SPACE-TIME; A CONCEPTUAL FRAME, OR A MIRROR OF BRAIN SYMMETRIES ?

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FOREWORD

For Blaise Pascal (1623-1662), philosopher and mathematician, time was something impossible, and even useless to define. He could do very well with this ambiguity, since it would not, for him, impede the objective meaning of this word. "Time is such. Who could define it ? and why should one try, since every one agrees with what is meant by when time is concerned, without need to say more". (The Spirit of Geometry). By the way, one may find out two concepts of time in western culture:

1) If one dwells on irreversibility of time processes with regard to reversibility of space operations, we could identify time with something like the "shape of the things to come"

2) If one lets aside relations of succession and simultaneity, we could see in time the motionless medium of all changes.

The first point of view was that of Newton (1642-1727), who promoted in physics an absolute time, at least up to Einstein. The second was that of Kant (1724-1804), for whom space and time are external shapes of our sensibility (he labeled this transcendental aesthetics !). Hence, space and time are not here concepts deduced by abstraction, but rather subjectivity and ideality of these forms of sensibility would warrant their objective reality. Grossly speaking, physicists have for long preferred Kant's concept to Newton's absolutism. To day, though, 4-dimensional Minkovski's space-time seems to favor a static rather than a dynamic conception of time, but Einstein did not fear to introduce a cosmic directional time, and we know that some fields of physics bear witness of an "arrow of time".

We shall, first of all, review some traditional conceptions of space-time, belonging to different cultural spheres; then, we shall examine some points of (modern) scientific theories. To sum up, we shall try a synthesis in shape of a conclusion.

1) TRADITIONAL CONCEPTS OF SPACE TIME; A SURVEY.

THE BIBLICAL SCHEME.

In our western Bible, the genesis text states that when Elohim created the world, "there was an evening, there was a morning: "day one ", and so on until "day six", thus establishing the foundation of chronology independently of sunset or sunrise scenarios since sun and moon were created only during the fourth "day".

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THE SCHEME OF CLASSICAL INDIAN COSMOLOGY.

In Indian cosmology, Parambrahman (the Eternal Father) makes arise from the inert nature (Prakriti) by his sacred word AUM, manifestation of the omnipotent force:

-KALA (time)
-DESA (space)
-ANU (atom, seed)

time is the seed of change inside the immutable; space is the seed of division inside the undivided. Collectively, in mass, the atoms are MAYA (illusion). Individually, they are AVIDYA (ignorance, separativity). These four concepts (word, time, space, and atom) are in fact but different aspects of the one thing. They look anyway like a striking prefiguration of the fireball scheme of western cosmology.

SPACE-TIME PHILOSOPHY OF SHRI AUROBINDO (1872-1950)

The original statute is that of a non-temporal and non-spatial Reality. Space and time would be the same Reality extending herself to obtain the unfolding of what was contained in her. Space and time are the names that we bestow on this self-extension of the one Reality.

The starting point of Aurobindo's analysis is the opposition between the unmanifested and manifestation. In a manner, one may say that manifestation belongs to a lower order of reality than the unmanifested, and that when we consider This which is supremely real, the manifested universe ceases to have any validity. The non-manifest is the non-temporal, the absolutely eternal, an absolute and irreductible being by itself, on which manifestation and its limitations can give only a limited, illusory and deceitful indication. One is thus led to the problem of the relation between time and the non-temporal spirit.

We are prone to consider space as a static extension in which all things stay, or move together, in fixed order; we see time as a mobile extension measured by motion and by events. A purely physical space could be considered in itself as a property of matter, but matter is a creation of energy in motion. Space, in the material world, could be either a basic self-extension of material energy, or its field of existence built by herself, its representation of unconscious infinity in which she is acting, a shape in which she stores formulas and motions of its own action and of its self-creation. Time itself would be the course of this motion, or yet an impression created by it, which would appear to us as a regular succession, backing up the continuity of motion.

At any rate, if spirit is the basic reality, time and space would be, either conceptual conditions in which spirit beholds its own energy motion, or basic conditions of spirit itself assuming a different look, a different mode according to the formula of consciousness where they are manifested. Otherwise stated, there are different spaces and times for each condition of our consciousness, either asleep or awoke, but each conveys some basic reality of space-time.

Thus, are time and space only subjective? in fact, mind-space and matter-space are the genuine spiritual extension, but translated by the mind into a subjective mental field, and by the sensorium into an objective field of sensory perception. Subjectivity and objectivity are but two aspects of a same consciousness, and the cardinal fact is that all given time or space is a state of being in which there is a motion of consciousness and of life-force, motion that creates or manifests the facts and the

events; it is the relation between the consciousness which sees the events, and the force which determines the sense of time and supports our feeling of the temporal motion, the temporal ratio, the temporal measure.

THE POINT OF VIEW OF IBN 'ARABI (1165-1241). SUFI MYSTIC.

As reported by Abdul Karim Jilî commenting on the "Book of spiritual Retreat", Ibn'Arabî stated in these terms: "...and know that the world fades out at each moment in the non-existence by the overwhelming victory of unity over multiplicity; and the same is produced at each moment by the authority of essential love- thus the manifested imposes its manifestation upon the first hidden thing, and the world is produced. Then , the hidden imposes its state of dissimulation upon the first manifestation, and the world fades out. Then, authority comes back to the manifest, and so on, ad infinitum...This scheme is called "recurrent creation ". The imaginary extension which seems to result from this flux of similitude is time, and motion is its measure."

This scenario looks much akin to SHIVA's cosmic dance in Hinduism. Surrounded by a flaming circle, NATARAJA (SHIVA) is dancing on a drum. This means that He presides simultaneously to the creation of the universe (by the sound of the drum) and to its destruction (by fire). Like in Greek mythology, the giver of death is also the god of time. (this is evidenced by one of the main names of his shakti, or feminine counterpart, which is KALI).

2) SCIENTIFIC CONCEPTS.

THE SPACE-TIME OF PHYSICS.

i) SPECIAL RELATIVITY.

Einstein's analysis of simultaneity did upset the traditional space-time concept of classical (Newtonian) mechanics, by stating that the relative chronology of two events depends on the motion of the reference frame in which they are recorded. The mathematics of frame change have been elaborated by Poincaré and H. A. Lorentz. So we speak of the Lorentz transform in the case of uniform motions, when space get contracted and time dilated in the direction of motion. In this theory, space and time are linked through the invariance of the speed of light (c);

ii) GENERAL RELATIVITY.

General relativity is a generalization of the concepts worked out by Einstein about covariance of physicals laws through varied reference systems. In this theory, one takes as space description a "manifold " where the presence of matter modifies and warps space-time.

The mathematical tool used is the positively curved 4-dimensional space introduced by the mathematician Riemann. The formulation of gravitation follows narrowly the tenets of this "manifold ", since the motion of massive objects borrows the geodesics of this space-time, i.e. curves with special curvature properties. The structure of this space-time is, in turn, conditioned by the presence of matter, and depends upon its detailed distribution among the scenarios unveiled by this particular space-time

system, we shall pick out the two most dramatic ones, fairly confirmed by recent discoveries in astrophysics:

1) The Fireball or "Big bang ".

An upsurge of primeval energy creates at once matter, and the space-time embedding it. The temperature of the "cosmic soup "decreases continually during the following expansion, and the various particle families of physics appear one after the other when their stability threshold is reached. The scenario could compare, in some respects, with that of Hindu cosmology.

2) The "Black Holes ", remnants of gravitational collapses.

A rich manifold of cosmological problems appear in this context; is the universe "open" or "closed"? is the original expansion still going on, or is it now slowing down? the present status of measurements does not allow yet a definite answer to these questions.

iii) SCALE RELATIVITY

The concept of relativistic invariance of physical laws under change of reference frame due to motion has been extended by Laurent Nottale to the case of scale change (dilatation or contraction). By deduction, Nottale proposed the concept of a fractal space-time -hence nondifferentiable- which gives account of many poorly understood "tricks" of nature (spurious infinite masses or charges, discrepancies,...); This non-differentiability proves also to be a clue for understanding time irreversibility through the distinction between forward and backward generalized derivatives. Through his analysis of the invariance of physical laws under changes of scale, Nottale established by group-theory methods new formulas for scale changes, very similar in structure to Lorentz formula for speed composition; he thus shows the impossibility of compressing space-time below a certain limit, which can be identified with Planck length ($1.61605.10^{-35}$ m), in agreement with string theory (a kind of "ring pass not», so to speak). It gives also a deeper insight on the physical meaning of electrical charge, and its relation to mass and motion, though the general problem of combination between scale relativity and motion relativity is a difficult and non-linear one. Anyway, a striking point of Nottale's approach is that he quantifies the non-differentiability of space-time by the means of...a partial differential equation of the Callan-Symanzyk type, used otherwise in quantum field theories. As regards astronomy and cosmology, this theory permits interesting predictions or explanations of new discoveries (infra-Mercurial planets around stars, quantification of speed in binary systems, ...)

SPACE-TIME, A MIRROR OF BRAIN SYMMETRIES ?

A SUMMARY ON NEUROPHYSIOLOGY OF THE BRAIN.

According to neurophysiologist Jacques Paillard, brain architecture results from a self-assembling process induced by genetic programs selected in the course of a long evolutionary history, and modulated by individual histories. The basic units of brain organization cannot be reduced to simple components like those of electronic machines. Each neuron cell is a complex systemic unit, and cannot be described in

terms of logical binary networks, but looks more like a microprocessor with 10^4 inputs. Thus the brain could, in theory, be considered as an assembly of 10^{11} interconnected microprocessors. In fact, these figures are deceptive, since the number of non redundant inputs activating a neuron is much lower than that of active connections. Moreover, each neuron does not operate like a universal microprocessor with interchangeable functions, but rather acts individually, with its own distinctive morphology, its individual history, its place in a neural assembly of interactive members.

Decision taking in this neuron system does not depend on the response threshold of a binary switch; they result generally from the consensus of large groups of cells whose individual "opinions" are differently weighted, depending on the changing ambient. This "democratic" polling is time-consuming and slows down the brain compared to fast computing machines. In turn, this modus operandi confers to the brain an astounding tolerance to errors and resistance to noise, an adaptive flexibility and a capacity for creative self-organization. Its data bases are permanently updated, enriched and amplified by its direct dialogue with environment via external sensory-motor loops, and by its self-knowledge via its instruments of self-awareness and conscious evaluation. these properties account for some of the surprising capabilities of human mind, as yet unsurpassed by the performances of artificial machines, and can explain to a large extent our perception of space and time.

The brain, a kind of "wet computer", is built up of two gelatinous masses labeled "hemispheres", grooved irregularly by deep furrows, occupying all the internal volume of the skull. Their total area, estimated about 4000 square centimeters, is shielded by a thin envelope 2 mm thick, the cortex. A microscopic examination of its external face reveals a myriad of small spots, which are in fact neuron bodies, perpendicular to the surface. Neurons are the basic components of the cerebral lattice. These components are interconnected by a dense network of conducting fibbers. The neurophysiologist must study this knotting to understand the connection mapping and to infer the distributive logic of the information circulating in the lattice. And how information is transmitted from one neuron to its neighbors must be understood to explain interaction between components and neuron operations. Contrariwise to computer analysis, the work of the neurophysiologist does not reduce complex systems to simpler elements, but discovers at each level of reduction a new world of complexity; thus, the behavior of neuron groups cannot be inferred directly from individual neuron behavior. As in the case of human groups, we meet interdependence phenomena, collective motions, influence conflicts and majority decisions, featuring a kind of neuron sociology.

If we consider now connection mapping, modern neuroanatomy provides us new techniques of analysis, including metabolic markers allowing an accurate tracing of junctions in local nets, and a systematic deciphering of interneuronal circuitry. These studies reveal the extreme accuracy of internal connectivity, but above all its mutability, its plasticity during brain growing, and a curious Darwin-like selection principle , which entails enhancement of functional circuits, while ruling out unused connections. There lies an important difference with the rigid and stable circuitry of artificial processors.

As regards the interfacial structures connecting neurons to each other, or "synapses", their structural and functional study has disclosed the subtlety of neurochemical

processes underlying and modulating their transmission capabilities. From the topographic distribution of these synapses on neuron membranes, from the nature of their chemical mediators, from the molecular features of post-synaptic membranes will depend a complex interplay of additions, subtractions, divisions, integrations, derivations, which make the neuron act as a genuine local microprocessor with varying functions according to its morphology and its location inside the brain. The study of synaptic functions reveal their extreme sensitivity to the effects of using (or not using) them, which establishes them as the privileged means of registering in the memories the exchanges of the nervous system with its surroundings. One may trace to this property the astounding ability of nervous system to detect stable or regular patterns in the flow of data coming from environment, or otherwise speaking to recognize invariant structures in this environment. This feature is of paramount importance in the genesis of space and time perception and conceptualization by the brain. At neuron level, data covariance contributes precisely to strengthen the transmission power of coactive synapses, while inhibiting at the same time out-of-phase synapses. the neuron-or neuron group-thus acquires the property to answer only to certain covariant inflow patterns, which corresponds to acquired predispositions of their synaptic structures, endowing them with a pattern recognition function.

We are facing here one of the fundamental originalities of biological systems, which consists in using systematically the historical dimension of events, treating it through the plastical property of their connectivity structures. The price to pay for this originality lies in temporal constraints, resulting in a surprising "sluggishness" of operations-compared of course to the speed of treatment of electronic computers;

Up to recent times, the structural complexity of the brain (10^{11} neurons for the cortex alone, 10^{15} for subjacent thick structures such as limbic cortex, thalamus, cerebellum,...) was rather appalling and discouraged detailed mathematical modeling-hence the success of stochastic models of neuron networks-but the discovery of modular architecture opened recently new ways of understanding brain structure and functions. Electrophysiological, histological and embryological data converge today to conceive the cortical mantle as a 2-dimensional array of elementary processing units, represented by vertical minicolumns, about 30 micrometers in diameter, and comprising for all the vertebrates a constant number of 110 neurons. These units seem to be grouped in bundles of about 1000 minicolumns, the number varying with location on the cortex. These bundles build up in turn functional columns of which diameters range from 300 to 1000 micrometers. The total number of minicolumns is estimated around 6.10^8 , and the number of processing units (constituting functional columns) is around 6.10^5 in human brain.

One realizes that, if the enormous complexity of the intertwining of billions of connections can be reduced by a factor 100 through the modeling of the brain with repetitive units of 110 neurons, the hope of a possibility of deciphering the internal microcircuitry of these columns is now open, though extremely difficult. There are also great hopes that a uniform internal logic could preside to the work of all these units.

Sensorimotor dialogue with the surroundings will help first to build and maintain the self-creating machine, to satisfy its energy needs, then will become a building tool, next an enrichment for a cognitive system, able in turn to deal with a mental

representation of its environment, and to draw a representation of itself in its memories. It is precisely from this self-knowledge that arises this singular experience that we call conscious, and which means the emergence of a new tool of regulation and of superior control, source of anticipation, of decision as well as indecision, of intuition, of imagination and creation, all of which artificial machines can offer only an *ersatz.*

A BASIC MULTI-LEVEL MECHANISM.

After this preparation, we may be a little more specific about the operating mode of the cerebral cortex, and we shall borrow from Yves Burnod (see bibliography) a mechanism that could explain the adaptive capabilities of the brain, such as visual guidance of hand motion, pattern recognition and language learning. Burnod adopts a strategy combining neurobiological and artificial intelligence approaches, relying essentially on anticipation schemes, and recreating a function consistent with experimental results.

The main feature of this theory is to propose a model architecture and functional rules at the four main levels of organization of the cerebral cortex;

-cell (memorization)
-cortical column (adaptive processing)
-maps (basic behavioral functions)
-network between areas (integrated learnings)

The generality of columnar architecture implies a functional unicity. The cortical process is basically an active " searching mechanism " able to memorize possible pathways in order to reach a goal from any initial position. It can explain two main cortical features, goal-directed behavior and active self-driven learning, which may be considered as building blocks of anticipative activities of the brain. This single process can construct various behavioral functions, depending on the input-output relations of each cortical area. In parietal areas, the mechanism can construct functions such as placement in space to reach a target; in temporal areas, it can recognize specified patterns independently of their size or retinal position; in frontal regions, it can construct structured sequences with several nested levels, such as word sequences in language.

1) Cellular Level

Each neuron type entails a particular function of space-time integration . It is at this level that we find the elementary memorization process, in a computer-like style. For this reason, Yves Burnod develops a general model of the neuron, which sums up its main capabilities of transmission, space integration and memorization. Each neuron receives a number of informations from afferent neurons by ion canals on specialized membrane zones. These various informations are progressively integrated, and the receiving neuron can memorize nervous information at 4 temporal scales at least, ranging from millisecond to long term assimilation. Burnod considers these processes as general, and applies this cellular logic to all neurons in the cortex.

2) Molecular Level

The cortical texture generates a mechanism of active searching of optimal combination of actions;

cortical columns form a 3D lattice, combining 2 types of afferences, thalamic and cortical, with several outputs on different layers. The input-output table generates 2 types of cortical activation:

i) thorough activation of a module produces a precise cortical action, but of limited extension.

ii) partial activation of a module, on the contrary, results in an extension of activity which propagates to the whole cortical network, inducing a phase of active research. This search goes on until the initiating modular action be executed, whatever the causal chain external to the cortex. This sequencing produces memorization conditions for the neurons in the column. These rules make the cortex to be the seat of a general adaptation mechanism rather than a simple organ for information treatment and memorization.

3) Tissular Level

Cortical connections form a matrix of systematic and redundant connections; at a superior level, cortical surface is organized into "maps". At the same time, the cortical mechanism defines modular extensions and activation sequences; it builds functional networks of modules which we may label "call trees". Thanks to the redundancy of combinations, the modular mechanism can build a sequence, then subdivide functionally a cortical zone into a set of independent modules. This property seems capital to explain the capacity of the cortex to generalize new learnings, then to differentiate them according to particular situations. These integrated actions may, in turn, be sequenced by the cortical mechanism in the same way as local cortical actions.

4) Global Level

The lattice of cortical areas transforms the general mechanism into specialized algorithms. cortical regions are devoted to specialized tasks: command of motions with a purpose, pattern recognition, vocal imitation, temporal organization of sequences, ...

at the global level, Burnod proposes a model of the network between cortical areas, recombining at least 5 different types of sensory-motor informations, either by privileged circuits realizing the main type of adaptation (audition-phonation, for instance), or by an interplay of symmetries; in this model, frontal areas and their connections are symmetrical (functionally speaking) of sensory and associative areas. For frontal areas, the connection network specializes them not only on a sensory-motor basis, but mainly through time scales: rapid positioning motion, behavioral sequences, fundamental programs and biological rhythms. Moreover, for longer and longer time scales, frontal zones will integrate larger and larger sensory-motor combinations. The cortical mechanism can thus build on frontal areas sequences with a variable number of embedded organization levels. The mechanism then becomes close to the piling-up scheme which allows computers to deal with arborescent structures. Building multi-leveled sequences makes possible coding and decoding of symbolic structured sequences, and thus allows the learning of language. In this way, we may say that tissular maturation, in conjunction with the regularities of the lattice between cortical areas, structure the cognitive development of the child, or of the young animal as well, on a lesser scale. For the human cortex has a geometry and a maturation mode which amplify considerably communication capabilities and sociabilisation of knowledge, language making cumulative the various individual adaptations.

To sum up, neurophysiologists reckon four major symmetries in the cerebral cortex. Three of them correspond to the main body axes, viz.

-Inside/ outside symmetry

-Fore/ aft symmetry

-Left/ right symmetry

The fourth one is the symmetry between the two main sensory-motor systems; audition/ phonation on one side, which can be related to our feeling of time, and vision/ manipulation on the other, which bestows feeling of space. During learning processes, the new relations, learnt in a cortical region, guide the construction of similar relations in symmetrical areas, which are interconnected between the two cerebral hemispheres. These systematical connections induce privileged functional relationships between symmetrical parts of the body. This symmetry is also implied in symbolic coding of sensory-motor representations of language.

1) Inter-hemispheric symmetry (left-right)

2) fore/ aft symmetry (between frontal and associative areas). This symmetry induces an isomorphism between space (associative sensorial areas) and time (frontal areas) This spatio-temporal isomorphism plays a major role in learning structured language.

3) Symmetry between lateral and medial faces of the cortex. It induces a symmetry between space information and molecular information.This symmetry gives meaning to sensory scenarios in relation with vital problems (relations parents/ children, predator/ prey, sexual partners, ...

4) Symmetry between the two main sensory-motor circuits (vision/ manipulation and audition/ phonation). These two privileged circuits are connected symmetrically with respect to Sylvius fissure. Owing to this symmetry, cortical mechanisms will systematically build algorithms coding cortical images (spatial) by sequences of phonemes (temporal) . Thus the major types of representation (molecular, spatial, temporal, visual, auditive) are systematically connected on the basis of the main symmetries described above.

CONCLUSION.

Inasmuch as we accept to consider universe as a big brain, or brain as a small universe, the ways of understanding reality combine themselves harmoniously, and offer a synthesis satisfactory for the mind (provided it be not too much demanding...).

Through our analysis, we seem to converge towards the concept of a kind of conscious energy, with a memory and a rudimentary state of autonomy, which expands itself while building its own representations. At an elementary level, this self-organizing trend manifests itself by certain regularities in thermohydraulic flows or cyclical chemical reactions (Bénard-Karman cells, Belousov-Zhabotinsky reaction).These regularities have been studied by the Nobel prizewinner Prigogine (1981) and his school under the title "dissipative structures ", of which fluid dynamic equations give a satisfactory account. At a more sophisticated level, one can explain the self -

organizing properties of neural networks endowed with some regular structures (Kohonen maps, for instance). But the higher we climb up in the complexity of phenomena and in the hierarchy of living beings, the closer we are led to the fundamental question: what margin of freedom is left to live and intelligent beings - man in particular- if an intelligent and self-organizing nature builds everything and weaves the canvass of events ? as write Ilya Prigogine and Isabelle Stengers in "The New Alliance" (1983):

"The change which makes beings to be borne and to die is it imposed from outside to an indifferent matter? or is it a product of an intrinsic and autonomous activity of this matter ?". To get out of this dilemma, we are led to confront the eternal problem of free will and determinism. as writes metaphysicist René Guénon (1886-1951) :

"The Being determines himself, not only in himself, but also in all his modalities, which are peculiar possibilities of manifestation. So, individual destiny of a being is determined by the ordering of the possibilities of manifestation in a logical succession, to comply with the specific modalities of the contemplated state. In the case of corporal modality, it is time which expresses this succession."

In fact, the point of view of chronological succession is only the expression of a logical and causal binding. Next, all things that exist in transitory mode in manifestation must be transposed in permanent mode in the unmanifest; then only manifestation acquires the permanence which warrants its principial reality.

So, it is not enough to consider time-this contingent and conceptual reality- to grasp the meaning of predestination, but we must get up to loftier and loftier levels, up to the Principle Himself.

This implies a vision of the world which is not only a linear sequencing of events, but also a synchronous perception of causes and effects in an extra-temporal perspective; it is the fee that René Guénon, just as Aurobindo, deems man must pay to be able to reach the contemplation of metaphysical order.

BIBLIOGRAPHY

René Guénon: Métaphysique Orientale (in French)

Les Etats multiples de l'Etre (in French)

Yves Burnod: an Adaptive Neural Network; the Cerebral Cortex.(Academic Press, Masson; 1987)

Laurent Nottale: Fractal Space-Time and Microphysics (World Scientific Publisher, 1993).

Shri Aurobindo: la Vie Divine (in French)), 4 volumes, Albin Michel. 1973

Jacques Paillard : preprint in Cognitiva 85 (in French).

Ilya Prigogine & Isabelle Stengers: La Nouvelle Alliance. 1983. (in French).