COSMOLOGICAL, QUANTUM AND UNDERLYING PRINCIPLES: CLUES TO THE FUNDAMENTAL ROLE OF CONSCIOUSNESS IN THE UNIVERSE

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There are a number of observational and theoretical reasons in support of the view that a variety of fundamental principles such as non-locality and complementarity may be underlying both the physical and the mental worlds. We first discuss evidence from quantum experiments that reveal spatial and temporal non-localities and from the cosmological realm, involving relationships of objects in the universe revealed by the so-called Universal Diagrams, as well as Eddington's and Dirac's observations of certain numerical coincidences involving physical constants and the existence of various cosmological correlations. The inherent limitations of cosmological observations and the apparent linkage of objects at different scales of the universe may be indicating that quantum-like effects are pervasive. A new type of scaling for physical parameters in the universe has been proposed by considering a relation between the fundamental masses and fundamental constants in nature. This allows us to develop an axiomatic approach towards the linkage between microscopic and macroscopic quantities.

These developments have made it plausible that certain fundamental principles cut across different fields of natural sciences and can be considered to hold universal validity. It is likely that quantum-like effects may be pervasive at all scales in the universe. If true, complementarity, non-locality and other principles should be applicable to other fields such as brain dynamics and open new ways of study. In the same way, one can search for analogous universal principles that hold in realms beyond the physical. If consciousness is the foundational substratum of the universe, principles developed in perennial philosophical systems should be even more universally applicable and cut across all levels of the cosmos, "internal" (*e.g.* individual mental and psychic, etc.) as well as "external" (*e.g.* collective unconscious, physical, etc.). We sketch here a possible new prescription for a unified "science", what I term *integrative science* that will encompass ordinary natural science and will extend it to realms where science has not been extended up to now. The prescription involves starting from the larger whole and then studying the particular components r parts, a reversal of the way that ordinary science proceeds. It also involves taking the statements of philosophical traditions quite seriously.

1. INTRODUCTION

It has become clear that quantum non-locality as revealed by the Aspect and Gisin experiments (Aspect, Grangier & Roger, 1982; Tittel, Brendel, Zbinden &

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Gisin, 1998; Kafatos & Nadeau, 1990, 2000; Nadeau and Kafatos, 1999) has demonstrated the inadequacy of classical, local realistic theories to account for quantum-like correlations and the nature of the underlying reality. The epistemological and ontological consequences are far-reaching (Kafatos and Nadeau, 2000) and imply a non-local, undivided reality. This opens the door for the thesis of a conscious universe. Drăgănescu (1998a,b,c,d, 2000a) and Drăgănescu and Kafatos (2000a) have explored the thesis of a *deep reality*, paralleling the thesis of a conscious universe. Moreover, Drăgănescu and Kafatos (2000a) explore the possibility that foundational principles operate at all levels in the physical as well as beyond the physical aspects of the cosmos. These foundational principles are meta-mathematical or pre-mathematical in the sense that mathematical constructs of the physical universe emerge from them. The cosmological evidence and its association with quantum principles has been explored before (see Kafatos 1998, 1999).

The inability of physical science to solve problems concerning the nature of ultimate reality and also to contribute to an understanding of the nature of life and of consciousness may be indicative that, rather than pursuing different paths in trying to understand them, these realities ought to be considered together, an undivided whole. Perhaps we cannot explain life, mind and consciousness without knowing the nature of the underlying reality and this may necessitate exploring the foundational framework for this underlying reality. Such an axiomatic approach may allow the question "is consciousness the deepest underlying foundational level of existence?"to be posed, which presently appears to be beyond the reach of science. Related questions such as "does the deepest existence possess the ingredients necessary for the emergence of life and mind as we know it?"; "how are energy, substance and information related to the principles of the underlying reality?", etc. (Drăgănescu and Kafatos, 2000a).

If truly universal, these principles should apply at all scales. For example, Roy and Kafatos (2000a) have shown that a generalized principle of complementarity is applicable to brain dynamics, in processes operating in the cerebellum. Non-locality also appears to be prevalent at different scales. Quantum theory has shown that the whole is not just the sum of its constituent parts. For example, the quantum vacuum is much richer and complex than any system of particles interacting among themselves. Studying particle interactions, no matter how complex, will not tell us much about the vacuum as the latter is unaffected by such interactions.

These developments are indicative of the need to develop a new way to approach problems that have so far eluded ordinary physical science. If indeed consciousness is primary, or universal and underlying all phenomena, then a study of physical phenomena, no matter how complex, will not yield any deep insights about consciousness and will, at best, only provide some hints of the deeper reality. In other words, the successful reductionist approach that has yielded so many advances in science cannot be applied to the science of wholeness.

Starting from the premise that consciousness is the underlying foundation of the physical, mental, psychic and all possible realms, one needs to look at the systems of philosophy dealing with consciousness. As such, universal statements of the different perennial philosophies, which are directly applicable to consciousness, may be the starting point for a new science of unified knowledge an *integrative science*. For example, one can examine principles and statements found in ancient Vedanta and Shaivite schools of thought and find their "reflection" or analogy at the physical realm. Then one can look at the insights gained to seek new developments in the integrative science, which includes the physical world. This is certainly a reversal of the usual scientific method, here we start from the whole, from the general, from the universal, from the unlimited and we end to the individual, the particular, the limited.

We first examine the applicability of a few generalized principles in the cosmological and brain fields of study. We then look at certain universal statements of perennial philosophies and proceed to outline the new methodology.

2. THE COSMOLOGICAL REALM

The most accepted theory of the large-scale structure of the universe is big bang cosmology which has achieved impressive results (Silk, 1989). Yet, any general relativistic Friedmann-Robertson-Walker big bang model, as well as any other non-big bang cosmological model, cannot be considered outside the process of cosmological observations, and is ultimately intricately interwoven with limits imposed by the process of observation itself (Kafatos, 1989, 1996, 1998). Any theoretical construct predicts *horizons of knowledge* at some ultimate, faint observational limit. For example, for the big bang theory, light cannot be used to observe further back in time or for very large redshifts (redshift being the relative difference of the observed from the emitted light, which in the big bang cosmology is a measure of the distance to the source) to test the big bang theory close to the beginning. The whole cannot be studied from the parts, the beginning is forever hidden from the present. Ultimately, observational limitations prohibit verifying cosmological theories to *any degree of accuracy for any observational test*. For example, for all practical purposes, the big bang galaxy formation theory runs into verification problems at redshifts, $z \sim 4 - 10$, close to distances discerned by the *Hubble Space Telescope* and future space telescopes. The reason is that the type and evolutionary history of the "standard candles" (such as galaxies) used to measure the Hubble expansion rate and overall structure of the universe cannot be unequivocally determined independently of the cosmology itself (Kafatos, 1989).

2.1. COSMOLOGICAL CONSTRAINTS

In cosmology, there are a number of facts about the large scale structure which must be considered. These in turn provide constraints for physical theory.

- The universe is essentially flat, known as the

flatness problem

$$\rho_{crit} = 2 \times 10^{-29} \left(H_0 \Big/ 100 \text{km s}^{-1} \text{ Mpc}^{-1} \right)^2 \text{gr cm}^{-3}$$

where H_o is the present-day value of the Hubble constant. If the universe is close to being flat today, it was *exactly* flat close to the time of the big bang itself, to one part in 10^{50}.

The density of the present-day universe is close to the closure or critical density, the limit between forever expansion and future re-collapse, or

$$\rho_{crit} = 2 \times 10^{-29} \left(H_0 \Big/ 100 \text{km s}^{-1} \text{ Mpc}^{-1} \right)^2 \text{gr cm}^{-3} \qquad (1)$$

where H_o is the present-day value of the Hubble constant defined as $\dot{R} / R$ and R is the scale of the universe. The Hubble constant provides an estimate of the *current* expansion rate (current measurements by the *Hubble Space Telescope* indicate its value is close to 75 km s^{-1} Mpc $^{-1}$). If the universe is close to flat today, it was *exactly* flat close to the time of the big bang itself, to one part in 10^{50}. This is known as the *flatness* problem. The usual interpretation proposed in the early 80's is that early on, the universe was in an inflationary state, washing out any departures from flatness on time scales of 10^{-35} sec. In more general terms, it would appear that the universe followed the simplest possible theoretical construct (flatness) in its large-scale geometry.

- The universe is remarkably homogeneous at large scales as related to the 2.73 K background radiation – T constant to 1 part in 10^6, known as the

horizon problem.

The universe is remarkably homogeneous at large scales as related to the radiation that fills all space. This is known as the *horizon problem*. The inflationary model proposed by Guth and others (cf. Guth, 1981) was developed in various forms to account for the flatness of the universe and also was proposed to solve the *horizon problem*. This problem is manifesting in terms of the apparent homogeneity of the 2.73 K black body radiation seen by *COBE* (Smoot 1996). The observations indicate that although the 2.73 K radiation was emitted ~ 10^5 years after the beginning, opposite sides of the sky at that time were out of causal contact, separated by ~ 10^7 light years. Other correlations in the large-scale structure of the universe exist such as very large structures in the distribution of matter (Geller and Huchra 1989). These structures may or may not be manifesting at all scales all the way to the scale of the universe itself.

- Cosmological constant "coincidence" 10^{120}, recent observations indicate a cosmological constant might be needed in a flat universe framework, known as the *cosmological constant problem.*
- Although the universe appears to be *close* to a flat, Euclidean, Einstein-de Sitter state as indicated from the fact that the density is close to closure, it is still not clear what the geometry of the universe is today; *exactly* flat (as many theoretical constructs require); open (yielding a forever-expanding, negatively curved space-time); closed (yielding a maximum expansion and a positively curved space-time); or maybe even open and accelerating (requiring a non-zero cosmological constant as recent observations seem to indicate). The cosmological constant was first introduced by Einstein to counter gravity and produce a closed, static universe stable – it essentially acts as negative gravity. It was later abandoned when observations by Hubble and others were favoring an expanding universe but has been recently re-introduced by cosmologists as the present observations seem to be indicating at face value that the universe not only is expanding but it is also accelerating in its expansion. Observations indicate that baryons (and luminous matter) contribute at most 0.1 or less of the closure density at present. As such, if one insists on exact flatness, one needs to introduce unknown forms of "dark matter" for the other 90% of what is required and, worst, unknown physics required by a non-zero cosmological constant. The dilemma we face is that if we insist on a flat universe, this forces us to in turn adopt increasingly, complex and unknown physics. The mathematical model is simple in its assumptions but the underlying physics required to maintain it is complex and even unknown. This reminds us the historical analogy of the Ptolemaic Universe: To keep the orbits of the planets circular in a geocentric universe (which was also a "simple" universe), required an increasing amount of complexity, more and more epicycles.
- The universe seems extremely fined tuned (cf. Kafatos, 1998). Eddington (1931, 1939) and Dirac (1937, 1938) noticed that certain "coincidences" in dimensionless ratios can be found. These ratios link microscopic with macroscopic quantities (cf. Kafatos, 1998). For example, the ratio of the electric force to gravitational force (presumably a constant), is a large number

$$e^2 / G m_e m_p \sim 10^{40} \tag{2}$$

while the ratio of the observable size of the universe (presumably changing) to the size of an elementary particle is also a large number, surprisingly close to the first number, or

$$R / \left(e^2 / m_e c^2 \right) \sim 10^{40} \tag{3}$$

It is hard to imagine that two very large and unrelated numbers would turn out to be so close to each other, Dirac argued. The two, Dirac argued, *must* be related. The problem though is that in (3) the numerator is changing as the

universe expands while (2) is presumably constant. Why should two such large numbers, one variable and the other not, be so close to each other? Dirac's (1937) *Large Number Hypothesis* states that the fact that the two ratios in (2) and (3) are equal is not a mere coincidence. He and others (cf. Dyson 1972) have attempted to account for the apparent equality between (2) and (3) by assuming that constants such as the gravitational constant may be varying. Other ratios such as the ratio of an elementary particle to the Planck length,

$$\frac{e^2/m_e c^2}{\left(\hbar G/c^3\right)^{1/2}} \sim 10^{20} \tag{4}$$

large numbers such as "Eddington's number", $\sim 2 \times 10^{79}$, etc. exist and "harmonic" numbers can be constructed from them (Harrison, 1981), *e.g.* Eddington's number is approximately equal to the square root of (2) or (3). These "coincidences" may be indicating the existence of some deep, underlying unity involving the fundamental constants and linking the microcosm to the macrocosm.

- Other, less traditional ways, such as the Anthropic Principle (Barrow and Tipler, 1986) have been proposed to account for the above fine tuning properties of the universe. It might though be possible to invoke quantum non-locality as the underlying principle.

To recapitulate,

The Universe is Extremely Fined Tuned

- Ratio of the electric force to gravitational force

$$e^2/Gm_e m_p \sim 10^{40}$$

- Ratio of the observable size of the universe (presumably changing) to the size of an elementary particle is also a large number, surprisingly close to the first number, or

$$R/\left(e^2/m_e c^2\right) \sim 10^{40}.$$

Dirac's *Large Number Hypothesis*

- Ratio of an elementary particle to the Planck length,

$$\frac{e^2/m_e c^2}{\left(\hbar G/c^3\right)^{1/2}} \sim 10^{20}$$

- Large numbers such as "Eddington's number", $\sim 2 \times 10^{79}$, etc. exist. "Harmonic" numbers can be constructed from them, *e.g*. Eddington's number is approximately equal to the square root of Dirac's relations.

2.2. THE ARROW OF TIME – AN ALTERNATE VIEW

Recently, Kafatos, Roy and Amoroso (2000) have shown that these coincidences could be re-interpreted in terms of relationships linking the masses of elementary particles as well as the total number of nucleons in the universe (or Eddington's number) to other fundamental "constants" such as the gravitational constant, the charge of the electron, Planck's constant and the speed of light. They conclude that scale-invariant relationships result, *e.g*. all lengths are then proportional to the scale of the universe R, etc. The arrow of time is introduced as these fundamental "constants" change (*e.g*. Eddington's number varies from $N_p \rightarrow 1$ at the time of big bang to $\rightarrow 10^{80}$ today, etc.).

Specifically, one may adopt Weinberg's relationship which in one of its forms is

$$m_e \sim \left(\frac{\hbar e^2 H_0}{(8\pi)^3 G c^2} \right)^{1/3} \tag{5}$$

where m_e is the electron mass, H_0 is the (present) Hubble constant and the other parameters in (5) are the usual physical constants. Weinberg's relation can be shown to be equivalent to Dirac's relationships (2) and (3) when the latter are equated to each other (Kafatos, Roy and Amoroso, 2000). We can then obtain a relationship linking the speed of light *c* to the rate of change of the scale of the universe. In fact, the proportionality factor is ~ 1 if one substitutes for values of fundamental quantities like the present number of particles in the universe, etc. The next step assumes that the relationship linking c and R is an identity, *i.e*. $c \equiv \dot{R}$ (for example, at the Planck time, one observes that this relationship still holds if the ratios of all masses $\rightarrow 1$ and the number of particles also $\rightarrow 1$). As such, in this picture *all* the fundamental constants are changing and not just one of them as was assumed in past works. It is interesting that, recently, the possibility that the cosmological constant Λ itself might be changing (Glanz 1998) has been suggested. As such, what is suggested as a framework for the universe is a natural extension of previous ideas. Therefore, as N_p changes from an initial value of 1 to the present value of 10^{80} ($1 \rightarrow 10^{80}$), the universe would be appearing to be evolving to an observer inside it or the arrow of time is introduced. Finally, the outcomes of this prescription are not just that an arrow of time is introduced and the mysterious coincidences of Dirac and Eddington now can be understood as scale-invariant relationships linking the microcosm to the macrocosm; but in

addition, all scales are linked to each other and what one calls, *e.g. fundamental length,* etc. is purely a convention.

The existence of horizons of knowledge in cosmology, indicate that as a horizon is approached, ambiguity as to a unique view of the universe sets in. It was precisely these circumstances that apply at the quantum level, requiring that complementary constructs be employed (Bohr, 1961). At the initial time, if we set the conditions like $c = \dot{R}$, as proposed by Kafatos, Roy and Amoroso (2000), we can axiomatize the numerical relations connecting the microcosm and the macrocosm. In other words, after setting $c \equiv \dot{R}$, at the initial time of Big Bang, this relationship remains invariant even at the present universe. This relation is a type of scaling law at the cosmological scale and connects the microcosm and the macrocosm. *Light connects everything in the universe*.

Now if there is expansion of the Universe, R itself is changing and more specifically, then the fundamental constants like G, $\hbar$, and c may also *all* vary with time.

Due to the variation of these fundamental constants, N_p will also be changing from the initial value 1. This implies that more and more particles will be created due to expansion of the universe. So an observer, who is inside the universe will instead see an arrow of time and evolutionary universe. As $N_p \rightarrow 10^{80}$, the present number of the nucleons in the universe, the fundamental constants achieve their present values.

In a sense, if one considers that the universe is undergoing evolutionary processes, one would conclude in this view that all of the fundamental constants themselves are changing. The other aspect of this view is that if one considers the fundamental constants as changing, the observer will observe an arrow of time in the Universe. So, the arrow of time can be related to a kind of complementarily between two constructs, *i.e*., the universal constants are constant, on the one hand, and constants are changing, on the other hand.

2.3. THE NON-LOCAL UNIVERSE

In the generalized complementarity framework (Kafatos and Nadeau, 1990, 2000), complementary constructs need to be considered to formulate a complete picture of a scientific field under examination (*e.g*. the large-scale structure of the universe) as a horizon of knowledge is approached. This means that as a horizon is approached, ambiguity as to a unique view of the universe sets in. It was precisely these circumstances that apply at the quantum level, which prompted Bohr to affirm that complementary constructs should be employed (Bohr, 1961). Moreover, the remarkable correlations exhibited at cosmological scales are reminiscent of Bell-type

quantum correlations (Bell, 1964) that were so abhorrent to Einstein (Einstein, Podolsky and Rosen, 1935) and yet confirmed by the Aspect and Gisin experiments.

Kafatos (1989) and Roy and Kafatos (1999) proposed that Bell-type correlations would be pervasive in the early universe arising from the common electron-positron annihilations: binary processes involving Compton scattering of the resultant gamma-ray photons with electrons would produce N-type correlations. In these conditions, the outcome of the cascade of processes (even in the absence of observers) would produce space-like correlations among the original entangled photons. Kafatos and Nadeau (1990, 2000) and Kafatos (1998) have in turn proposed three types of non-localities: Spatial or Type I non-locality occurs when 2 quanta (such as photons) remain entangled at all scales across space-like separated regions, even over cosmological scales. (Fig. 1)

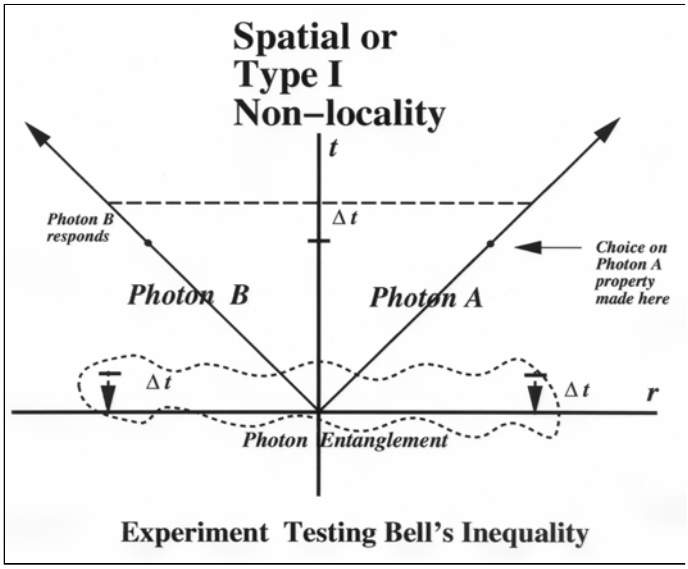

Fig. 1

Temporal or Type II non-locality (or Wheeler's *Delayed Choice Experiment*) occurs in situations where the path that a photon follows is not determined until a delayed choice is made. (Fig. 2)

In some strange sense, the past is brought together (in the sense that the path is not determined) by the experimental choice. This non-locality confirmed in the laboratory could also occur over cosmological distances (Wheeler, 1981). Type III non-locality (Kafatos and Nadeau, 1990, 1999) represents the unified whole of space-time revealed in its complementary aspects as the unity of space (Type I) and the unity of time (Type II non-locality). It exists *outside* the framework of space and time and cannot, therefore, be discerned by the scientific method although its existence is *implied*.

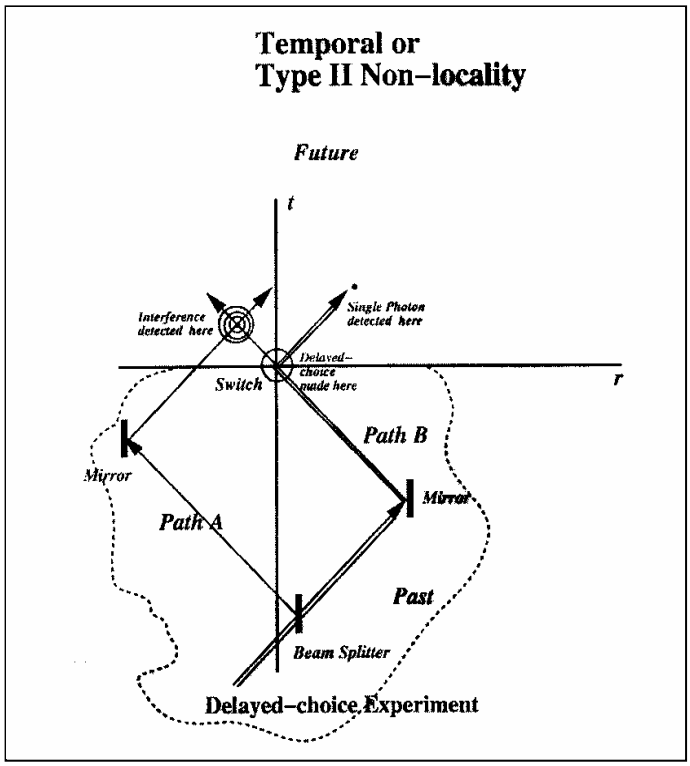

Fig. 2

3. THE UNIVERSAL DIAGRAMS – VISUALIZING THE WHOLENESS OF THE UNIVERSE

A series of *Universal Diagrams* (UD) have been constructed (Kafatos, 1986; Kafatos and Nadeau, 2000; Kafatos and Kafatou, 1991) and reveal deep underlying wholeness. These can be constructed by placing various physical quantities of many different objects in the universe on common, multidimensional plots. 2-D diagrams have been constructed involving the mass, size, luminous output, surface temperature and entropy radiated away of different objects in the universe. These diagrams originally constructed for astronomical objects (Kafatos, 1986) have been revised and extended to all scales including biological entities, industrial and man-made objects, etc. Two of these 2-D diagrams are shown here (Fig. 3, entropy radiated *versus* mass; Fig. 4, luminosity *versus* mass). The diagrams show continuity among different classes of objects and can even be used to find *likely* regions where to-date undiscovered objects could be located are (such as super-superclusters, large planets, etc.). The overall appearance of the UDs does not change as more objects are introduced, rather the specifics of smaller regions become more refined. Over smaller regions, different power laws can be found to fit

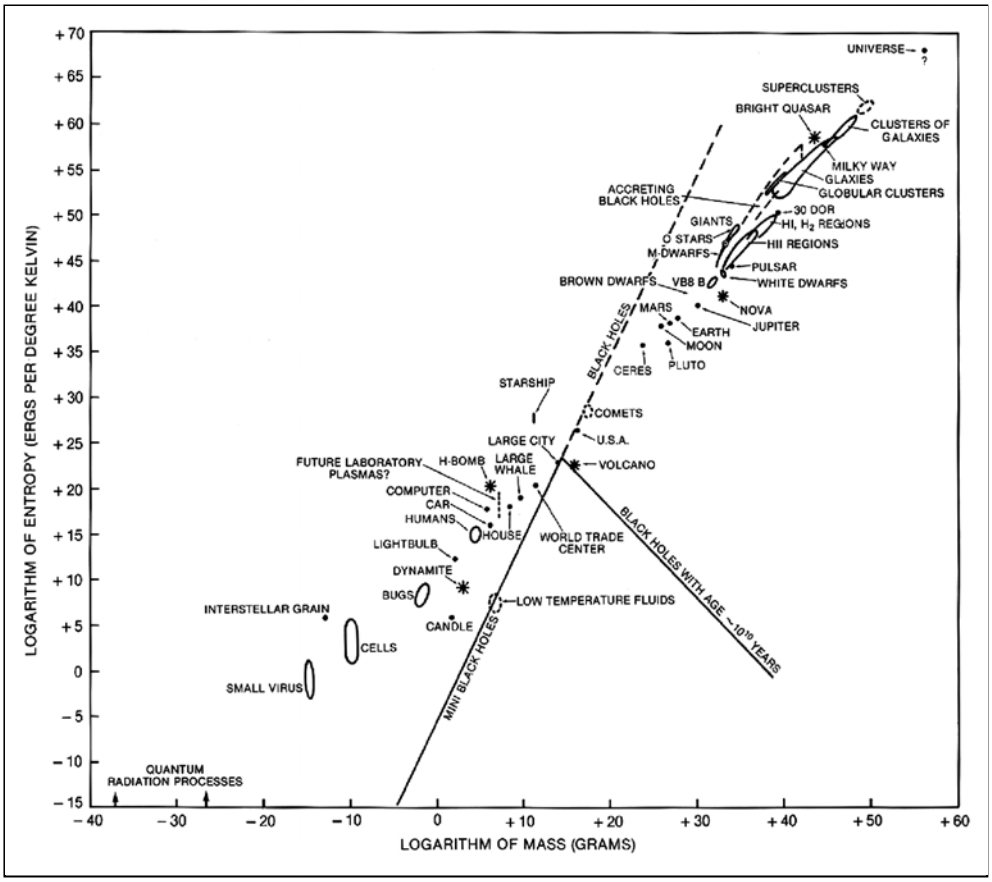

Fig. 3

the data, while more *global* relationships can be found that approximately fit many different classes of objects (such as an approximately linear relationship between entropy radiated away and mass). It is found that black holes provide boundaries in the UDs and often cut across the main relationships in these diagrams. The values of the constants (and their ratios) and the laws of physics are determining the overall relationships and as such the diagrams *must* be related to the ratios (2) and (3), although it is not totally clear at present if additional principles may or may not be required. There are large scale *correlations* revealed in these diagrams among different dimensions (other than space and time examined above) or parameters which extend beyond the quantum or cosmological realms, to realms such as living organisms, etc. It follows that *non-locality* in the sense of global multidimensional correlations, is revealed by the UDs to be a *foundational principle* of the structure of the cosmos along with *complementarity* (Kafatos and Nadeau, 1990, 2000).

4. THE QUANTUM BRAIN

A variety of processes have been identified in the brain that either are quantum-like or, as some researchers have tried to show, are true quantum in nature. Irrespective of which is the case, the evidence points to the existence of underlying principles which have analogy in the quantum world, such as non-locality and complementarity. Here we briefly provide some relevant points, not attempting to provide a complete review of this vast field, but rather to highlight the connection of the quantum to the brain.

4.1. CEREBELLUM AND COMPLEMENTARITY & HILBERT SPACE DESCRIPTION

- Motor Behavior *vs*. Cognitive Functions in the Cerebellum

A plausible generalized ***complementarity*** principle proposed by Roy & Kafatos (2000a) helps us to understand the dichotomy between the motor behaviors and cognitive functions in the cerebellum. It leads to consider an entangled state between the motor and cognitive functions similar to the entangled state of wave and particle aspects of photon. ***Non-local correlation*** is supposed to exist behind this entanglement. It should be emphasized that no actual quantum processes are proposed to operate here, rather one has quantum-like, generalized principles operating.

- Hilbert Space Description

Moreover, Roy & Kafatos (2000b) have explored the idea that Hilbert space structure may be providing a geometric description for neurodynamics, providing perhaps support for Pribram's (1991, 1998) ideas. Geometric structure is viewed in terms of Hilbert structure starting from the neuronal characteristics themselves. This is because cells in the visual cortex and other parts of the brain have the property of orientation selectivity (Hubel, 1995).

Recently, Matsuno and Paton (2000) have examined evidence referring to quantum information in biological systems and conclude that complementarity can be assumed to be operating in biosystems.

4.2. NON-LOCALITY IN THE BRAIN

Pribram (1966, 1998) and others pointed to the relevance of holography to the difficult problems of brain function in perception (*e.g*. constancies) and memory (*e.g*. distributed store). Evidence has gathered that the holographic metaphor may be relevant in terms that visual cortical function is mapped in terms of the constrained Fourier process essential to the holographic model (Pribram, 2000). The holographic model points to non-locality as an underlying principle.

Others have also pointed to the existence of non-local properties in neural systems (Chauvet, 1993), involving hierarchical systems and non-local field operators.

4.3. THE WAVE FUNCTION AND THE BRAIN

Quantum processes and the existence of wave function have also been postulated to be operating in the brain. The sites of these processes need to be identified and Hameroff and Penrose (1995) invoke *real* collapses of the wave function in microtubular sites, as self-orchestrated collapse. Quantum synaptic mechanisms are proposed by Beck and Eccles (1992).

5. FOUNDATIONAL PRINCIPLES

A new approach of starting with foundational principles is proposed (Drăgănescu and Kafatos, 2000a, and Struppa, Kafatos, Roy, Kato, and Amoroso, 2000). There are good reasons to believe that the present-day science (which concerns itself with explanations of structural realities and as such can be considered to be a *structural science*) is limited in its approach, in the sense that it cannot completely explain life, mind and consciousness, as well as the nature of matter and reality. The proposed approach is to explore foundational principles as the *underlying structures themselves* similar to the Ideas of Plato (rather than relying on the physical structures to account for the underlying non-structural or *phenomenological* levels). Although one cannot neglect the impressive accomplishments and impact of science as it has been developed over the last few centuries, it is also clear that a new, fundamentally different approach is needed to avoid an alienation between science and other human endeavors.

Accepting that few fundamental principles are the source of all scientific and philosophical human endeavors, it may then follow that reductionism (one of the main operating principles of modern science) can be reinstalled in new philosophical and scientific approaches. A foundational approach has to be developed to assure that there is no danger of absolute and complete reductionism. In fact, in exploring foundational principles one can re- examine whether reductionism itself is a consequence of a generalized principle of *Simplicity*: A whole is composed of simpler parts yielding discreteness. Reductionism is then the methodology of exploring the discreteness and relationships arising from it.

It may be supposed that all existence, consisting of the physical, mental and psychological worlds, consists of complementary principles in the deepest sense. It may be supposed that from the depths of existence a single universe (or world) manifests (or many universes as in the Many Worlds Interpretation of quantum theory) which maintains a direct connection with the original foundational principles and underlying levels. It may also be supposed that a variety of other

possibilities in the sense of different levels of existence or universes are possible as well. As such, an ontological model of the entire nature of reality is needed, a new model that extends present science, which should be able to respond to such ontological problems.

It follows that foundational principles are more fundamental than physical theories (Kafatos, 1998a). Still, the foundational principles have to rely on a general model of existence and need to be developed in a systematic way (Kafatos and Drăgănescu, 2000b).

The entire existence is considered as having two main parts or components: a deep underlying reality (Kafatos and Nadeau, 2000; Drăgănescu, 1985, 1979/1997) and one or more universes, not connected to each other. These two components are not quite separable because universes or worlds are born from the deep underlying reality and maintain contact with it. The deep underlying reality is a matrix on which a universe develops and the substrate of a universe is also a part of this deep underlying reality.

Seen from inside a specific universe the physical laws are mainly formal, or structural. The physical laws of the deep underlying reality are, on the other hand, *mainly* semantic in character (Rosen, 1988; Drăgănescu, 1990, 1993, 1996). The emphasis on *mainly* derives from the realization that the deep underlying reality, as part of a universe, introduces in turn the influence of its semantic laws to supplement the formal, structural physical laws of the universe.

The proposed model, according to Drăgănescu, Kafatos, and Struppa, *et al.*, as a basis of forming foundational principles in the philosophy of science, would assume the existence of a deep underlying reality with associated principles and the recognition of the primacy of the phenomenological sense (which in the specific case of mental phenomena can be termed as *experience*), at both the physical and informational levels of reality.

The epistemological and ontological consequences are far-reaching (Kafatos and Nadeau, 1990, 2000; Nadeau and Kafatos, 1999) and imply a non-local, undivided reality which reveals itself in the physical universe through non-local correlations and which can be studied through complementary constructs or views of the universe. Quantum theory and its implications open, therefore, the door for the thesis that the universe itself may be conscious (although this statement cannot be proven by the usual scientific method which separates object from subject or the observed from the observer), Kafatos and Nadeau (2000), Nadeau and Kafatos (1999).

As we saw, Roy and Kafatos (2000) have examined the response and percept domains in the cerebellum and have built a convincing case that complementarity or quantum-like effects may be operating in brain processes as well. As such, complementarity may be applicable to neuroscience as well, or to conscious processes, to living structures in general.

To recapitulate, Drăgănescu (1998b, 2000) and Drăgănescu and Kafatos (2000a) have explored the thesis of a *deep reality*, paralleling the thesis of a

conscious universe. Moreover, Drăgănescu and Kafatos (2000a, 2000b) have explored the possibility that foundational principles operate at all levels in the physical as well as beyond physical aspects of the cosmos. These go beyond the two principles revealed in studying the quantum and cosmological realms.

In conclusion:

- New approach of starting with foundational principles is proposed (see Drăgănescu and Kafatos, 2000a). The present science (which concerns itself with explanations of structural realities and as such can be considered to be a ***structural science***) cannot completely explain not only life, mind and consciousness, but the nature of matter and reality, in general. The approach here is to explore foundational principles as the ***underlying structures*** *themselves* (rather than relying on the physical structures to account for the underlying non-structural or ***phenomenological*** levels).
- Reductionism itself is a consequence of a generalized principle of ***Simplicity***: A whole is composed of simpler parts yielding discreteness. Reductionism is then the methodology of exploring the discreteness and relationships arising from it.
- It may be supposed that existence itself consists of complementary principles in its utmost depths. It may be supposed that from the depths of existence a single universe (or world) manifests (or many universes). ***Different levels of existence or universes*** are possible.

Drăgănescu and Kafatos (2000a), propose the following set of foundational principles:

- The principle of ***complementarity*** is a foundational principle of existence.
- The nature of existence is both physical and informational (sub-principles can be constructed from this basic principle).
- The ontological principle of self-organization is a foundational principle.
- The fundamental Consciousness of Existence is a foundational principle.
- The ultimate reality is the deep underlying reality or existence.
- The universe generated from the deep reality is non-local.
- The universe is quantum-phenomenological.
- The objects with life, mind and consciousness in a universe are structural-phenomenological.

Other Principles

Guided from the quantum theory one can perhaps extend the list of the above principles to include additional candidates such as:

- Correspondence
- Light as the “glue” of the universe

We conclude here that foundational principles may be needed to begin to understand the all-pervasive phenomenon of consciousness. These principles operate *beyond* or *below* the physical universe and as such are meta-mathematical or pre-mathematical in the sense that mathematical constructs of the physical universe emerge from them. The implications for consciousness in the universe and for constructing a new *science of holism* or a new *interdisciplinary science of consciousness* (Drăgănescu, 1998b) need to be further explored.

6. UNIFICATION

Concerning the methodology of science, the current structural science is based on theory, especially mathematical models, and measurements. The most critical part of the scientific method today is the role of measurements. Today structural science is accepting indirect proofs of the actual theoretical models (*e.g.* the theory of quarks, the beginning of the universe, etc.). Indirect proofs became, more important, even fundamental, with enlarging or deepening of the quantum theory, even in the current structural approach (Drăgănescu and Kafatos, 2000a). It has become obvious for many years now that current structural science is insufficient and incomplete to describe the entire reality of Existence. It cannot describe objects with phenomenological processes, or objects with life, mind, consciousness, as well as the deep underlying reality of Consciousness itself. The structural realm is at the top and in some sense it is the weaker of a continuum of underlying levels of Existence.

The new prescription of a unified *science,* taking the term here in its original meaning signifying *scientio* or *gnosis*, utilizes generalized principles that cut across many different fields of *gnosis*. The foundational principles explored here are partly rooted in scientific facts, partly based on philosophical considerations extrapolating new scientific data not yet incorporated in the existing system of science (see also Drăgănescu and Kafatos, 2000b).

A mixture of views from many different fields of science, such as cosmology, brain dynamics, quantum physics, etc. from the philosophy of science and from ancient perennial philosophical views may provide a new way to approach the undivided wholeness in the Universe (taken to include not only the physical universe but everything else as well, including the far vaster universe of mental, psychic and spiritual realms). It would constitute a new dawning of human awareness of the universe and our place in it.

These principles may be used as working hypothesis for extending science, for elaborating new scientific theories. In the new paradigm proposed here, these principles will be refined as the unified field of human knowledge develops. A new structural *and* phenomenological view of the Universe will emerge (Drăgănescu and Kafatos, 2000a). Then, a truly unified view of the Universe which takes into

account both the existence of the *deep underlying reality* and the fundamental role of Consciousness will emerge.

The new prescription of doing science consists of the following:

- **Starting from the whole, study the parts.**
- **Find connections from perennial philosophies and other fields of science to explore possible new developments and new ideas.**

One may look at some perennial statements and see if they apply to the physical world. A useful illustration is the dance of Nataraj, the continuous five-fold action of universal Consciousness or Paramashiva, in the perennial philosophies of Vedanta and Shaivism (Struppa *et al.*, 2000).

The new prescription of a unified ***science,*** taking the term here in its original meaning signifying ***scientio*** or ***gnosis***, utilizes generalized principles that cut across many different fields of ***gnosis***. The foundational principles are partly rooted in scientific facts, partly based on philosophical considerations extrapolating new scientific data not yet incorporated in the existing system of science (cf. Drăgănescu and Kafatos, 2000a, 2000b).

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