

THE EVOLUTION OF MATTER

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(I) PRELIMINARIES

(I.1) PRELUDE

What follows is the first part of a multidisciplinary endeavor, written by three researchers who have specialised in various aspects of the dynamism of human matter, with the common object of understanding its evolution. All natural forms of matter are related by the fact that all are products of the ongoing process of cosmic evolution initiated by the so-called Hot Bang some 13.7 billions years ago [**Science 302/5653**, (2003) p. 2038].

Thus the question before us is about evolution. More specifically, from the point of view of my present remit, the question is whether evolution can be fitted into a *Theory Of Everything* as an integral part of it. Such a theory, TOE for its defenders, is grounded on a set of beliefs: (a) that there is only one world accessible to us, (b) that such a world is in principle intelligible to a human mind, and (c) that a single language suitable for the representation of all that is observed can be created. This is a very ancient view, whose earliest traces in the records of our culture can be found in the pre-Socratics, in Plato and continues in a long line of their successors, all the way to the present. These assumptions, and the view they support, at first blush seem to be reasonable in the light of our collective experience. But a harder look at the science we have inherited and at the various contexts of its operations soon dispels this illusion. For the science we imagine and the science we practice are not identical, and not simply because it is an unfinished business. To see this, it is best to examine the limitations of science and the circumstances that attend its development.

The notion of *matter* employed in science is derived exclusively from its behavior, which is related to the energy exchanged in the process of observation. Therefore, the features of the evolution of matter are best examined against the background of the *cosmic* energy gradient, a consequence of the expansion of the space/time which followed the hot bang and continues to the present.

The first important feature to notice is that the *emergence* of natural systems occurs in *successive waves* down the *energy density gradient*, also referred to as Time's Arrow [Chaisson 2001]. The emergence of natural systems is the terminal point of a dynamical process of complexification whereby more elementary systems become enslaved by the high energy of the entangled fields that move them [Haken 1988, Eigen 1992, Peebles 1993], creating an energy gradient with the environment. It is *triggered* when the density of the background radiation left by the expanding universe has reached a critical value, defining the upper limit of the dynamical stability of the material system (e.g. life forms could not have emerged earlier in a much hotter environment for lack of dynamical stability).

This is a consequence of the mechanism of evolution, which proceeds by accretion of parts and is therefore *internal* to natural systems. Evolutionary waves are identified by some *new behavioral* property common to all the systems emergent in the corresponding energy band. In addition, matter tends to diversify laterally within the width of the energy band, exhibiting the same defining characteristic, e.g. life, by sporting some variant of it.

The second feature to be noted is the progressive complexification of *the internal dynamical architecture* of natural systems as the local energy density decreases. Material systems occupy space, starting with the appearance of the first *elementary* particles shortly after the hot bang. The phenomenon of energy transformation from a purely radiant stage to a spatial one is attributed to the most prominent property of energy, that of being quantised.

The third dynamical feature of matter is its *localisation in space and time*, wherein it acts as a singular material point, its behavior being *unitary*. The local manifestation of energy is sometimes referred to as a *collapse*, or as a *reduction of the wave*, but these are only metaphors hiding the lack of consensus among physicists on its conceptual perspective [Cini & Levy-Leblond 1990]. The importance of this form of energy is that it is the only observable one, the radiant form being known only through its effects on matter.

(I.2) METHODOLOGICAL PRELIMINARIES

(I.2.1) THE OBJECTIVES OF SCIENCE

Briefly stated, science is designed to represent nature as humans observe it. The original formulation of this objective goes back to ancient times, when Western understanding of nature was still largely mythological. By the sixth century BC, written evidence shows that this approach came to be distrusted largely because of its dependence on beliefs that were regional rather than universal, and socially based, recognized as a weak criterion of credibility [Freeman 1959]. A more general and complex criterion was progressively substituted, that effectively dissociated the operational rules for the representation of nature from the pantheon, the gods no longer having a role in the story to be told. This attitude has remained dominant in the scientific enterprise, more sharply focused on what can be observed.

From its inception in the sixteenth century, the methodology of the science of matter has been based on two independent pillars, the *observation* of what there is and the *mathematical representation* of what is observed. In the course of time, the *means* of observation and the *mathematics of representation* have become the principal instruments of science, and both have developed considerably in the last few centuries, more especially in the twentieth, with the need to replace the classical science of matter with the *quantum* science of the *evolution of matter*.

The implementation of this methodology has been constrained by four simple conditions whose satisfaction is required for any scientific representation of nature. The main details, which vary with the context of observation, will be given as needed in the rest of the chapter.

(a) The *Empirical Condition*. All *events* found in contexts of observation have to be accounted for in the representation of what there is. *Events*, in the relevant sense, are the *discrete traces* left locally by underlying dynamical processes.

(b) The *Externality Condition*. The initial set of events is then transformed into a set of *ordered data* by the projection, onto the observation plane, of a mathematical matrix which *filters the events* from a theoretical perspective. The data thus transform into *relata*. The validity of the transformation of discrete events into *relata* is conditioned on their existence being individually independent of the observer: without it, there could be no objective observation.

(c) The *Mathematical Condition*. The emergent series of *relata*, the *phenomenon*, is ultimately represented by a structurally perspicuous language, i.e. mathematically. The perspicuity of this complex representation is required to identify the events as data in the corresponding phenomenology and to warrant its empirical status. It is also needed to warrant its theoretical status by deriving it from the overall structure of the theoretical model, in accordance with the assumed unity of nature.

(d) The *Pragmatic Condition*. This condition adds further support to the mathematical armature elaborated by the theoretical perspective of nature. This is illustrated by the spectacular success of the new technologies based on it, and that of their numerous applications and discoveries, e.g. NMRI. They testify, up to a point, to the aptness of the theoretical tools used in the search for nature's secrets.

(I.2.2) MATHEMATICS OF OBSERVATION

Mathematical functions are used in the science of matter as the means of representation of structural patterns of behavior. They sport two distinct types of variables whose values are given on separate levels. On the *observational* level are *independent variables* that denote *sets of discrete events* in space/time, which are so called because of the *existential independence* of all such *events*; while on the *functional* (or *operational*) level of the mathematical function one finds the *dependent variables* - i.e. the *operators*- that *order* the discrete events, the essential process that transforms them into the *individual relata* in the *unifying structure*.

The discrete events thus defined may be viewed as the *givens* of nature, in the sense that their individual existence is not dependent on that of the others (any one of the events could exist or not, leaving everything else as it is), a defining feature of their discreteness. Their existential independence is the ultimate empirical foundation of the science of matter, and the warrant of the *objectivity* of its observations. It is the *single most important characteristic* which distinguishes it from all other disciplines with an interest in nature (for example philosophy, which is fragmented by exclusive interpretations of perennial questions, making for a plurality of various views). By contrast, the *externality condition*, grounded in the existence of individual events, is not affected by whatever principle governs their ordering, since it only stipulates that *all* of the *events* found in the domain of observation be *accounted for* in the ordering process, not excluding the spurious ones whose exclusion from the ordered set has to be justified. While the science of matter (i.e. the science of evolution, since matter is the only form of energy that can be directly observed) is

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While the science of matter, (i.e. the science of evolution, since matter is the only form of energy that can be directly observed) is grounded in singular events, its *evolutionary* character is to be found in the abstract *phenomenology* which represents their *ordered sequence*. When it is projected onto the plane of observation, its *representational value* is estimated in that context by the isomorphism of the ordered sequence of events wherein they play the roles of *relata*, becoming *data*. Observation, therefore, is made up of two sequential steps, an empirical one and a conceptual (mathematical) one.

(I.2.3) OBSERVATION IN THE SCIENCE OF MATTER

(1) *Observation* in the sense of the science of matter is best defined as a *Transactional Process of Energy Transformation* between two or more radiant sources *external* to each other. This externality condition is essential if the traces (*the events*) left in a domain of observation by the energy transactions are to be both *discrete*, hence *singular*, and *objective*, i.e. if their *locality* in space time is different from that of each radiator or source.

The *externality condition* plays a constraining role in the interpretation of the syntax if the language is to represent what there is. There are two groups of constraints, one grammatical and the other semantical.

(a) The *grammatical group* is inherent in the theoretical assumptions that determine how the conceptual notions are to be encoded in the *mathematical* syntax. The impact of these constraints is of two sorts.

(i) In the first place, they affect the *conceptual* architecture of the *theoretical models* through which nature is to be represented, hence understood. These models are not islands in the science of matter (they are expressed in the same language), nor is what they represent structurally independent of the rest of the cosmos, energy being non-local.

(ii) They also affect the *methodology* governing the application of these models to possible domains of observation. The methodology consists largely of *derivations*, from relevant theoretical models (for example, from an equation of state) of the mathematical structure of possible phenomenologies within specific energetic limits (a purely syntactical process).

This methodology also addresses the issue of the instrumental conditions required by the above derivation to articulate the strategy of observation, e.g. the energy range of the domain of observation. This stage of preparation, being entirely within the theoretical domain, is governed by constraints applicable to the available energy (a non observable) and is thus grammatical, not semantical.

(b) By contrast, the *semantical group* of constraints is designed to govern the *projection* of the mathematically derived phenomenologies onto the actual plane of observation. A *phenomenology*, as the term is used here, is the signature of a *type* of possible phenomena; it defines the range of the key parameters within which the phenomenon may be instantiated. The primary object of the actual experiment is then to determine whether the projected phenomenology has been instantiated within the constraints on its semantical variables.

A function of the above constraints is to rule out data free speculations in the science of matter. However, they do not warrant the truth of any representation derived from the theoretical models, they only rule out theoretical options not consistent with what is observed to exist within the scope of the conceptual perspective. Both groups of constraints are key elements of the foundations of the science of matter.

(2) Prominent also because of its inevitability, and more complex than the above constraints, is the *role* of the human observer in the representation of nature. In particular, two *sets of events*: $\{S\}$ may be distinguished in any human observation [Farre].

(a) The *first* is the set of localised events in *the transactional domain* of the two sources (or *radiators*), such as a material system. Let's called it the *instrumental sequence* $\{S_i\}$, and let one of the radiators assume the role of an *instrumental observer* (O_i) (according to Fermi, the *transaction* is a symmetrical exchange of energy between the two sources, each one is both a radiator and a receptor [E. Fermi/H. Bethe 1938])

(b) A *second sequence* of events $\{S_h\}$ is the result of energy transactions between an other *pair* of radiant sources, made up of the instrumental set $\{S_i\}$ and the *human observer* (O_h). The overall transaction is normally very complex, being effected by a whole series of hidden processes within the human neural system ultimately coming to *closure*, and emerging in the cognitive domain of (O_h) as an *ordered* sequence $\{S_h\}$ of the events in $\{S_i\}$. This second sequence belongs to the *transactional domain* between the two sources $\{S_i\}$ to (O_h), and is located in a complex (i.e. bimodal) human transducer [Pribram], that could be called a *conceptualiser*. Thus in the case of human observation we have two distinct sets of events localised in different *modal domains*.

(3) The question regarding the *objectivity* of the *empirical evidence* in the science of matter is to be addressed at this point. The answer to it lies in the relation between $\{S_i\}$ and $\{S_h\}$, which are not sequences of the same type, even though they are closely related. Being an instrumental sequence, $\{S_i\}$ is not conceptually ordered, while $\{S_h\}$, being the information of the human observer, is. As such, the two are fundamentally different belonging to different energy domains delineated by independent *energy surfaces*. These are manifestations of their locality in space/time, and also function as effective *energy shields* for the internal coherence of natural systems within reasonable energetic boundaries, as well as support the dynamical unitarity of the material system in its environment. The principal effect of the opacity of these surfaces to transactional processes between the radiating systems is that the sequences $\{S_h\}$ and $\{S_i\}$ are not

process whereby events become data.

As indicated earlier, $\{S_i\}$ is a set of individual local events existentially independent of each other (any one of them could exist or not exist, and everything else would be the same). Their temporal accretion in $\{S_i\}$ is not governed by an ordering principle that transcends the instrumental sequence: each event remaining independent of the others. By contrast, the secondary sequence $\{S_h\}$ is a complex set of *relata*, each individual datum supervened by a principle that relates it to the elements of $\{S_h\}$, whose data being created on a base provided by nature, a property of the acts of the human observer (O_h), not by the instrumental observer (O_i).

(4) The non-transactional processes that relate the two sets $\{S_i\}$ and $\{S_h\}$ on either side of the energy boundary are akin to the process of *quantum holography* exemplified in NMRI and in SAR [Schempp, Binz, Farre]. They ensure that the *conceptual* ordering of the primary sequence, when viewed in the same conceptual perspective as $\{S_h\}$, is *isomorphic* to it. Therein lies the *criterion of objectivity* for $\{S_i\}$ the *existence* of whose events (i.e. the givens of nature) is *prior to*, but *independent of*, the perspective within which the human observer (O_h) views them.

However science is human, and in the context of the science of matter, the instrumental observer (O_i) is *designed* to transact energy with a particular type of radiating source *within* the conceptual framework of the human observer (O_h), this in order to determine whether the primary sequence $\{S_i\}$, which is the recorder of the transactional processes that took place between the primary pair of radiators, is what was expected when the instrumental observer was designed. Thus the *experiment*, which is the means of observation in this context, is not a serendipitous accident but the result of a careful analysis of the assumed state of nature. The properties of $\{S_h\}$ are normally anticipated on the basis of derivations from theoretical models and of the preparation of the local energy profile (the experimental set up). Whether these expectations turn out to be justified is the immediate objective of the experiment, and their failure to do so will, if the preparatory work is ascertained to have been done properly, lead to a revision of the assumptions that governed the design of the experiment (Cf for example, the eventual replacement of CED by QED, following the changed appreciation of Planck's 1901 results)

(5) In principle, given the assumption of the unity of nature, the *grammar* of the language representing the behavior of matter should be universally applicable, even if not all of its resources need to be marshaled in every context. This may sound like a reductionist echo, but it is not. This language is consistent with both the non-locality and the non-orthogonality of the different modal fields which make possible the temporal series of modal domains, their quantal protectorates and their syncopation [Laughlin & Pines, Farre]

(6) To recapitulate briefly. In all human observations, we find two sequences of events, each localised in a different modal domain: $\{S_i\}$ and $\{S_h\}$, the observer in the secondary sequence being a human radiator. The two sequences are distinct, both locally and existentially: the existence of the primary type does not depend on the presence of any human radiator: each sequence being the effect of interactions of modally compatible energy fields. And the evolution of matter long antedates the emergence of our species. Each sequence is thus *existentially*

G. L. Farre: On Human Matter 2004: 7

independent, but *conceptually related* to the other, the ordering principle for $\{S_h\}$ being projectible onto the primary sequence via the design of the experimental set up.

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