

Introduction

Max Planck's discovery [1] that fundamental energy is discretely transmitted, together with Max Born's probabilistic interpretation [2], led Werner Heisenberg to formulate, in 1927, [3] the hypothesis that the emission of radiations is a statistical phenomenon. Once the condition of a particle is known, it is only necessary to define the probability for its location, since, at the subatomic scale, any actual measurement implies disturbing the measured object. Heisenberg's "uncertainty principle" affirms the inability simultaneously and accurately to determine the position and the speed of any subatomic particle.

We can, therefore, say that, in a phenomenological or analog scheme, systems and processes are described in terms of facts to be directly measurable in a larger scale, while in a quantum or digital scheme events are particular and need, for their formulation, the use of the notion of quanta. Statistics are necessary to leap from the quantum scheme to the phenomenological scheme. But this leap means moving from a lower scale to a higher scale, i.e., from a set of discrete, separate digital units to a constant analogical process. Indeterminism happens in all the possible scales, but its determination is solved at a higher scale by means of statistics. The problem of quantum mechanics is that at its own scale, the most fundamental of all, no statistical resolution of quantum phenomena can exist, since there is no lower scale. This conclusion forces us to assign indeterminism for particular situations. If the transmission of energy, which is how the relationship between a cause and its effect takes place, is not a constant flow, but a flow of quanta or discrete units, in the scale of these discrete units there is no need that such-and-such a unit should be transmitted at such-and-such a moment. From the point of view of a higher scale the transmission of energy is a perfectly analogical process, since it is statistical.

Structure and Force as the Two Complementary Sides of Things

The whole universe and its things are structure and force, which are made up by matter, energy, time and space. Also, the nature of these essential elements is essential for a true understanding of reality and nature.

Structure and force are the two faces of being and constitute a complementarity. They naturally issue from the concepts of matter and energy, which are the primary manifestations of the universe. That complementarity constitutes the universal, unifying and ordering principle of all things. The multiplicity of things acquires unity in this complementarity, because everything is simultaneously structure and force, everything originates in matter and energy, and is part of other structures according to progressive proportions. We perceive that things of the universe mutate and can conclude that the causal relationship is a force that transforms energy and produces change, and that the forces that are set free depend on the functionality of structures according to natural laws that can be known scientifically. In the course of the evolution of the universe, structures become progressively more complex and functional in ever higher scales.

The universe is not the container of things in a space-time referent, nor is the space-time field of causality. The universe consists mainly of the interaction of structures and forces that

produce the organization of matter while developing space-time. The dimensional parameters of time and space are understood precisely by the two terms of this complementarity.

The empirical basis to establish that force and structure are the two complementary, universal, constitutive, and transforming aspects of the universe lies in the distinction between matter and energy. For matter (as mass) and energy, Albert Einstein discovered their convertibility and equivalence, which he expressed in the famous equation $E = m c^2$. And as in the case of mass, the equivalence with energy in electrical loads has been established.

Structure

To understand the concept “structure,” one has to first analyze the notion “mass.” This notion was introduced by Isaac Newton [4] to explain both gravity and Galileo’s principle of inertia. Abstraction and simplification is necessary to describe physically the phenomena of force and change, but this interferes with a true understanding of matter. In spite of being evident that a set of mass points that conforms a body has volume, we would not advance much if mass is only seen in its ability to occupy places in spaces by belonging to bodies.

Even though a structure can be conceived as a material point without any extension, as in the theory of the gravitation, the location of a gravity centre, the distance to another body, and the amount of mass, are properties of matter. A structure is determined organized matter, and reciprocally, matter does not exist unless it constitutes a structure. One might imagine that a structure is a cluster of massive points without extension, occupying a determined space at a certain moment of time, in pre-existing space-time. But the significant issue is that no matter how small a corpuscle, it is functional and has aptitude to relate to other corpuscles in the same proportion. The relationship of two or more corpuscles generates a structure as well as a particular space-time.

Although a structure, in the perspective of dynamics, is reduced to mass and from the point of view of mass we do not find anything else than mass, the basic energy is condensed into matter that contains mass and other properties. All this produces an extraordinary functionality that allows the spatial for structure of diverse degrees of functionality and complexity starting from the fundamental particles. These properties are extension, volume, electric load, a composite of diverse types of subatomic particles. Each of them possesses spin, many of which have the form of corpuscle and also of wave, and are related to other particles for at least a specific type of the four forces. They subsist in time if they are not undergoing change. As simple the structured mass can be, it generates space-time and possesses some type of functionality through which it is capable to be a cause or to be an effect, of being the source or the recipient of forces, and of containing, accepting or yielding energy.

A structure is fundamentally the relation or the causal link that is established between two or more structures that, besides other specific functions, are functional to each other and vice versa, and becoming its substructures. In addition, the said structure acquires its own functionality by virtue of the functionality of its substructures and the relationship that the said substructures establish. For example, two atoms of hydrogen and one of oxygen relate because of

some of their respective functions, producing the structure of a typical water molecule, which possesses also its own functions, among these having specific weight, gravity and so on.

Due to its functionality, matter has the capacity to assembly itself, to be ordained, to be constructed and to be organized, i. e., to be structured. When we think about the notion “structure,” we shall understand also the ideas of group, constitution, order, assembly, construction and organization, disposition, arrangement, system, distribution, scheme, etc., which constitute synonymous of the possibilities of matter, and refer to constitutive parts of lower scales and are included in units of higher scales.

A structure should not be seen as rigid, as a building, or as anything geometric, as a molecule, or as anything static and permanent. A structure includes the more intangible things of nature, such as perceptions and ideas. In the same way, a structure is capable of generating force, and force is capable of structuring mass and electrical load. The mass-electric load operated by force acquires the quality of structure.

Force

In nature energy cannot exist in itself: either it is “condensed” in matter as mass and electric charge or it participates in the causal link between two or more structures (gravity, electromagnetic radiation, etc.). It therefore needs the intermediation of matter. Energy is a power that a structure possesses, and no structure can exist nor act without energy. Every structure can yield or acquire energy. In this action, it needs of at least another structure, and the relation that they establish is that of a cause and its effect. When a structure yields energy, one speaks about cause; when the structure acquires energy, one speaks about effect. But the energy that a structure acquires, while it is an effect, can be so large that the structure itself can be destroyed. Every transmission of energy changes both, the structure cause and the structure effect.

As physics understands it, energy is the capacity a body has to realize work. This capacity depends on the speed and the mass of a body –also on its electric load–. According to its definition, energy is the maximum work that a body is capable of and is half of its mass multiplied by the square of its speed. Thus we see that the energy of the body increases with the square of its speed. On the other hand, the speed of a body does not have an absolute frame of reference; it must be necessarily referred to at least a second body and has validity only with regard to this second body.

Structure and Scale

In the course of the history of the universe, whose origin was an infinite quantity of energy contained in an infinitely no-space point, it is possible to suppose that the big bang produced an enormous condensation of energy into matter. After this singular event and while, from the point of view of the big bang, matter –not space– remains expanding at the speed of light from the big bang, the net profit is that matter has been undergoing an increasing ‘structuration’, containing scales increasingly higher. As a consequence, if matter is the way of

condensing energy, the increasingly structured matter takes advantage of energy in an increasingly efficient manner.

To understand the causal relationship between structures due to force, one should introduce the concept of “function”. Any structure is functional because it exerts force or because it obtains forces. Function is what allows a structure to be a cause or an effect. It is the specific combination of forces of a particular structure, that is to say, this structure is particularly functional because it is cause or effect of a specific combination of forces. A function of any structure of our universe exerts weight, since all structures are composed of massive particles, though a structure can have other most decisive functions that distinguish it, like the logical relation of ideas.

In the same way a structure is affected in a determined mode by a particular force, a structure has a particular way to exercise force, or, to be a cause. Force is not an entity that exists independent of structure, because both are complementary. If every force is necessarily linked to some structure, the force is exercised according to the functionality of that particular structure. Force acts according to the way its complementary structure works. Similarly, the force acts on another structure according to its particular configuration for which is functional as effect.

Function can be defined as the specific way that a structure has of either being a cause or being an effect, i.e. the specific capacity to interact with the way other structures exist. The causal relationship is established by the pre-determination of the functionality of both structures that intervene in the transfer of energy by means of the action of force. A structure is functional in the sense that it is capable of generating energy as well as of receiving energy. The force belongs to the functionality of the structure's cause as well as the structure's effect. Without the functionality of both there can be no transfer of energy. If emission and reception of energy does not exist in a given time, the causal relationship does not take place. Just as any specific combination of forces is related to a specific structure, a structure is functional either as a cause or as an effect. A causal relationship needs at least of a structure that functions as cause and of a structure that functions as effect. If this does not happen, the functionality will be only potential. The degree of functionality of a structure depends on the efficiency in the use of energy, and a structure will have better possibility of surviving if it is more functional. Functionality is imperfect in most complex causal relationships.

The causal relationship is deterministic and works in the same way in all the situations where the conditions are the same. The base for the existence of the natural laws is precisely the fact that all beings or things of the universe are simultaneously structures and forces. The specific function or the way of a particular behavior of the structures is the basis for the existence of a certain natural law.

The things of the universe are structures that are hierarchically ordained in scales according to space and complexity. From the fundamental particles and up to include the totality of the universe, any structure is a substructure of some structure and contains in turn substructures. The substructures of the immediately lower scale are its digital or discrete units, while the structure itself is the analog scheme for them, determining their individual conduct by means of statistics. The structure of the lowest scale relates and organizes the fundamental

particles. The structure of the highest possible scale is the same universe, since it is the only existing structure that contains the totality of structures.

The structures are ordered in progressive and hierarchic modes according to the dimension or complexity of the scales. A structure is greater than its substructures, since it contains them. Also, a structure is more complex than its substructures, since, besides possessing the functions of its substructures, it possesses its own functionality. Every structure belongs to a certain scale and is composed by relatively heterogeneous structures of lower scales. In turn, it belongs as a substructure to structures of higher scales.

If one takes an evolutionary point of view into account, two processes may be distinguished. The first one is the functionality of the substructures, which allows for the existence of structures of higher scales, and which they integrate. The second one is the functionality of a structure that allows both its own subsistence and the creation of an environment for its own substructures. These two reciprocal processes make possible the explanation of evolution: on one hand, the functionality allows the leap into a larger scale when two or more structures of a given scale are related, giving rise to a structure of a larger scale; on the other, the super-structural functionality makes the existence of structures possible at lower scales. In a wider perspective, the environment of the universe allows 'structuration' in any scale, providing that the lower scales have already been structured.

Two types of hierarchic orders may be distinguished within the structure of the universe. First, from the spatial (quantity) point of view, the structures, including human beings, can occupy a determined place between the smallest structures of all, which are the fundamental particles, and the largest structure of all, the universe itself. Secondly, every structure occupies a place according to its degree of functionality and complexity. In consequence, while the universe, as structure, has been expanding, containing in itself an increasingly diversity of structures, matter has become more complex in the course of time by structuring things with more degrees of functionality.

The structures of all the possible scales of the universe are basically constituted by fundamental particles, as the bricks of a building. And buildings also have walls, roofs and floors. The things of the universe are composed by finite sets of fundamental particles combined in particular manner. The basic functionality of the fundamental particles, characterized by the capacity to exert force, allows for the particular structure's own functionality, regardless of its scale. All the forces known in the universe come from the fundamental particles, and a function is nothing but that a particular combination of the basic forces.

The fact that all the structures of the universe are composed by the same type of fundamental particles has threefold significance. First, it is the foundation that grounds the unity of the whole universe; the fundamental particles have the same behavior in the universe as a whole, which allows for the discovery of the universal natural laws. Second, the four fundamental forces that explain the functioning of all the things of the universe come from the fundamental particles. Third, it is the foundation what allows us to explain the mutability of things; things transform into other things, because its components in the fundamental scale can interact some with others and generate structures of higher scales.

The fact that there is a structural hierarchy of complexity indicates that an ever progressive order exists with respect to the higher scale. In this manner, the structure of a quark is composed by fundamental particles; that of a nucleon, by quarks; that of an atomic nucleus, by nucleons; that of an atom, by nucleus and electrons; that of a molecule, by atoms; that of an acid or salt, by molecules; and if we proceed in the way of biology, that of a protein, by amino-acids; that of the cellular organs, by proteins; that of a cell, by cellular organs; that of fabrics and fluids, by cells; that of an organ, by fabrics and fluids; that of apparatus and physiological systems, by organs; that of a living organism, by physiological systems; that of a social group, by living individuals; that of a biological species, by social groups; that of an ecosystem, by biological species, and so on. If we consider the scale “living organism”, we can reach up to the maximum known complexity, namely the human being.

The things of the universe are organizations of many scales of very diverse sizes, some being contained inside others, so that every scale is successively enclosing the lower scales. Thus we can understand that every structure, exempting the fundamental particles, is constituted by substructures as discrete (or digital) units. If a number of structures within the same scale form part of a viable and subsistent structure, the new constituted structure is functional. The substructures of the immediately lower scale are the discrete units of a structure, and are in turn structures since they are equally composed by discrete units in a lower scale. A structure is composed by the discrete units of the immediately lower scale, and these are composed by the discrete units of the scale successively lower, down the way that reaches the fundamental units, supposedly the substructures of the absolutely lowest scale.

Space-time

The following are basic propositions on time and space. The dimension of these parameters is related to quantity, since both can be measured and both can be used as measures. Both are the measurements of the movement of matter and through movement time relates to space. Time is what takes a body to move at a certain speed in space. A clock, which is an analog instrument that indicates us the time that is flowing, has this capacity because its gears rotate at a constant speed, and the spaces covered by every cog in every gear are similar. The regularity of this movement is given by the pendulum, which is determined by the constant of gravity. Time seems to flow at a constant rate. But its flow is determined by change which varies according to energy. Water evaporates at a constant rate if heat input remains constant.

The interaction of two bodies creates a distance. Three bodies create a triangle found in a two-dimensional plane. Four bodies interacting and not coincidental in the same plane generate four planes, shaping a three-dimensional space. In the universe this particular space is common to all its things that relate somehow to the mentioned bodies. The capacity to interact is possible because causally relate bodies belong to a common present that corresponds to the same space-time relative to their common origin in the big-bang. The speed of light is the maximum possible speed in the interaction of two bodies. If the speed of light were infinite, time would be null and void and the interaction between structures would be instantaneous.

Since Einstein we know that absolute time cannot exist in space. In the universe, things move in relation to an observer from zero up to the speed of light. Space and time are universal measurements for any movement, and both are framed by the speed of light as its absolute reference. Since the magnitude of the maximum possible movement in the universe has an absolute limit, namely the speed of the photon, Einstein concluded that space and time are relative, i. e., both parameters are correlative with regard to this movement with absolute value. He introduced the concept “space-time” [5] as two relative parameters that are related between them and have the speed of light as their absolute reference.

At the far end of the scale, the minimal distance between two particles, the smallest that can exist, is the number of Planck. Consequently, time and space are not infinitely small, as it has been generally supposed. Both parameters begin to exist starting from the mentioned quantity. Neither infinitesimal time nor infinitesimal space is possible. In the universe there is a lowest limit and a top limit for causality. The lowest limit is the dimension of energy given by Planck’s constant, which determines the lowest scale possible for the existence of the causal relationship. The top limit for this relationship refers to the maximum speed that movement can have, which is the speed of light.

What underlies all movement is change, the origin of movement. Movement is the visible and measurable side of change. Therefore, both time and space are the measures of the extension and the duration of a process. In both cases time and space measure a cause in relation to its effect. On the one hand, time measures how long it takes a cause to affect something and how long a change takes as it happens. In this sense the duration can last for a brief instant, or can last much more, according to the rule of natural laws. On the other hand, space measures the distance between the position of a cause and the position of its effect. When change is measured through the causal relationship, time becomes irreversible, because there is energy expense and energy regain, the ‘structuration’ of something, and the generation of force. Time cannot be identified with becoming, as Heraclitus assumed. Becoming is proper to movement. But movement is a particularity of change. Change is behind time, since it refers to the complete thermodynamic process where there is movement, but also transformation. A thing changes in a way so typical that we can infer a universal law, which makes a causal relationship be deterministic. Still, any single change possesses a fundamental indetermination.

The previous reasoning shows that the existence of time and space depends on the interaction of structures, which is the basis of change. The following step is that neither time nor space pre-exist things. Time and space do not exist prior to matter and energy, but develop or express themselves in every interaction of material bodies. If matter and energy manifest themselves in structure and force, neither time nor space can exist independently, but their existences depend on the existence of the complementarity. Time and space not only depend on structure and force, but they are temporarily and naturally *a posteriori*. Time is the rate at which energy is transferred between structures in the causal relationship. Space is the place configured by structures, now as substructures of their causal relationship.

In the first instant, at the beginning of time and when space was not even compressed into the infinitely small, only primeval and infinite energy existed. From this first instant, in what has come to be known as the “big bang,” when this primeval energy began to be “condensed” into

matter, and fundamental structures – mass and electric load – that exert force starting at the quantum scale, the becoming of matter, the development of time and the extension of space became possible. This development and this extension were not then, nor are they now independent from the conversion of energy into mass and electric load. The fundamental particles responsible for these two properties are highly functional and generate their own spatial fields of force within which they can interact causally.

The primeval energy, which contained the codes of all the laws of nature, has given rise to the subsequent ‘structuration’ of matter from its first condensation into fundamental particles and into intelligence, in an act of creation that does not have any known conclusion. Just as the structure of matter shapes space (space is inconceivable if not a part of a structure), the functionality of the structures that transforms energy into force makes time possible (time is generated by the causal relationship). So, just as structure generates space, force generates time.

If force is defined in terms of the alteration of the movement of matter in space-time, and matter is defined as its ‘structuration’ according to the spatial coordinates, then force will have to define time. In this equation force becomes free from space, since space is annulled for being on both sides of this equation. Inversely, this means not only that time depends on force, but that force develops time. We saw that energy pre-exists force. The energy that comes from a cause is always future time, is potentially existent. When it enters the spatial parameter, energy, mediated by the complementarity structure-force, turns into force, and time develops.

This idea is understandable if we think that force, which carries specified or differentiated energy, is the necessary inter-structural link between the cause and its effect; it is the meeting point between the structure cause and the structure effect. In order for an effect to happen it is necessary that its cause be mediated by a force if both the cause and the effect are to be identified by functional structures. In the causal relationship the cause generates a force that the effect consumes and, in this action, both are modified somehow. The force generates the causal relationship when the transfer of energy is actualized.

Since in any causal relationship a temporary sequence takes place, the force is the instance that intervenes between the “before” and the “after” of the event; it constitutes the “now” of the event that irreversibly modifies the structure. In any change there is a transfer of energy according to the first law of thermodynamic; any change is irreversible, according to its second law. Therefore, we can underline that force generates becoming and develop time.

An isolated event, a sole cause and effect relationship, does not say us much about space-time. It just manages to tell us that an event separates the before from the after in some place. The space-time dimension is the set of the multiple particular events that are successively related because they are being actualized at a certain time, which is the present for a certain place in space. But this dimension cannot be linear. Time is not independent from space. The succession of events is not given only in a spatial point. It includes an interdependent fabric of different events whose correlation is a matter of the position in space not just of the observer, who is a particular reference, but of the big bang, which is the absolute reference of the whole universe. The universe is the array of the causal interrelationships that originated in the big bang. And

because of this common origin, the universe has unity and its natural laws are fulfilled for all time and place.

I have tried to show that space is related to structure, and time is related to force. The universe is not the space-time field where forces and structures play, but the game itself is the space-time developed by the interaction structure-force. If the primeval origin was infinite energy contained in a non-space, its evolution in the course of time has followed the path of a constant and increasingly complex 'structuration', which has continuously gone develops space and consumes energy.

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