note this set by **F**. We include in **F** also words representing identification labels of the concrete objects we need to construct, i.e. to describe the construction of the systems to be studied.

(We do not ask ourselves what significance has the word „significance" : we assume that we, humans, know how to operate with this concept, as we are by our nature consciously thinking beings.)*

We build new words, not belonging to **F**, by defining them with the help of combinations of words from **F**, meaning that besides the concatenation operation a priori existent as it is attached to the concept of alphabet, we introduce a new order relation inherent to this construction. This construction is an act of defining, i.e. an act of attributing significance**.

*(** we do not ask ourselves neither what means „defining" by the same reason as above. We must strongly differentiate the usual language of the present paper giving us the framework to these questions which we will not answer, as the common sense has already answered them and another „language" based on the initial alphabet A and the set **F** of fundamental words.)*

As we have already argued repeatedly in connection to what we should do about defining or not defining and about common sense meaning, in the following section we have to make an exception and in order to construct the above mentioned order relation, we need to define „defining".
So, we define the **operation of defining** a new word by concatenation of a finite set of fundamental words separate one of another by the „space" character.
We will call **dictionary** an assembly of definitions, meaning new words, each of them being „equate" to a finite set of fundamental words separate each of another bt the „space" character.
In a dictionary there is an order relation we will call „**defining hierarchy**". We will say that a dictionary has order zero if it is identical to the set of fundamental words **F**. If a dictionary contains only words which have been defined only by means of fundamantal words, we will call such a dictionary having order 1.
If a word has been defined by using besides words from **F**, also words from a dictionary of order 1, we will call that word having order 2 and the dictionary containing it will be also of order 2.
In a similar way, if a word has been defined by using, besides words from dictionaries having

orders 1, 2, ... n-2, also words from dictionaries having order n-1, this word will be called having order n and the dictionary to which it belongs will have order n.

Let us call layer of order n the set of all words of order n in a dictionary. We will call a word A to be defined before the word B if there exists an uninterrupted string of definitions leading from A to B.
We will call the generating set of a subset of words being contained by a layer, the set of all words from the layers having lower orders which are necessary to define all words of that subset.
We will call proposition any generalized word containing at least one space character**.

(We will not need for the moment this definition, but when we will use properties of proposition sets, we should keep in mind that one can transfer these properties to the generalized words.)*

Any dictionary over a set of fundamental words **F** is included in $\mathcal{A}$(**F**), which is the set of all generalized words which can be built up starting from words in **F**.

Besides the order relation called above „defining hierarchy" existing in all dictionaries from $\mathcal{A}$(**F**) and meaning that a word is defined before another word, we will also use the order relation given by logic implication, meaning the order given by the significances of propositions, all those implications building together a theory.

In order to see how this third order relation appears, we will try first to define the concept of axiomatic theory. (other definitions will follow later : that of non-physical theory and physical theory, based on considerations about associations with numerical spaces.)

It is an unanimous accepted fact that an axiomatic theory starts from a finite number of axioms and contains all logical implications of those axioms. The logical implications can be „generated" and be „propagated" based on the significances attributed to the axioms and on the corroboration of the significances of two or more axioms taken together.
So, we have again some given significnaces, beyond any possibility of formalization, in the same way as axioms are given, and fundamental words of a dictionary.
This is why we could conceive an axiomatic theory starting from a finite set $\mathcal{S}$ of axioms from $\mathcal{A}$(**F**) and another finite set $\mathcal{S}$ of implications (called logical implications) given a priori, by definition.
Obviously, in order to have some logical implications, we need to have also other propositions besides the axioms. This is why an axiomatic theory will be built up starting from a dictionary $\mathcal{D}$ (including a set of fundamental words **F**), together with a set of generalized words obtained by concatenation from words of the dictionary and a set of implications given by definition.
Thence :
The set $\mathcal{S}$ of generalized words (with s elements) will be called the **set of axioms**, while the set which will help us to define the implications will be a new set $\mathcal{I}$ included in $\mathcal{A}$(**F**) and its elements will be called **immediate theorems**. Between the axioms taken in combinations of 2,...s-1 and the new set of words $\mathcal{I}$ will be given by definition a set of implications which will

be called logic implications. Each word in $\mathcal{I}$ is obtained by convatenation from words in $\mathcal{D}$, but no word in $\mathcal{I}$ belongs to $\mathcal{D}$. The set $\mathcal{K}$ of implications from combinations of elements of $\mathcal{S}$ to the elements of $\mathcal{I}$ are given a priori and represent the way the immediate theorems are implied directly by the axioms. These implications are the basis to the construction of the third order relation mentioned above.
The complete theory $\mathcal{K}$, included also in $\mathcal{A}(\mathbf{F})$, will be buit up with the help of logical operators $\wedge$, $\vee$ and $\neg$, while the logical implications will be the ones specific to logical computing. So, building up the theory will continue by extending the a priori implications from $\mathcal{I}$ by the classical logical implications.
How can we correlate such a theory to a numerical space in order to build up a physical theory ?
By taking into accout, on one hand, that any physical theory is regarding only aspects from the objective universe which can be measured and on the other hand, the fact that physics studies relationships between these measurable quantities. Third of all, we should take into account that any kind of measurement does not mean attributing to a measurable quantity a number, but an interval of numbers, in which the „true" value of the measured quantity lies with a certain probability.
This is why the foundation of quantum physics made by Jauch and Piron is attributing the logical values "true" or "false" to propositions of the type "the physical quantity X has the value lying in the interval I" and uses this type of propositions for the whole forthcoming construction.

Continuing our exposure leads to a dilemma of the kind "what was before, the egg or the henn ?". This dilemma, formulated in terms of our subject is : what was before, the measurement instrument, or the physical quantity ?
This means that we search for an answer to the question, which is the most natural way to start :
a.) From the measurable physical quantity conceived as an equivalence class of all instruments of a certain kind ?
b.) From an abstract notion, given a priori, by definition, while the principle of the instrument to measure it and becomes in this way a derived notion of the a priori given one ?
c.) From some concrete objects, called **calibration standards**, by generalizing a certain aspect of perceiving them ?
The theory Jauch-Piron considers the physical quantities to be some experimental arrangements given a priori, as the states of a system are also "defined" a priori as the results of some manipulations of the physical system, called the preparation of the state.
Nevertheless, coming back to the assertions from the last page of chapter VIII, Resonances part I about theories which existed before building up the instruments*,

(* Quote : "*we, the researcher of that certain unknown something, are identifying that something with a mental model which, after having built it, we can associate it to the set of instruments necessary to the research together with the values or intervals of values obtained by measuring and with the theories existing already before the construction of those instruments*").

we could take as "preexistent" theories those linked to the quantities for which humans have

already an intuitive perception and which they differentiate with the help of their senses, a reason to consider them as fundamental quantities. So, it is about quantities allowing to be evaluated subjectively by direct perceptions, like distance, time, weight, heat, light, colour, consistency, tear resistence, hardness, elasticity, etc., as it is detailed in Annex III (About memory, Resonances part I).

Such words could build a subset of a set of fundamental words **F** of the dictionary $\mathscr{D}$. Nobody and nothing could stop us from coming later with a more detailed and more extensive significance of the notion of physical quantity and implicilty also of these words designating the different physical quantities we have to work with.
As we already have stated, we will take in $\mathscr{A}$(A), more exactly $\mathscr{A}$(**F**) the set $\mathscr{S}$of axioms being the first step to start building a theory $\mathscr{T}$, submerged in $\mathscr{A}$(A), respectively in $\mathscr{A}$(**F**).
One of the next steps should be attributing numerical intervals. To whom will we be attribute them ?
As already mentioned, to a subset of **F**, which we will call the set **M** of fundamental quantities. With the help of these words from **M** we will obtain other, derived quantities which we will include in $\mathscr{D}$. as a subset $\mathscr{L}$(**M**) $\subset \mathscr{D}$.
$\mathscr{L}$(**M**) should be open to development, meaning to receiving „new members" anytime this is necessary.
Afterwards, we will take the set of all real intervals, which we will associate to each of the elements of **M**, and not only to these ones, but to all derived quantities from $\mathscr{L}$(**M**), in other words, we will define a measurable physical quantity.
So, the definition of physical quantities which correspond to a „preexistent theory" should be the set of pairs formed by each element of $\mathscr{L}$(**M**) with the set of all real intervals.
In other words, any such pair formed by a word **q** in $\mathscr{L}$(**M**) and the set of all real intervals is the set of propositions of the type :
„the physical quantity **q** has a value lying in the real interval **I**, where **I** covers all real intervals"
This is the set from which the theory Jauch-Piron starts and after revealing its mathemaical structure, this theory marks out the equivalence of this structure to the structure of the formalism of the classical quantum mechanics (the formalism of the first quantization).
To reach a conception about physical quantities as a generalization of the concept of measurement instrument or as a generalization obtained from labelling objects, but starting from a „preexistent tyheory" there is still a lot to build up.
Even if we did not yet define a physical quantity, we have found something to operate with, no matter which of the 3 alternatives a.), b.) or c.) from page 3 of the present chapter we will decide to introduce as a definition. So, we will operate with the help of the elements of the set $\mathscr{L}$(**M**) :
Before the level A.) (Resonances, chapter VI, the one about systems), we have the preexistent theory $\mathscr{T}$.
Then, through the levels A.-D.) we reach the point, the purpose of the system.
We have to observe that we reach the same result when identifying objects by labelling, of course this will be on a more concete level and one can reveal the purpose of a concrete system , built up from concrete objects.

This purpose consists in triggering a phaenomenon, no matter if this one takes place in an utilitarian instrument or in a measurement one.
Especially in a measurement instrument, this triggering aims exactly the phaenomenon we want to study.

This is the level where the human mind establishes what it wants to obtain : a concrete profit or knowledge. Now the human mind is testing the preexistent theory to see if this one can give birth to forecasts in connection to a **new, imagined or only forefelt phaenomenon***.

(Later we will call this level „**generalized sensor**" and that „construction" triggering the phaenomenon will be called „**signal generator**")*

But this level represents a description too, made also by words (propositions) which belong themselves to the initial dictionary if this one was from the beginning large enough, or to another one, specially enlarged to this purpose.
Still here, where we have the words representing the „components" of the system, we can define a „composition" relation of the system from its „components".
And in order to avoid a confusion between a composition law in algebra and this above mentioned „composition" we could call it embodiment law and we could try to define it in each case separately by a graph which will be unique and specific to the embodiment under study.
In order to get used to this concept and to get it „handy" we will try further to build up some examples.

Chapter X

Some simple examples of embodiment

Example 1 : the pump
Components : VA admission valve, VE emission valve, P piston, TP piston shaft, C cylinder being already set up to receive and mount in the valves.
Let us have the embodiment law „mechanical assembling where th components fit geometrically" and let us note it by @.
Then we could have the following compositions (embodiments):
VA@C=new_word1=cyilinder with VA. We note it by CVA
VE@C=new_word2=cylinder with VE. We note it by CVE
VA @ CVE = new_word3 = complete cylinder. We note it by CC.
VE @ CVA = CC
VE @ VA @ C = CC
C @ VE @ VA = CC, etc.
VE @ VA = ϕ, where this element will be something similar to the void set in set theory or to the proposition always false in propositional calculus. We will call it the absurd component, or the pointless component.
P @ VA = ϕ
TP @ VA = ϕ
C @ TP = ϕ
VE @ P = ϕ , etc.
TP @ P = new_word4 = complete pistonul. We note it by PC.

We observe that the dictionary gets permanently richer in new words, as long as these words have a significance. The significance is established by the mind analyzing if :
a.) two components can be assemblied
b.) the result of assembling can be a new element in a future construction. Here it is possible that at a certain moment assembling two components fitting together is pointless, but later somebody could imagine a way to use this combination of parts in a complete new construction.

Consequently, a combination of words obtained by concatenation could be regarded as the pointless combination, but at a certain moment this combination could get a new point or purpose and could be accepted as a new word in the enlarged dictionary.

We have mentioned above both combinations by concatenation and by embodiment (noted @). These are different things; let us look a moment to the differences and to the similarities.

Actually, the enlargement of the dictonary takes place in the following way :
When by concatenation of existing words the human mind associates to the resulted word a significance or in case the mind decides to create a new word hahving a well defined significance, then this new word will be introduced into the dictionary together with the explanations defining it and these explanations are of course a concatenation of words.
Taking the special case of the components of a system fitting together by the operation @ and the mind sees an utility to the resulted assembly, it designates this assembly (it creates a new word) and explains it (defines it). In this case, assembling by embodiment @ produces an object described by concatenation of words, thus we have to do with both operation : concatenation and embodiment and the resulted word designates the assembled object.

We still have to mark out the following aspect :
As we haved enriched the dictionary by new words, we have also introduced new signs, so we have practically enriched also the alphabet, while the new signs do not belong to a "ancestral fundament" of sounds, as we have established in chapter IV to consider the characters, letters, signs or whatever they can be called. What should we do with those signs ?

They have to get into the dictionary, that is obvious, it is a must ! But they have a special status: it seems that they should enter also into the alphabet !
This situation could raise trouble, because these signs cannot be used for concatenation, as words of the type $@\Phi\in\subset$ do not represent anything, they cannot even be pronounced, so if we will introduce them to the alphabet, they cannot stay together with the other signs. If such a sign appears in the dictionary in the layer "n" with a neat definition, there cannot be associate to it any pronounciation, any fundamental sound, it will be pronounced as the assembly of words which have defined it. For example, we will read the sign Φ as the void set, the absurd proposition or the pointless component, depending on the theory in which we use it. So, it is better if these signs not to wear the name "sign" or "letter" of the alphabet, but, as it is done in practice, to wear that that one of "symbol", and to be considered as short forms of words, instead of new letters of the alphabet. So, a symbol would be a word in the layer "n+1" of the dictionary having the same definition as a word in the layer "n", while the effective words of the layer "n+1" have definitions obtained by concatenation from words in the layers i, where $i \leq n$. (The definitions of the words from the layer n are obtained by concatenation of words from the layers i, where i cannot be equal to n).

It would be a too wide digression to detail different aspects of concatenation of symbols, of formulae, of significances of formulae, respectively of symbol calculations. They do not leave the logic of hierarchical dictionaries and obey the same laws.

Example 2 : An electric or electronic circuit.
If we had in case of a mechanical system the necessity that the components fit one to another conforming geometrical or mechanical criteria, the geometrical arrangement of parts in an electric circuit circuit is not critical and fulfills mainly ergonomical or design criteria. But what is counting really in this case is that the parts fit one to another according to their electric compatibility, while the functionality of the system, thus his point, his purpose is

given by the way the electrical signal is passing through the components. This electrical compatibility critrion is determining the mechanical "fitness" of parts, meaning the thickness of cables, the materials, the way and the place the components are fixed on the circuit board, the connectors, all that results from the the way the electrical characteristics impose some constraints to the coarse, mechanical structure of the circuit.
Thus, when describing an electroniuc system we do not get rid of the necessity of drescribing the underlying mechanical system. This means that according to the vision of describing systems with the help of preexistent theories, while is is sufficient to describe a mechanical system by associating to a set of words a set of mechanical quantities, in the case of electrical systems we have to associate to a set of words quantities from two preexistent theories : mechanics and electricity.

Example 3 : an installation to synthetize a chemical compound.
The role of the electric current in the preceding example will be played here by the chemical reagents. This is why selecting the materials and in a smaller extend, the geometric forms of the components of the installation will be imposed mainly by the chemical compatibility with the reagents and with the effects of the reaction intended to take place. The physical quantities playing the essential role will be the the pressure resistence, the thermal resistence and the corrosion resistence.
Here too we need for the description of the system by words to associate the description with two preexistent theories : mechanics and chemistry.

Example 4 : A molecular absorbtion spectrometer (UV/VIS/IR)
Leaving aside the electronic circuits necessary to automate the system, we will focus our attention on the electrical quantities and phaenomena making possible to measure the light being absorbed by substances. Although explaining the phaenomena of emission and absorbtion of radiation energy implies using of a quantum theory, from the point of vue of using a molecular absorbtion spectrometer, the theoretical explanations can be omitted. Concrete measurements of molecular concentrations and empirical correlations between different types of chemical compounds and their specific absorbtion wavelength have been done abundantly and to obtain results of measurements there is no need for more.
Regarding this kind of instrument, the central importance goes to the electric phaenomena specific to the photomultipliers and to the chemical phaenomena specific to the "unknown chemical object" under study. Also very important is the study of the lamp generating the radiation necessary to the measurements, because in such cases of phaenomena inaccessible directly to the human senses, measurement instruments have as a central element the pair **"signal generator/sensor"**.
To describe such an instrument there is the need of words corresponding to the mechanical construction and to the mechanical quantities associated to them, of words corresponding to the description of the electrical and electronical parts necessary to drive the instrument, together with the associate electrical quantities, but also thre new sets of quantities : the electrical ones tied to the photomultipliers, the optical ones necessary to obtain the interaction between light and substance, the ones necessary to describe the construction of the lamp and finally, the chemical ones, representing the purpose, the point of the whole construction.

Example 5 : An atomic absorbtion spectrometer, an inductive coupled plasma spectrometer or a mass spectrometer

In these cases our attention will be focussed on the electrical and chemical processes bringing the substance into the state of plasma or generating a monochromatric radiation, so we have no more under study molecular properties, but those of atoms, ions or radicals resulted by molecular decomposition.

To the words associated with the sets of quantities from example 4, one has to add the electrical and/or magnetical quantities corresponding th the state of plasma and those being correlated to the chemical propertiess of atoms, ions or free radicals.

We have to stop here, because going further, we cannot resume ourselves to quantities which are typical for preexistent classical theories : the particle accelerators, meaning the instruments helping us to explore subatomic structures impose the use of quantum theories and these ones include principles we did not refer to until now while developping the construction based on alphabet/fundamental words/dictionaries/axioms/systems.

This is why we should put an end to this chapter, although we did not yet really put things in order, but only a little bit, as should have been the title of chapter IX. For now, we intend to concentrate on the central theme of the paper, this is to try to “extract” the functionality of a system from the way the point of assembling of the components is subordinated to the point of the system itself and is representing actually the point of the system.

Chapter XI

The differences between the description of a system based on preexistent classical theories and that one associated to quantum or post-quantum theories. Different conceptions about physical quantities

Of course, th first of these structures is the one decribed in the precedent chapter, where the physical quantities are defined in a preexistent theory, based on direct observation and on the idea of existence of quite simple instruments as extensions of the human senses.
actually, most of the handbooks of physics do not approach the deep significance of the concept of physical quantity because, even if we have not yet focussed our whole attention on this subject, we met already some dilemmas. Physicists surpass usually these dilemmas by not taking them into consideration : if a specialist in one of the domanis of classical physics is asked what a phyisical quantity is, he will answer that this a property of matter which we can measure. If we put the same question to a specialist in one of the domains of quantum physics, he will answer that a physical quantity is a linear operator over the Hilbert space of square integrable complex functions.
Another possible answer we could obtain and which is based on another hypothesis being present in any preexistent classical theory is that the physical quantities are real functions, perhaps even rational. These functions have as arguments homogenous geometric solids having a centre of gravity or in case of fluids, the physical quantities are defined over the whole space they take in. Most frequently the solid body itself is not the argument of the function, but its gravity centre, meaning that the functions have not only real values, but also real argument.

Who can tell that an instrument measuring the thermal energy of a gas is equivalent to another instrument measuring the energy of a radiation wave or to one measuring the energy of a moving solid ? The answer is anew that preexistent theories can, because each of them has defined the energy seen in its specific way.
So equating instruments cannot be made by leaving the preexistent theories, but based on those, further equating is also based on calculations with real functions the way each theory is performing.
Actually, all physical quantities are derived from those of energy, space and time if we admit the assertions from Annex III (About memory).
Energy is the only physical quantity which transforms itself from one manifestation to another, many of the other physical quantities are specific to only one or to a few theories. So, there is a mechanical energy, a thermal, electrical, magnetical, electromagnetical, but there is no thermal length, nor tension of the radiation, and so one.
Actually in many situations one does not measure directly the desired physical quantity, but a certain aspect which, being correlated by calculations based on a preexistent theory, leads to

the aimed physical quantity. This is why in classical theories, calculations of values of a certain quantity by algebraic operations with functions representing other quantities is something usual and in most cases the corresponding calculation rules are given as definitions of those quantities.
It is much more difficult to see the physical quantities are interrelated in a quantum theory. This is why we should focus our attention on those theories, as we already have touched in previous chapters the notion of quantization, but until now we have not yet built anything based on this concept and we did not use any reasoning being specific to quantum theories, inapplicable to the other theories.
The concept of quantization is usually introduced either historically, by citation of experimental facts leading to glaring contradictions to classical theories, as well as citation of the solutions which have been found to eliminate those contradictions, or axiomatically by identifying the notions of physical quantity and state with some mathematical objects. There could be also a meta-axiomatical approach by founding those identifications with arguments based on general considerations about measuring processes and about the mathematical structures implied by the assembly of those processes.
The historical presentations, and in a larger extend the vulgarization digressions appeal in the first order to shocking aspects given by the fundamental differences of behavior between the classical and quantum physical systems : non-localization, tunnel effect, unpredictibility and in the largest extend, the dualism wave-particle.

It is worthwile to notice that most of the surprising behaviors of quantum systems come from that fact that common sense thinking hardly abandons the phylosophical model of existence of „ultimate particles", indivisible ones, no matter how they were called : atoms in the XIX-th century and elementar particles in the XX-th century. The idea of indivisible particle is actually sinonimous to that of „lack of any structure" : in its „inner", the elementary particle is „completely" amorphous. Otherwise it should have a structure and an interior, it should have components being in a relationship of functional interdependency, thus it would be no more indivisible.
If we refer to the considerations made about functionality and about interdependency of functional elements, we have to remind that the most important aspect of this interdependency is the fact that every element is related to all others, of a kind which is not simplist-mechanicist, but in a way in which the point of the system results from the points of its components and **mainly in the reverse way**, in which the points of the components are subordinated to the point of the system.
The „point" is a concept preexisting the concepts of space, time and energy, meaning it is „more fundamental" than these ones, so the „relationship to all" comes before representations based on a „middleware which is the space".
The assertion „the particle is indivisible" is opposed to the assertion „the particle is structured". And if is is structured, it is „composed" of „components" beyond the order of magnitude of the resolution of measurements made to circumscribe them.
Eventually, what are the experimental measurements telling us ? They lead to the conclusion that, in certain situations, meaning following certain ways of „preparing" the state of an assembly of „elementary particles", this assembly is behaving as if it were a wave and in other situations, as if it were an assembly of punctual localizations.

One can conclude that the sensor used to „record" what is happening to the assembly of particles is not completely adequate to none of these two situations.
Those „records" confirming the particle behavior bring us nothing new compared to conception of indivisible particles, this is why really relevant is that behavior which suggests a wave.
The wave is a concept which **cannot be defined in an isolated point in space**. This concept has a point only if one attributes values to certain physical quantitites for all space-points of a certain domain of the physical space.
A more general concept, a more „generous" one, having a higher capacity of significance than the concept of wave, is that of **field**. In newer theories, the dualism wave-particle, which is widely debated also outside the range of physics, is „swallowed" by by this concept consisting in the fact that the particle is considered a particular state of the material object named quantum field.
Obviously, the idea that a particle is composed of „components" in the same way a motor is composed of parts, disappears. But we can keep the idea that the human mind can perceive points (senses) on different generalization levels, in order that those belonging to a lower level of generality should be subordinated to a more general point (sense).
The idea of field is tied too to the concept of space in a similar way it occurs in the case of the wave, meaning that here too we talk about functions of real argument, these being defined as in the case of waves, in all points of a certain domain of the physical space.
As already mentioned above, I would like not to appeal in this phase of the exposure to the „middleware" which is the real three- or four dimensional space, but to take into consideration only relations between the „components" „building up" the physical system, meaning that **any physical system has a structure**, no matter how „simple" it is and that this structure has its own genesis based on structures on a lower level of generalization.
We try to develop the idea that „structuring" means „quantizing", because in a stable structure the concept of continuous transformation is not admitted.
A material functional structure is by its own nature discontinuous. The example below is trivial, but suggestive :
Replacing a part by another in a mechanical assembly can be made either by a part being made exactly from the same material and having exactly the same form and dimensions than the one being replaced, or by another part fulfilling certain compatibility criteria. It is the same in the case of an electrical circuit : the criteria allowing to replace a component having other characteristic parameters than the replaced one are given by the limits of „supportability" of the other components, as the maximum current, voltage or temperature allowing the system to work without to suffer damages. There are some thresholds, beyond of which transforming means **value jumping.**
To extend a little bit our example, even the idea of gear of an automobile contains a kind of rudiment of quantization, even if eventually the speed of the mobile can vary continuously. Actually these are steps of acceleration and the gear of an automobile is actually an acceleration „quantificator". The same „rudiment" can be found in any measurement instrument with more than one measurement range. This is a very important theme and we will come back to it when reaching the subject of the second quantization and renormalizable theories.

For the moment let us focus on the hypothesis of equivalence between the notions of physical functional system, structure, quantization, matter, space + time + physical quantities.
(we could be conquered by the idea to add also „information", but here, an important difference between information and the other notions raises : information is coded structure, while the other are intrinsic structure. We will reserve to this subject a special approach.)

Let us come back to the idea of hierarchy of points (senses) which is to be found in the range of intuitions, in that of direct perception of significances. We will not be able to mark out representations in the concreteness of physical space or in the concreteness of expressing of hierarchies in words until these representations are crystallizing on the mental level of intuition. This is the significance of the above sentence claiming that „*the „point" is a concept preexisting the concepts of space, time and energy, meaning it is „more fundamental" than these ones, so the „relationship to all" comes before representations based on a „middleware which is the space".*

Quantization does not come from nowhere, it **starts from a preexistent classical theory**, afterwards this one is quantified, when it becomes obvious that the idea of continuum is an illusion. Actually, the idea of continuum is equivalent to the idea of amorphism. Even more, in the study of physical systems as it is performed in classical theories, the notion of state is something trivial, without a large range of significance. It has more relevance when it is about states of aggregation or states of moving or non-moving.
But in the frame of the same state of aggregation or in the state of moving one does not take explicitly into account the existence of a set of states, meaning that one does not define and one does not study this kind of set. One assumes tacitly that in the frame of the state of moving there is a continuous infinity of sub-states, so that passing over from one state to another can be only continuously, while the effect can be observed by continuous modification of a physical quantity.
We have already mentioned that in classical physics, while studying the behavior of a solid, one follows the evolution of a continuous function which could ideally be assumed to be „defined" over the set of states of the solid, but actually this function is defined over the set all possible positions of the gravity centre of this solid. If this centre follows a certain curve, this curve cannot be else than continuous and the acceleration or the kinetic energy of the solid vary too continuously along the curve.
Let us take a few examples : the temperature of a certain fluid at a certain moment, the atmospheric pressure at a certain geographical place at a certain moment or the variation of it in time, the speed of solid in free falling after a certain time interval from the beginning of the fall. In these examples, the speed, the pressure, the temperature are considered to belong to the solid, to the material system, not to his state.
The solid or the fluid are considered to be homogenous media (in order to simplify solving such problems, they are supposed to be amorphous) and the possibility to be in different states is not interesting or irrelevant to what one aims. The associated physical quantities are supposed to be characteristic to the homogenous medium in its whole extend or to outer situation in which this one is placed. Coming back to the above examples, the temperature of the fluid is measured in order to establish the heat to which it has be exposed, rather than to determine its inner state.
The ideas of state and of discontinuity are used merely in connection to the state of

aggregation and the discontinuity appears at the threshold, for example from the liquid state to that of gas.
So, in non-quantum theories the physical quantities are considered to be real functions associated to the gravity centre of the solid or to the whole space filled by the fluid. Of course, these are extreme examples by their simplicity, but they are representative for the „classicist" thinking.
The speed of a moving solid is the first derivative of the real function describing the curve along which that solid is moving through Euclidian three-dimensional space.
The temperature in a point of the space filled by a fluid can differ from the the temperature in another point of the same space, the amplitude of a wave propagating through the whole three-dimensional space is also a real function having real argument and their partial derivatives obbey the conditions resulting from the heat equation or by the wave equation.
Nobody asks or nobody makes interesting or relevant statements about the state of the system or of the medium under study. Although it is not the case, the systems are treated as if we could not draw any interesting conclusion of the fact that they can have different states. And the point of the sensor, better said, of the couple signal generator/sensor would be that to deliver us the measured values of these functions. No matter how many different steps of transformation and amplification needed to the sensors to become effective extensions of the human senses, nor has any importance the complexity of the detailed way all components are working together to fulfill their purpose, from a theoretical point of vue, all waht counts is that supposes tacitly that those real functions have well defined values and are continuous, so that confidence intervals and statistic of the results would be a matter of metrological technicalities and not of modelling physical phaenomena by means of real continuous functions.

The quantum theories show great differences compared to the conception the classical theories, summary characterized above, are beased on. Quantum theories approach in a different way both the concept of state and that of physical quantity and this approach is much closer to what we have presented at the beginning of the present chapter, i.e. the conception implying that a physical system is a functional system having a non-trivial set of states ang being characterized by an „exterior" or by an interface of the kind „signal generator/sensor", or by a relation between the set of inputs and the set of outputs, as it is the case in the classical theory of systems.
This implies jumps in the set of states in the most natural way and we can say that it is not at all normal to expect that the values of physical quantities vary continuously. Furthermore, no serious metrologist will speak about the value of a physical quantity, but about the interval in which that physical quantity takes values with a certain probablility.
Basing on the idea of functional system, we can consider the states as functional states, as „operating modes", as hypostases of the way of functioning corresponding to different proper structural alternatives of the system. This is why they cannot pass continuously from one state to another. (As already mentioned, a continuous transit implies logically, by the significance of the concept „continuous", the lack of structure).
Also, the response to exterior stimuli, meaning to the signals coming from the signal generator will differ depending on the kind of emitted signal, otherwise said depending on the physical quantity whose controlled variation represents the generated signal. And this

signal will „chose" in a certain way the functional states allowing the system under study to respond in a proper way.
We could add that a system is the assembly of his possible hypostases of functioning, of his possible ways of operation, meaning that the system can be identified with the assembly of his possible states if we accept this point of vue.
One should probably add somethin g about the possible states of a continuum medium, of a fluid, for example. There are situations where a continuous medium can show discontinuities leading us to the idea of quanta : a whirl; this one either exists or it does not exist, while the number of whirls formed in a fluid can be only integer.
In connection to this example one can also add that, admitting the idea from this chapter about the equivalence between the concepts of structurizing and quantizing, it becomes obvious that „the first quantization" and „the second quantization" are absolutely conventional designations : in our example with the whirls, one can observe a first quantization of the continuous medium by the quanta of „rotating flow" which are the whirls, and a second quantization of the continuous medium by the molecular structure of the fluid. A third quantization is no more possible here because interrupting the continuum of the electron cloud of the molecular structure by the existence of the atomic and subatomic structures is no more effective on the initial continuous medium, meaning on the fluid where we have observed initially the existence of whirls, because the electron cloud of the molecule is another continuous medium, different from the first one.
We should also observe that a **continuous medium** is not simply a space of continuous cardinality, but it **is the result of regarding a discontinuous medium in permanent movement**.
We have entered anew a jungle of significances and representations and we have now again to get back to put a little bit things in order.
That we will do in another chapter.

Chapter XIII

Models of unknown natural objects in connection to constructed systems. Looking for the most natural way to introduce physical quantities.

When approaching the description of a natural system, the first example was that of waves on the surface of a lake: we have told that we are defining the system we want to study, by isolating it from those elements of the environment we think not to have any influence on the behavior of the system in different situations, in other words, we make a **cut-out**.
The above situations are different imaginary events, meaning parts of reality mentally isolated from their environment pursued in their time evolution : „event" is certainly something evolving in time. The researcher pursuing serioulsy and with perseverence a certain phaenomenon does not limit himself to isolate mentally a certain part of reality : he starts building an artefact in order to isolate really those parts of reality, meaning the real unknown objects or insufficiently known.
The artefact is the measuring instrument with its two main components : the signal generator and the sensor.
The signal generator is „responsible" of creating the „situations" mentioned above. And the sensor is transmitting us how the unknown object has reacted in a certain situation.
The signal generator produces a state transition in the unknown object and the sensor is reporting us what the object is doing in that new state.
The submicroscopic object or system cannot be perceived on his own, but only by means of the couple signal generator/sensor, so we, those people reseraching such parts of reality inaccessible in a direct way, cannot speak seriously about the unknown system, unless consiedring it as the assembly signal generator/sensor/unknown object and not as the unknown object on its own.
So, when we want to speak generally about natural systems, we can talk either of the assembly signal generator/sensor/object, or of the assembly signal generator/sensor without the unknown object , this latter assembly being only the outfit, the extension of the human senses, adapted to a hypothetical unknown object, thus to a mental object, being also mentally in concordance with a preexistent theory.
The hypotetical unknown object is exactly the model about which we wish to speak in the present chapter.
Being a model, it is „modelling" a real object and thus it must have at least temporarily, while working with hypotheses being about to be verified, a correspondent in the objective unknown reality. So it has to be describable by propositions (generalized words) from a hierachic dictionary being sufficiently rich to cover also the corresponding preexistent theory.
So, the unknown object as a model is a functyional system interacting with the functional system or systems signal generator/sensor described rigorously by the just mentioned

hierarchic dictionary. And in case this dictionary is not rich enough to cover the model too, has to be enlarged in order to cover it.
Until now we did not tell anything new, we have only reformulated and resumed certain aspects introduced and discussed in the previous chapters.

The completely new element is the following **AXIOM** triplet which are in certain extend justified in chapter XI, the one about quantization :

I.) To any unknown object considered to have a model and represented by a system having the form of a hierarchic dictionary, there exists at least one subsystem, which by composing with other systems can yield the initial unknown system. (**Decomposition axiom**)

II.) To any signal generator represented by a system having the form of a hierarchic dictionary, there exists at least one subsystem, which by composing with a subsystem of a model, either forms a new system, or leads to a state transition in the model. (**Excitement axiom**)

III.) To any sensor represented by a system having the form of a hierarchic dictionary, there exists at least one subsystem, which by composing with a subsystem of a model, either forms a new system, or leads to a state transition in the sensor. (**Measurement axiom**)

In order to give an „anchor"to these axioms in the conceptual region of the physical quantities, we will use the firm base given by the concept of calibration standard.
The calibration standard represents the starting point of the notion of physical qantity. It stays at the basis of numerical evaluation, thus at the basis of using numbers in detemining the „quantity" of something and thus at the basis of the idea that quantities are functions defined on the set of objects and having as values numbers. The same concept of calibration standard stays at the basis of the notion of measurement unit and goes back to the eldest times, when the provenance of the calibration standard was the most familiar environment : foot,cubit, span, finger, nail, grain, knot, sun (year), moon (month). So, the measurement unit is a material object used to compare another object to the first one and it is the fundamental instrument needed to attibute the value „1" to something in the exterior world, meaning in the objective reality. From here starts the whole operation of attributing values, afterwards of attributing numerical intervals and this is beacsue any attribution bases on that first attribution of the number 1 and takes it as a reference.
Concerning the definition domain of the functions which will be the physical quantities, we have to add that these functions cannot be defined over the set of objects, because the values can differ for the same object from one state to another, thus these functions have to be defined over a set of states. However these should not be the states of a certain object, but a set „collecting" the states of many systems, which should be grouped in conformity with a criterion of „compatibility" or „similitude".
It seems to be acceptable for the set of states not to be one definitively and a priori established set for all systems, because, first of all, not any quantity can be defined for all systems and second of all, the quantities have to be definible in the frame of a preexistent theory, which marks out that zone of reality on which the theory applies : some quantities are pointless in

the frameworks of certain theories.

Let us look more carefully to what happens while performing a measurement.
We have a signal generator as a hierarchic dictionary having at its top the proper meaning generator, the actual generator, for example an electron beam. Let us consider an appropriate (convenient) selection of states SG from the possible states of that generator. By „a convenient selection" we mean establishing those well known states of the signal generator allowing its control by correlating its states in a reproducible way to the values of a physical quantity which will be the „control quantity". In our example with the electron beam, the control quantity can be the discharge voltage which can be selected by the user by means of a control set up by the designer of the instrument.

Let this physical quantity be mG:SG---->I, where I is the set of all real intervals. The signal generator offers to the user by its construction the possibility to select a state of the electron beam, so that we can aim the value of the quantity, meaning the interval where we should find the value of mG (in our example mG is the discharge voltage).
This electron beam will interact with a system (a real object or, theoretically the same thing, a model compatible with the theory covering the reality domain to which the object belongs), leading to state transitions, both in the electron beam and in the real object or the model. Let us consider that this state transition is lifting the atoms of a certain kind from their normal state into an excited state, followed by the emission of a visible or ultraviolet radiation.
The sensor will be a photomultiplier, the top of the pyramid being the hierarchic dictionary dealing with "perceptions".
We will take now another quantity mS:SS--->I, where I is anew the set of real intervals and SS is a convenient set of states of the photomultiplier. The concrete designation of that quantity in our example is radiation (light) intensity.
To measure it, we have to compare it to the light intensity of a light source which we will by convention, take as a calibration standard, as a standard. So, the "**quantity**", meaning how great is the value, results from comparison of two situations or better said of ways of functioning or **functioning principles** of the same kind.
If a system can have a multitude of states, meaning a "multitude of operating modi" in the framework of the same specific working principle, i.e. specified until the last detail, so the general functioning principle is an equivalence class of a set of concrete systems "equated" on basis of a certain criterium.
For example, if the unknown object to be studied emits light, this light will be compared to the light of a light source which is wellknown from "all points of view". "Wellknown" means that one has established and unanimuosly recognized the way numerical values are attributed to to certain states of the photomultiplier in which this one has been brought by the external stimuli. In real measurement arrangements, a chain of effects takes place, as there are a lot of annecdotal examples of engineering kind in comedies or in cartoons : the high voltage generator gives rise to the electric discharge, this one gives rise to a flux of electrons, this one excites the atoms of the substance under study, these ones emit radiation, this one produces in the photomultiplier a photoelectric current, this one rises in the amplifying system an amplified current being proportional to the photoelectric current, and this one is measured and compared with the same chain of effects produced in the same succeeding order by a

wellknown light source, meaning a calibration standard .
Well, **where is the physical quantity in that description ?**
Where is the general principle and which is the criterion representing the basis to equate the in detail specified principles ?
At first sight we should consider equivalent all systems being able to measure light intensity and to establish by convention that they should represent an equivalence class to be considered a physical quantity which will be called light intensity. But before that, the concept of light intensity should exist, regardless of the existence of instruments, in order to not produce a vicious circle by defining this equivalence class named "light intensity" based on the instruments capable to measure light intensity.
Another approach could be to take the set of all devices or electronic components showing a photoelectric effect and to equate them by measuring their photoelectric current while they are irradiate by a light source considered as standard, afterwards to start from this standard to to equate the different readings generated by the different devices being irradiated from other light sources, to be also considered as standards.
In this way we have calibrated the scales of these "measurement" devices and have obtained an attribution of different numbers to different calibration standards, regardless of the devices. So, the scales once calibrated, the characteristic details of each device do not matter any more, but only the attribution of numbers/intervals.
Now we could start speaking of a physical quantity, meaning an independent principle having no connection any more to any specific instrument.
Regarded in that way, a physical quantity appears to be a generalized system, menaing that equivalence class we intended to find.
Nevertheless, this generalization depends on the set of calibration standards we have chosen and on the quantity "current intensity" we have used. So, the above sentence should be adapted in the following way : An electronically measurable physical quantity is defined as the equivalence class of measurement systems related to a set of calibration standards. One can see immediately that the calibration standards are another kind of systems than the measurement systems : they are of the kind "signal generator" or of the kind "system under study", while the measurement systems are of the kind "sensor".
Resuming, we can try once again to formulate a definition :
A certain set of signal generators can represent the basis to equate the set of sensors being sensitive to these signal generators, while the resulting equivalence class can be considered a physical quantity.
If, for example, the sensors would be sensitive to both wavelength and light intensity, chosing as calibration standards light dources having different colors, one can generate the equivalence class of sensors sensitive to wavelength, while that class could be represent the definition of the physical quantity "wavelength". The same thing can be said about intensity if the calibration standards are chosen to represent different light intensities for the same wavelength.

Chapter XIV

Physical quantities. Measurement units, scales.

We return to the alphabet being the start point of the construction of hierarchic dictyionaries and to the free algebra generated by it.
To any known concrete object in the environment we establish an unique label to identify it. As the set of finite combinations of characters of the alphabet is infinitely countable, we have not to worry about finding enough labels for the selected objects, especially as the set of known objects is finite.
We will include the set **E** of labels into a set **F** of fundamental words, enriched depending on the necessities of the construction.
Any existing concrete instrument can be represented by taking all labels of its components and by describing in propositions the way the components interact to fulfil the purpose of the instrument. Actually we describe the operating mode of the instrument, this one being identical to its purpose. The descriptions represent eventually the functional correlation of parts and that correlation can be described both by words and graphically. Propositions of the kind "the part labelled x is tied to the part labelled y" or "the part labelled x acts on the part labelled y" or " the parts labelled x and y act on the part z" can represent arrows in an oriented graph.
The equivalence between the logic sketch of a computer programme and the programme itself written in a programming language is the most convincing illustration for that correlation.
The equivalence can be extended on one hand to the concrete instruments and on the other hand to the principle sketches representing the functioning of those instruments.
Also, these two ways of representation we consider as being equivalent can be included in the classical formalism of systems as being relations between the set of inputs and the set of outputs.
If we want to be specific to the case of a measurement instrument, we will bring together the hierarchic tree representing the signal generator, another representing the signal generator and a third one representing the model, or rather their associated graphs.
We can submerge the whole assembly into a rich enough hierarchic dictionary, respectively into a over-graph to comprise all three.
A special problem will be represented by the model because here we have not concrete objects to label, so the graph and the description are "suspended in the thin air".
Furthermore we have to think of the clibration standards, we have to find for them too a place in this picture.
But first of all let us see what can be done with the model. Its "components" are hypothetical, so they are some thought entities, not observed to be real. But keeping in mind that concrete objects from the real world, in order to become „able" for mental operations, have to be first

reflected by thinking, we can simply declare that the "components" of the model are real and "observable" too (and kept as work hypotheses as long as they do not troble us by weird "behavior". So, we take the decision to label these "components" too, as they would be real and to operate with them as such.
With the calibration standards we do not have problems of that kind, they even are concrete objects, so we label them too.
The standards interacts with the couple signal generator/sensor in the same way the unknown objects do, or we can assume that the models behave in a similar way to the standards, the difference consisting in the fact that the standards are concrete objects or states of wellknown concrete systems, while their knowledge is unanimously accepted.
So, if we begin to know unknown systems or objects by studying them, even exploratory, there still exist some a priori ressemblance marked out by the intuitive mind, between certain unknown systems and certain wellknown systems, like calibration standards.
Thus, to take into consideration a particular aspect of an unknown system or to "look at it" in a special way, it is very important how the intuition is selecting the set of standards to which the unknown system or object should be compared. Closely tied to that selection is also the selection of the sensor corresponding to the chosen standards. About the signal generator there is not so much to tell, because some sensors can interact directly with the standard, while in other cases, the standards cannot "impress" the sensor but by prior interaction with a signal generator.
I think, we have reached the stage where we have all the elements to define a physical quantity by means of hierarchic dictionaries.
Let's resume :
We take an alphabet A and the free algebra $\mathcal{A}(A)$ generated by it.
Let's have **F** a set of fundamental words and **E** and **S** two sets of labels. We can consider **E** and **S** included in **F**.
Starting up from labels from **S** and words from **F** we build a hierarchic tree, respectively a system of oriented graphs to represent a **sensor**. To this, in order to become "the heart" of a measurement instrument, we will attribute a set of numerical intrevals in the following way :
We label with elements from **E** a set of objects or systems as being calibration standards, or better said, **we label a set of wellknown states of some wellknown objects***, by defining a function **s1: E-->I(R)** from the set of standards (or labels of standards) to the set of real intervals.

(the cardinality of the set of states exceeds the continuum in many cases, but when we use the expression "wellknown" we refer to recorded events, to facyts which have been already isolated and localized by someone in the past and verified to be reproducible by someone else. These events being already happened cannot have other than finite numbers. This is why they can be labelled).*

Afterwards we will proceed in the same manner with a second sensor and with the same set of standards, meaning that we will define the function **s2: E-->I(R).**
We will say that **we have defined a physical quantity** if s1(x)= s2(x) for any x belonging to the set E of standards, or generlyzing, if for any two sensors constructed with labels from **S**, we can define two functions sa and sb from **E** to **I(R)** the set of all real intervals, so that sa(x)=sb(x) for any x from **E**.

And the equality of the two functions for any standard from **E** means that the certified value of a standard is measured equally by any sensor.
But before to exist standard certificates containing certified values with calculated uncertainties, there have been **conventions**. It has been agreed by a significant majority of researchers to attribute to a certain object or to a system or to certain wellknown state of a welknown system, "perceived" by a certain kind of sensor, the number 1, for example. This convention is not a rational, deductive fact, it is a decreeing, a **decision** taken by a majority after having analyzed a proposition. There is no reason to tie to a certain object, namley a calibration standard, the value 1 and not another number, like 4.18 or 20000.(13) or any other real number. But as a next step after this decision in a natural way appeared also the notion of **"measurement unit".**
This unit has been afterwards divided and multiplied, resulting the sub-units and the multiples of measurement units.
This is the way one has "drawn" scales for any sensor.
What means a scale ? It means a "grid" of values distributed uniformly between the certified values of the calibration standards. The "mesh" of that "grid" is given by the uncertainty declared by the calibration certificate and by the sensitivity of the sensor, these two factors being those establishing the parameters of the grid.
Finally one obtains a finite set of disjoint real intervals of equal extend, consecutively arranged and with complete coverage from the minimum to the maximum value.
Now we know how to measure those calibration standards to which one has already attributed neat, undeniable values. The purpose of the existence of measurement instruments is to measure values in the case of unknown systems or unknown states of some systems. In this new case, the function **s:E-->I(R)** should be extended to an over-set **S(E)** of the set **E**, which should be rich enough to find inside states of the systems we want to study, while the extended function has to obbey to a severe constraint :
sa(x)=sb(x) for any x in the over-set **S(E)** of states, and this is not at all trivial.

Very often, the sensors, respectively the instruments containing them are fitted with more than one scale. What is their point ?
When we want to measure a quantity we expect to obtain a real value, actually a rational one, meaning epressible with a finite number of decimals and this value is submerged in a real interval.
But the scale has two ends : if μ is the resolution, the interval (Vmin,Vmin+μ) is the first interval and (Vmax- μ, Vmax) is the last interval, where Vmin and Vmax are the minimum and the maximum values of that scale. To any measurement performed by the sensor end to any calibration standard **eM** with a declared (or nominal) value lying between Vmax-μ and Vmax, the function associated to the measurement **s: E-->I(R)** will have the value s(**eM**)=(Vmax- μ, Vmax].
Similarly, for any measurement performed by a sensor **em** with the nominal value lower than Vmin+μ, the same function will have the value s(**em**)=[Vmin, μ) and if we put Vmin=0, we will have s(**em**)=[0, μ).
Let's suppose now we take a calibration standard with the nominal value beyond the ends of the scale, for example **em<** and **eM>**, we must have s(**em<**) = ($-\infty$, Vmin], respectively ($-\infty$,0] in the case Vmin =0, and s(**eM>**) must be [Vmax, ∞). This means that this scale cannot seize

the difference between a a higher value than Vmax and ∞, respectively between a smaller value than Vmin and -∞.
The case Vmin=0 is special because its approach is more significant if we refer to values becoming smaller in absolute value, meaning coming closer and closer to zero, than to values going to -∞. The value (-∞, Vmin] is to be treated symmetrically to the value [Vmax, ∞) and thus it does not bring anything new.
This is why we can assume without limiting the exposed problem, that the function s has as values onlz intervals of positive numbers.
Drawing nearer to 0 by finer and finer resolutions raises actually the problem of commutaition of scales :
The situation described above referring to the ends of the scale imposes selecting another scale being able to represent, respectively to measure values samaller than μ and higher than Vmax.
The extension of the scale will lead to poorer resolutions and and the contraction of the scale to better resolutions, but we will have more values which will be considered equivalent to + ∞.
This is why it is necessary to fit a sensor with more than one scale.
Of course, when the value of a measurement falls outside the scale, meaning it is placed at one of the ends, sending back the result [0], (-∞, Vmin] or [Vmax, ∞), the existence of several scales offers the solution switching to another scale, where we can expect a reasonable reading, meaning one with finite non-zero value.
Real problems arise when we represent graphically the extension of the function **s: E-->I(R)** to **s:** S(**E**)**-->I(R),** of course under the assumption that S(**E**) can be totally ordered.
Let's suppose we have succeeded in finding a totally ordered subset of S(**E**) and now we want to represent the function graphically.
Let' s also suppose we have managed somehow to introduce a topologies on S(**E**) and **I(R),** so that the graphical representation should have the aspect of a continuous line of thickness μ.
In addition to that let's suppose that for arguments growing in the sense of the order relation, the values of the function s grow too, get nearer to the end of the scale, and at a certain argument they begin to „get out of the scale".
In this case we must switch to another scale with a worse resolution μ1 and a higher Vmax1.
It is possible to obtain after a finite number of steps a graphical representation being completely in the scale, meaning that the value of the function s, which at a previous step was outside the scale, now at the new step, to be an interval within the scale. But it also is possible that we will have for an infinity of steps the value of the function s always at the high end of the scale.
We have thus the scales Iμ0(R), Iμ1(R), Iμ2(R), …..Iμi(R).... with i belonging to **N** and μi >> μi-1.
Similar things occur in the case of the other end of the scale, where we have the interval [0,μ).
If we reach after a finite number of steps a scale with a resolution good enough to obtain as a value an interval with non-zero ends, we can state as above that we have succeeded measuring, respectively that we have succeeded representingh graphically the function.
If this is not the case, meaning that, no matter how fine we chose the scales Iμ0(R), Iμ1(R), Iμ2(R), …..Iμi(R).... and the corresponding resolutions with μi << μi-1, the „reading" of the value is invariably „0", we have to ask ourselves what is happening.

A first answer in both cases would be that the sensor is useless for these states of S(**E**). What does it mean, it is useless ?
It means either that the interaction between the system whose state from S(**E**) we are studying and the sensor used for the measurement does not take place, or the interaction is a destructive one, while the destruction affects either the system or the sensor. So, the sensor type is not enough to define a physical quantity, as we have proposed in the previous chapter. What is to be done ?
We return to the calibration standards.
We try to measure the standard eM> with **a new sensor, functioning on a different principle** and allowing readings within the scale and not at the ends of it, so that the nominal value of the standard could be put in correspondence to an intreval of the new scale.
Here we are in the situation that **there are not for any two sensors** built up with labels from **S**, two functions sa and sb from **E** to the set of real intrevals **I(R)**, so that sa(x)=sb(x) for any x in **E**, meaning that we are not yet in the situation of having defined a physical quantity.
A short example : if we want to calibrate a thermometer filled with mercury at 1000 °C, we will always be at the and of the scale and we will not be able to perecive the difference between 1000 °C and +∞. But if we replace the mercury sensor with a infrared sensor we can calibrate a scale of this sensor where temperatures of 50 to 100 °C can be found, but also others correspoinding to orders of magnitude exceeding the boiling point of mercury.
And to continue the example with the general conclusion above, we see that the physical quantity „temperature" cannot be reduced to or identified with that of „thermometer", because the phaenomena representing the basis of temperature measurements, differ highly from an instrument to another. This observation brings us back to what we have established at the end of the previous chapter, respectively to the conception that a physical quantity can be caharcterized only by taking into account both generalized classes of sensors and generalized classes of calibration standards against which the sensors are to be calibrated.
How can we proceed in order not to stay in the stage of physical „pre-quantity", but to overcome this obstacle representing the inexistence of functions sa(x) = sb(x) for any x from **E** ?
First, we have to overcome this appearently glaring contradiction : the first sensor yields for the calibration standard eM> the value sa(eM>) = [Vmax, +∞), while the second yields for the same calibration standard the value sb(eM>) = [V, V+μi), where V is a rational number.
This can be obtained by adapting, respectively by limiting the scales for each sensor type.
So, let us take a set of sensors s1, s2,...., sn, which we will consider to be finite, because we intend to take into consideration only real sensors, and none from those to be potential, constructible or imaginable.
To any sensor we assign a maximal scale, given by the limitations of its functioning principle and of its concrete constructive peculiarities. This scale will be covered by a real interval Si = [Vimin, Vimax].
Let us define the function s : S(**E**) ----> **I(R)** in the following way :
If the nominal value of x from S(E) belongs to Si∩Sj, then s(x) = si(x) = sj(x), by definition.
If the nominal value of y from S(E) **belongs to Sk\+Si, where is different of k and covers all other values from 1 to n, then s(y) = sk(y), by definition.**
The function s defined in this way is a physical quantity.
Resuming, we can say that we have defined a physical quantity if we have found an

equivalence relation (with the corresponding splitting into equivalence classes) for graphs representing functioning principles of the sensors of the measuring instruments and another equivalence relation for the set of calibration standards which are measurable by at least a part of those measuring instruments.
In other words, if we succeed to split the set of sensors into equivalence classes, so that every class should represent another functioning principle, then to every functioning principle one can assign a different function of the type s, as it has be defined above.

We have also another possibility : to take equivalence classes on the set of couples "sensor-calibration standard", using the following model :

1.
Every sensor and every calibration standard is identified by a label.

2.
A couple sensor-calibration standard is compatible by definition if from their interaction is resulting a value lying in the interval (Vmin, Vmax), associated to the scale of the sensor.

3.
Two sensors are equivalent with respect to a calibration standard and to a tolerance if the values resulting from their interaction with that calibration standard are identical up to a tolerance established initially.

4.
Two calibration standards are equivalent with respect to a sensor and to a tolerance if the values resulting from their interaction with that sensor are identical up to a tolerance established initially.

5.
Two couples "sensor-calibration standard" are equivalent with respect to a tolerance if, taking into account that tolerance, both sensors are equivalent with respect to both calibration standards and both calibration standards are equivalent with respect to both sensors.

6.
Two couples "sensor-calibration standard" are equivalent with respect to a scale if they are equivalent with respect to any tolerance expressed as an interval included in that scale.

Chapter XV

Using continous real functions

In many situations one uses tacitly the hypothesis that the measured values and their corresponding confidence intervals are not so relevant for understanding the studied phaenomena, but an ideal phaenomenology, being beyond the inaccuracy and uncertainty specific to real measurements. This ideal phaenomenology seems to manifest itself in continuous spaces, having as their best representations the continuum of real numbers and real or complex almost everywhere continuous functions.
It is usual for most researchers to approximate by different methods of the numerical analysis those ideal functions after they have been constructed, and to retain the first few terms of the approximating function in order to compare the results obtaimed by these approximations with the results of real measurements. If the calculation results get close to the measured results one draws the conclusion that the ideal function initially constructed is a good theoretical reflection of reality. (Sometimes results having the same order of magnitude, i.e. the same number of zeroes or of decimal places, are considered to be significantly close to one another).
The sets of scales associalted to any instrument, respectively to any physical quantity are not considered to be inherent characteristics to that quantity, but rather technicalities of the measurement, some aspects of routine and concrete aspects of engineering.
We would like to introduce further the system with multiple scales for any physical quantity and to try to find out if this system brings significant novelty from a theoretical point of view.
One can see without any former argumentation that associating to a physical quantity an infinite set of scales is equivalent to give this quantity a fractal structure. To what purpose ?
To using the fact that the scales are limited by the constructive specificity of the sensor, to using the fact that due to this specificity, one has to attribute to each sensor another limitation, but this limit always exist. Is this an advantage ?
Yes.
Because it forces us to give up the illusion that the number $\square$ exists and that we can operate with it. Of course no serious person claims that this number would exist, but there are extremely numerous serious people acting as if they unconsciously believed that this number exists and are operating with it as if the hypothesis of its existence is obvious.
But introducing multiple scales is something very natural : practically, one repeats one of the ways of "obtaining" the set of rational numbers from that of natural numbers :
We will construct the following sequence of sequences :
First step :
0, 1, 2 , 3, 4, 5,....

Second step :
0.1, 0.2, 0.3, ...1.1, 1.2, 1.3, ...2.1, 2.2, 2.3,....3.1, 3.2, 3.3,....
Third step :
0.11, 0.12, 0.13,....., 0.21, 0.22, 0.23, ..., 0.31, 0.32, 0.33, ...1.11, 1.12, ...1.21, 1.22, ...3.11, 3.12,...

At the n-th step we will have :

$0.1+0.01+0.001+.....1*10^{-(n-1)}$,
$0.1+0.01+0.001+.....2*10^{-(n-1)}$,
$0.1+0.01+0.001+.....3*10^{-(n-1)}$,
.....
$0.1+0.01+0.001+.....9*10^{-(n-1)}$,
.....
$1+0.1+0.01+0.001+.....1*10^{-(n-1)}$,
$1+0.1+0.01+0.001+.....2*10^{-(n-1)}$,
$1+0.1+0.01+0.001+.....3*10^{-(n-1)}$,
.....
$1+0.1+0.01+0.001+.....9*10^{-(n-1)}$
.....
$2+0.1+0.01+0.001+.....1*10^{-(n-1)}$,
$2+0.1+0.01+0.001+.....2*10^{-(n-1)}$,
$2+0.1+0.01+0.001+.....3*10^{-(n-1)}$,
.....
$2+0.1+0.01+0.001+.....9*10^{-(n-1)}$
.....
.....
$9+0.1+0.01+0.001+.....1*10^{-(n-1)}$,
$9+0.1+0.01+0.001+.....2*10^{-(n-1)}$,
$9+0.1+0.01+0.001+.....3*10^{-(n-1)}$,

This fractal will allow us to express any rational number with n-1 decimal places by means of the n-th step. This means we can write in decimal form without any limitation any number with any chosen precision.
This means from a mathematical point of view that associating to any physical quantity a set with an indefinite number of scales does not impose any limit to expressing the results of measurements of physical quantities.
Furthermore, using this instrument could overcome a lot of prolblems generated by singularities, as follows :
If for a certain state x from S(**E**) and a ssensor with a certain maximal scale Si = [Vimin, Vimax], we will have the value si(x) = [Vimax, ◘), based on the definition of physical quantities given in chapter XIV, we cannot consider this value of si(x) as the value of the function/physical quantity, but we have to look for a sensor with a maximal scale Sk to fulfill Vkmax > $\gamma \times$ sk(x). In this case the value of the physical quantity is finite and equals sk(x). si(x) = [Vimax, ◘) is a false singularity, because it is only appearently infinite due to inadequacy of the sensor to the value to be measured. This way of avoiding singularities is not given structly by using the fractal structure, but this one is combined with the fact that we have kept in the definition of the physical quantity the different domains of the maximal

scales Si. This fact allows drawing a “narrower grid”, meaning a grid wich is not extending in the whole space covered by the fractal, by only that one cobered by the scales Si.
Another fact coming outside mathematics brings a supplementary limitation the framework given by the above presented fractal. It is about the Planck constant and the uncertainty relations of Heisenberg. The fractal will not „propagate” itself simply from one step to another as in the rule presented above, but it will have from time to time “jumps” giveb by these non-mathematical limitations.
If we were supposed to make graphic representations of some incommensurable quantities according to Heisenberg's principle, the “mesh of the grid” constructible by the fractal have to be limited by Heisenberg's condition, i.e. the product between the increase of the argument and the increase of the function cannot be smaller than **h**. Thus, we cannot “refine” the grid in an arbitrary way.
actually, transforming this mathematical object into a theoretical instrument dedicated to physics cam be done by restraining the strictly mathematical rules by the action of any “empirical” criteria found in physical reality.
Due to the above considerations we think that a fractal numerical space is more adequate to be used in physics than the continuous real axis, and that this is valid not only the case for the usual three-dimensional space, but also for all physical quantities. actually, the fractal scales should be chosen depending on the concrete problem to be treated, meaning this choice has to depend on the states of the studied systems and on the physical quantities we try to use in order to evaluate the unknown system we have under study. And such restraints as that mentioned above could represent a sort of “stamp” characteristic to each physical domain to which the study is applied. Nothing can us stop to believe that there might exist an infinite sequence of such “limitations” and that Planck's constant could be just the first term of this sequence. For sure, nothing can prevent us from believing that a simple, ideal fractal, obtained by equal steps and repeating to infinity the same the same rule **is not the best framework** to represent physical quantities, respectively physical phaenomena.

Chapter XVI

Establishing a model, cuts, labelling, systems, objects.

In the chapters VIII and IX, when we have shown how intuition creates new objects which we treat as if they were mentally reflected objects from the real environment and which we can label as they were real objects, we did not analize the following aspect :
The intuition generates at first a generic „mental object", meaning not a specified one. Thus, intuition creates directly a generalized object, not one having the same degree of concreteness as a particular object which is unknown, but supposed to exist in a certain concrete situation, while this supposition is born out of intuition.
So, the "first impression" sent to us by intuition while creating a new object comes from a generic class of objects and in order to start labeling we need to do some more "concretization operations". How ?
We have to decide if we will operate mentally with them as if they were the "material representation" of a concept, whose significance we have to evaluate, or if we will suppose to deal with concrete objects. In the first case we should take into consideration all imaginable (or possible) objects, but this would lead to a set which cannot be labeled because it is not countable.
If we will decide to chose the second case, we will have to suppose that there exists an unknown object in the environment which has generated those signals registered by the instruments used in our study. Even if the object is not a single one and actually it is a statistical population of **reproducible states,** these will be contained in a finite set and can be labeled. Thus, labeling is a extremely important condition to realize a cut.
How is this ?
We did not yet define the cuts, but we have used this word with its intuitive significance and now we need to approach it more carefully. Actually, we have **selected** different objects from their environment based on a certain criterion, and **the cut represents cutting those links between the objects and their environment which seems irrelevant to our purpose**, while the relevance is exactly the criterion of the selection.
What remains is namely the cut. That means the mental operation is the following : the intuition "decrees" that there exist the objects labeled with the labels {e1, e2, ...en} and that they form a functional system, meaning that their selection has in our opinion a "point" and other existing objects, which are not labeled, have no interesting links in our opinion to this "point".
The purpose of the selection is the "coagulation" of this "point" as we can perceive or imagine, it based on the knowledge we have in the framework of the pre-existing theory and also based on what the intuition has told us and what results we have obtained by measuring.
The model is the expression of this point and concretizing it is made by drawing arrows

between the vertices formed by the n labels {e1, e2, …., en}.
What will happen in the situation in which none of the imagined objects can be "linked" to an instrument, respectively signal generator and/or sensor, because there are not yet instruments able to detect or highlight the presence of that object in the environment ?
In this case the model will "live" only in the framework of the theory in which it appeared, but in the framework of this theory and **to the extent that we can attribute to this model sufficiently many properties, it can get the right to "wear" a label**. This "right" and this capacity are crucial, because they permit us to operate with countable sets and this we do all the time, even if we pretend to study continuous media, meaning objects which normally have to be attributed to continuous real or complex functions of real argument.
As we have observed at the end of chapter XI, perceiving of discontinuities or of characteristics of continuous media are the result of a certain way of looking. **If we adopt a viewpoit which marks out discontinuities** and additionally, **we restrain ourselves to a limited domain of reality, these discontinuities**, these quantum "perceptions" **become countable due to the limitations of the domain and thus, they can be labeled**.

But let us come back to the "life" of the model inside the theory : if the model has been sufficiently endowed with supplementary properties to offer concreteness so that it can be labeled, it means that the theory, drawn by intuition, has enough resources to "concretize" other imagined objects too. Thus, intuition could "create" an imagined reality being in accordance with the theory, meaning that there will not appear logical contradictions or paradoxes. This accordance will be considered valid until proven otherwise, meaning until somebody will descover an error or a logical discrepancy, a paradox inherent to the named construction or even experimental measurements which will contradict it.

There is still something very interesting to notice :
We have discussed cut-outs, isolating a certain portion of reality and we have also discussed physical quantities being representatives of a certain way of "looking" at the portions of reality we have isolated. This is why we share the opinion that "a certain way of looking" can be also a cut, but a different one : while the cut out takes what we are iterested in and lets apart what we consider irrelevant, "a cerain way of looking at" is sectioning, meaning it cuts through the portions of reality, it cuts them along the "cutting plane" consituted by that way of looking at. The best example for this "sectioning" are the two dimensional technical drawings of three dimensional objects : I do not refer to perspective drawing, but to showing together the sectionongs XY, XZ and ZY, which only being all three together can give a correct representation of the three dimensional object. And to keep in the framework of the same example, the cut out of the object means building a physical three dimensional model of the oject. Speaking of a model, it is easy to have in mind a comparison between the couple "model/physical quantities" and the couple "cut out/sectioning".
In order to apply the above observations to the to the couple "measuring instrument/calibration standards" we have to notice still another fact :
The working principle of an instrument is resulting after cutting out the objects which constitute the the instrument and after "extracting" the essence of "cohabitation" of those objects in the framework of attaining the functioning of the instrument. This concurs with finding the point, the purpose, the significance of that construction). This working principle

yields “a way of looking at things”, meaning a cut through, a sectioning. This one gives us the criterion allowing us to cut out a set of objects which will consitutute a set of calibration standards. Out of the set of all sets of calibration standards which have been selected based on a certain sectionong (given by a functioning principle), we must select those sets of calibration standards which yield compatible scales, meaning scales which can be obtained from one another by multiplicating with a constant factor. This selection of sets will represent an equivalence class. Afterwards we have to find the other equivalence classes giverb by the other sets of compatible scales.
Only now we have a physical quantity.

Chapter XVII

Special models : disconitnuities in continuous media

We have shortly left the argumentation againts using continuous functions of real argument and we already have to come back to that subject in order to analyze more carefully certain aspects.
A first example for the situation represented by the title of this chapter could be a wave. The number of maxima is an integer, so the imagery of discontinuities in a continuous medium is obtained immediately. This is similar for the case of a vortex, a tornado, for example, or in the case of a tsunami or in the case of the front of a sudden flood on a river.
It would be extremely simple if the light would propagate the way people believed still at the end of the XIX-th century, in the continuous medium of the hypothetical ether, exactly as waves are generated and are propagating in water !
But in the case of the particle beams the wave is built out of the particles themselves and not out of a different continuous medium. They form a continuous medium by themselves through flow or movement, in other words by the proper coherence of that particular particle beam, by its own coherence. This is another kind of continuous medium, completely different from what we can imagine in a traditonal way. **The particles are the discontinuities proper to the coherence of the beam they form.**
In order to lead the analogy further, in this case we have replaced the molecular cohesion in liquids by the coherence of the particle beam. While in a liquid the molecular cohesion forms the liquid by giving him the typical properties of a liquid, a wave is formed in this continuous medium by means of the cohesion forces "holding together the liquid in the state of liquidity". A gas is "hold together" by the "thresholds" of the vessel in which it is kept, the sound wave, for example is formed and propagating within the limitations of these "thersholds".
On the contrary, a wave packet of particles, a particle beam, has no cohesion similar to the liquid and has no constraint like a gas when a sound wave is generated in it. The "continuous medium" of the electromagnetic wave has not the properties of fluids . It cannot generate pressure, it cannot form currents (the most discussed etheric wind in the 19^{th} century does not exist) and it has a penetrability which is not comparable to that of fluids : it is beyond any power of imagination. The "structure" of elementary particles seen as functional systems fulfilling the axioms of the XIII-th chapter, "contains" elements of this ultra-subtle medium which can be characterized rather by the properties which it does not have, than by listing proper characteristics.
This medium is generating the structure of the most "weird" functional systems called traditionally elementary particles.
If we refer to the standard model of quantum field theory, in the framework of the formalism

of the second quantization, this misterious continuous medium is what is called the **vacuum state of the field**, this is a state in which the field is acting as if it were **devoid** of any structure, but in which it can **generate** any structure.
Perhaps this "vacuum" is not quite so "empty" and isn't also quite so "amorphous".
If we should find a "makeup" of an object or functional system, or "elementary" particle, in form of a "discontinuous" structure existing in a continuous medium, of the kind of a wave, of a whirl, of a vortex or of another kind, we should note that one can attribute to the liquid, as a medium with a limited expanse, the set of all its molecules (or clusters of molecules), but the same is no longer valid in the case of a wave or a vortex : one cannot atribute to the wave or to the vortex a certain subset of molecules, because the wave or the vortex are "entered" or "left" permanently by other "new" molecules from the "mother"-set. This discontinuous structure is built up in principle by all molecules (all constituive components) existing within the limited expanse occupied by that fluid.
And if we can say that a vortex is a perturbation of the cohesion of the fluid, we couls think that an individual particle is a perturbation of the coeherence of the particle beam. Logical loop ! Inadmissible !
Could it be possible to try the same method as used for systems of propositions ?
In a closed coeherent system S1 of propositions, if we reach a paradox inherent to this system, we have to "plunge" S1 into a richer system S2.
What means "a paradox inherent to the system" ?
A paradox which appears by using a sentence referring to itself and forming thus a logical loop* .

*
for example "the statement of this sentence is false" : if it is true means that it is false and if it is false means that it is true. In the same way can be characterized the sentence "this is not a sentence"

In order to avoid the paradoxes, one has to sumerge the system S1 of propositions into a larger proposition system S2, in which there is forbidden to have self-referring sentences, while statements about propositions in S1 are allowed only in S2.
The system S2 has to be protected of paradoxes by submerging it into a larger system S3 and so on at infinity.
In our case we need such a chain of inclusions comprising proposition systems which describe real systems.
This conditins is compatible to the axioms introduced in chapter XIII.
The above bolded sentence can be reformulated in order to make the self-reference more obvious :
We define "some thing" (for example a functional system) as a perturbation in a continuous medium formed by the "set of those perturbations".
We could try the following tranformation : we could generate from the proposition "An individual particle is a perturbation of the coherence of the particle beam" another proposition :
"An individual particle described as a functional system by a set of propositions from a hierarchical dictionary of propositions D1 is a perturbation of a beam of particles which can be described by a hierarchical dictionary D2, so that D2 should comprise labels which can be

used to describe the functional systems of D1".
In this way we avoid the "ethernal return" to an all comprising vacuum state, by using a "quasi vacuum state" responsible of the generation of a set of structures, while this new state can be "represented" or "produced" or "generated" by another "quasi vacuum state" of the second order which will be responsible of the generation of another set of structures, namely those structures being the fundaments of the first quasi vacuum state.
Having as a model the procedure of submerging the proposition systems S1, S2, ….Sn,... we can continue in this way to infinity.
We should rise the problem if labeling all those "components" which enter this infinite game is possible.
Our answer is **yes**, based on the fact that we can always select a finite domain of our "perception", because no matter of how large or small the scales are which will be used to "measure" the domains we will take into consideration (billions od light years or a billionth part of a femtometer), these values are definite numbers, of course finite ones. So, if the answer "yes" is justified, we could take into consideration a very important parallel between the fractal structure of the physical quantities and the fractal (or quasi fractal) structure of the misteriuous continuous medium, no matter if it will be called vacuum state or if we will "exhume" the old "ether" and disowne it of the properties proven to be illegal and will attribute it weird properties rising from taking into consieration of the newest conceptions about reality.
This conception seems to be not so far of the fractal structure of the curved and twisted space proposed by Nassim Harramein, a structure which makes it possible that "space generates massive particles".
Nevertheless, we claim the existence of a significant difference :
Based on the conception shown in the present paper, the space, including the space-time continuum, like any other physical quantity, appears in the human consciousness through a process (which is mostly unconscious, but evolving to an ever increasing degree of consciousness) which is modeled the way we have described it in the chapter about physical quantities (chapter XIV).
The structures generating particles (not only the massive ones, but any kind), "evolve" in parallelism to the fractal structure of space, but they should not be identified with it.

Chapter XVIII

Some formulations with more rigour

Definition 1
Let us take a set E1 of labels and a hierarchic dictionary D1 comprising them : E1 ✚D1.
Let us take also a functional system **s** built over labels from E1.
Let be E2 a set of labels taken so that for any label **e** from E1 there exists a functional system **s2e** built over labels from E2 and there exist also a dictionary D2, E2 ✚D2, so that the functional system **s2e** defined in D2 corresponds to the label e.
….....
Let En be a set of labels so that for every label **ε** from En-1, there exists a a functional system s**nε** built over labels from En and a dictionary Dn with En ✚Dn, so that the functional system s**nε** defined in Dn, for ✐n ×N, corresponds to the label **ε**.

We will call the pair **En, Dn a fractal level n-th order** if the sets En and Dn belong to sequences of label sets and sequences of dictionaries built in accordance to the above rule and if the systems defined in the dictionary Dn are all built over labels from En.

Remarks :

a.) Due to the decomposition axiom (axiom I in chapter XIII), we can include the notion of object in the extended significance of the notion of functional system. If the object is for example a pit of rock which simply "does nothing", its functionality is the identity function.
b.) In the general case the functionality of a system is not a function, but a relation and the description of this relation can be equivalent to its associated graph.
c.) According to the definition of the **model** (chapter XIII), the systems defined on the fractal levels n, for n ×N, are models and not systems identified and "measured" by means of instruments, meaning they have no experimental confirmation of their objective existence, but they are imagined objects (or systems) which are supposed to be real.

Definition 2

We define a **cut Tn on the fractal level n a selection (a set) of systems** (which can be simple objects, like in the above remark, or real functional systems), **which have been cut off their links to other systems existing on the same fractal level n,** followed by defining a graph corresponding to a system built out of the selected systems. This cut will be called **cut-out**.

Definition 3

Any measurement done to a cut-out, together with the set of measured values will be called **cut trough** or **sectioning**.

Remark :

d.) As we have not studied and identified models from fractal levels >n, for ✐n × **N,** we can assume about them and about their relations (links) to the other systems, anything we want, as long as these assumptions do not contradict the theories in which they have been defined.
e.) different sectionings represent different "ways of looking", in the same manner a real object in 3 dimensional space is represented in technical drawings by cuts along different planes.

AXIOM IV
Any model on the fractal level n has links (is related) to at least all models on the fractal levels n-1 and n+1 (**holistic relationship**)

Direct conclusion (I)
A cut Tn marks out the links between the selected objects (or systems, or models) and declares as being unsignificant all other links to the all other objects on the same level n. The definition of the cut makes no statements about the links to the models from the levels n-1 and n+1. We can suppose that these links remain active.
A cut takes the selected models out of virtuality and makes them able to be identified and studied by means of measurement instruments (tandems signal generator/sensor), so that the graph associated to the cut shall be that of the functional system defined by the system selection in which both the signal generator and the sensor are included.
The virtual links existing before doing the cut are supposed to remain unaffected.

Conclusion (II)

The links between models are supposed to exist without any restriction for any model with all other models, so we can consider that these are functions from a model x to his correspondent f(x), for every x being a model, meaning that every link is represented by a different function.
This is valid for links between both models on the same fractal level and links on different fractal levels.
Limiting ourselves to links on the same fractal level, we can draw the conclusion that the set of all links between all models on the same fractal level includes the set of all functions from Mn to Mn, where Mn is the set of all models on the fractal level n.

(To be continued)