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CRISIS IN PHYSICS AND A TENTATIVE APPROACH TO OVERCOME IT*

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"The Search for Truth is more precious than its possession- Lessing"

In spite of many notable predictive successes of quantum field theory, no body who cares for a unified theory of physics which is mathematically consistent is satisfied with the methodology and techniques of modern field physics. I think that a crisis has developed in physics worse than that which prevailed in 1905 and in 1925. In order to overcome this crisis satisfactorily we need a heretic who would be bold enough to discard many of the methodologies of the past 50 years and open up a new path with intuitive physical insight and consistent mathematical formalism. As we shall see later, the problem perhaps can be formulated correctly but its solution to yield tangible new physical results utilizing a satisfactory scheme of mathematics is beset with so many difficulties that it would need the cooperation of talented physicists and mathematicians.

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It had been proved long ago with physical and mathematical consistency that all the fundamental equations of classical and of quantum physics, at least so far as single particle Schroedinger and Dirac equations are concerned, can be derived deterministically as special cases of nonlinear partial differential equations. Further, it had been shown that if one uses Schroedinger's ψ-function one has no other alternative but to fall back on a statistical description of nature. But our work had definitely proved that this is not necessary. The wave field of a particle, considered as a physical reality, does not satisfy the requirements of eigenfunctions of linear operators. (For a review of this work see references [1&2]. I regret very much that for reasons beyond my control the ref.[1] contains many obvious printing mistakes).

Although this theory has not yet progressed so far as to supersede the presentday quantum theory, it had already vindicated Einstein-de Broglie's concept of Physics, namely, that it is possible to develop a consistent microphysics based on objective physical reality.

Since an overwhelming majority of physicists, obsessed with getting concrete physical results, are still pursuing the conventional path, sometimes changing their methodologies with changing fashions of the past year, I think, there is sufficient reason to start a crusade now for the reestablishment of deterministic microphysics. If we want to develop a Universal Field Theory which would encompass not only gravitation and electromagnetism but also fields of "elementary particles", I believe, one must try to develop a deterministic physics without overlooking the fact that physics is an attempt to grasp objective reality conceptually.

I do not expect that the old guards will be influenced by my opinions, but I have reasons to believe that a growing number of young physicists and mathematicians are much more sympathetic to such ideas than the current fashionable approaches.

In former times unknown heretics were burnt on stakes but a famous one like Galileo could escape such a fate

only by retraction of his convictions. Of course, now-a-days this is not possible. It has been substituted by the punishment of completely ignoring such efforts, effacing out such heretic work from the history of physics. Such a bigotry on the part of the leaders of modern physics is the principal cause for the stalemate in the correct development of a mathematically consistent Universal Field Theory. But much more tragic is the fact that these reputed physicists are not yet convinced that a crisis has really developed in physics. Leaving aside the opinions of the founders of modern physics like Planck, Einstein, de Broglie, Schroedinger, even the founders of quantum mechanics who belong to Copenhagen school like Dirac, Heisenberg, Pauli had repeatedly and emphatically expressed the opinions that though Schroedinger and Dirac equations represent consistent physical theories, the quantum field theory like Quantum Electrodynamics (QED), Quantum Chromodynamics (QCD), cannot be accepted as consistent physical theories. Pauli sarcastically called such physics as "Substraction Physics". In a recent review of quantum field theories Weisskopf [3] had sadly remarked that physicists for lack of something better had come to "live in co-existence with infinities".

All the founders of quantum mechanics are convinced that we need a Transquantum Physics which would supersede the presentday quantum theory. The only dispute is how to achieve this. Most of them believe that we have to abandon many of our cherished beliefs by quantizing space and time. Some like Menger wanted lump or statistical geometry. Others like Wigner would like to replace the concept of coordinate points by some invariants. But no one as yet knows how to introduce such novel concepts in a mathematical formalism that would be tractable to develop a new physics.

The presentday leaders, however, do not bother themselves with such questions. They are quite satisfied with the linear formalism of quantum theory and hope to go forward by introducing in it mathematical formalism like Lie Groups, fibre bundles, supersymmetry, etc. which are supposed to represent internal coordinates and symmetries of elementary particles. They ignore the fact that space and time are the arena of physics and that our *understanding* of physics must ultimately be within the context of space and time. Further, they do not like to recognize that physics is essentially nonlinear and measuring processes involve nonlinear interactions. Pauli had rightly said that linear physics is a mathematical abstraction.

If one carefully studies the development of physics, one would at once recognize that when a crisis comes no amount of mathematical jugglery can lead to a new physics. For the creation of a new physics, one must start with a new postulate and some new empirical observations. Mathematics comes afterwards to formulate the new physical ideas and experimental results in a consistent way. The best illustration of this is offered by relativity theory.

It should be noted that one cannot arrive at Lorentz transformation by cerebration alone. With the help of group theory and the postulate of restricted principle of relativity, one may arrive at a similar expression with an ultimate velocity but can never find that this ultimate velocity is c, which is an empirical fact. Similarly, in general theory of relativity we have the postulate of the equivalence of all possible continuous coordinate transformations and the empirical fact about the equality of inertial and gravitational masses. The latter cannot be derived theoretically.

In order to appreciate the nature of the present crisis, let me first ignore the opinions of Planck, Einstein, de Broglie, Schroedinger but quote some of the remarks of the founders of quantum mechanics who believe in Copenhagen interpretation of physics, since modern physicists might have more faith in their views. But before drawing your attention to their remarks and stating my own tentative programme for the reestablishment of deterministic microphysics, permit me to say a few words about the development of Newtonian physics which has some similarity with the present situation.

The greatness of Newton lies in the fact that he was fully aware of the unsatisfactory nature of his postulates. He never believed in action at a distance . As Einstein had remarked, he had to accept the concept of absolute space because within the framework of Newtonian physics acceleration

has no meaning without the concept of absolute space. Newton also noted the strange coincidence about the equality of inertial and gravitational masses. But he deliberately refused to speculate on such questions because at the time he had no other alternative but to follow the path which he established. For two centuries great scientists like Lagrange, Laplace, Poisson, Hamilton, Jacobi and others developed a wonderful structure of analytical mechanics. We had shown that this structure of analytical mechanics can be kept in tact for microphysics with only a slight modification of the dynamical mass. It is wrong to assume that classical mechanics is an approximation for the case $h \to 0$. Classical mechanics remains strictly valid even when $h \neq 0$, provided the wave field of the particle does not suffer diffraction. Of course, Newtonian physics did not take into account the wave nature of the particle. In deterministic microphysics we have to take this new fact into consideration.

Anyway, what I want to emphasize here is the fact that these great scientists never bothered about the foundations and postulates of Newtonian mechanics. They had much to do without bothering about foundations. Only two centuries later Mach successfully convinced others that there is no need to assume the concept of absolute space so far as mechanics is concerned. But even to such a sceptical and critical mind the significance of the equality of inertial and gravitational masses escaped notice. And of course, no body before Einstein challenged the Newtonian-Kantian concept of space and time. I think that even now physics has not incorporated adequately the true nature of the concept of time, the irreversibility of the evolution of time.

It is also interesting to note that though general theory of relativity is considered by many as one of the greatest intellectual feats in the field of science, Einstein never considered the theory of relativity as a revolutionary one. To him it was the logical culmination of Newtonian physics. But he considered his photon theory as revolutionary and history has vindicated his insight.

Now, how does physics progress . ? As reemphasized by Dirac [4] the development of physics proceeds with many small steps until we come to a crisis which established theories cannot explain. In order to overcome this crisis a big jump in our concept of nature had to be made. Steady development is largely logical and is based on the secure foundation of the subject matter and a consistent mathematical formalism. But when we encounter a big jump it means that something entirely new has to be introduced. But the new concept never springs up into its final logical form all at once. Experimental discoveries and theoretical investigations lead to refinement of concepts. Sometimes we have to discard old concepts altogether, but very often we have to harmonize the old concepts within the domain of the new concept. For *understanding and comprehending* a phenomenon, the first condition is the introduction of adequate concepts. Only with the help of concepts which pertains to physics along with some others which do not strictly belong to physics like congruence and transitivity, we can really comprehend what is being observed. When different theories, each covering a wide field of facts, clash we unify them with newconcepts. Usually this new theory created with new concepts (which might be meaningless for the old theory) actually unify the old theories which come as special cases. There has always been urge to unify physics. But never before in this process of building up a new coherent theory one has sacrificed mathematical consistency and remained satisfied with the *ad hoc* manipulations. Sometimes for the progress of physics one had introduced mathematical tricks which could not be justified mathematically as in the case of Dirac delta function. But people had never been satisfied with such *ad hoc* manipulations and were greatly relieved when Schwartz had legitimised the delta function. So the question naturally arises : can we mathematically eliminate the divergence difficulties of modern quantum field theory ? It appears that this would not be possible unless we discard the presentday techniques and introduce new concepts and new methodologies.

A scientific theory, particularly when big jumps appear, must be based on ontology. Epistemology *alone* would not suffice for the justification of the philosophy of science. Everybody who thinks about the foundations of physics feels like Dirac [4] :

"Working rules make me very unhappy. I feel that we do not have definite physical concepts at all if we just apply working mathematical rules. That is not what the physicists should be satisfied with. It shows that our present position is far from satisfactory. It is a mistake to attach too much importance to present concepts". One should also note Heisenberg's dissatisfaction with the modern approach to elementary particle theory.

Even in the field of quantum theory of Heisenberg, Schroedinger and Dirac which was supposed to be made mathematically consistent by the work of Hilbert and von Neumann, serious doubts have been raised for the use of linear Hilbert space and the separability condition to describe the wave field of a particle, (see references [5]). To cite a simple example, the eigen function of a single free electron cannot be represented by a Hilbert vector. As stated before, the wave field of a particle in general does not fulfill the mathematical criterion of eigenfunctions of linear operators because the wave field obeys a nonlinear equation whose solutions usually contain singularities and branchpoints. As rightly pointed out by Jammer [5], quantum mechanics is ultimately a linear physical theory for the physics of processes and not of properties, a physics of interaction and not of attributes, even not of primary qualities of matter.

Exact physics, however, is nonlinear. We can never *understand* physics unless we attach objective reality to the primary qualities of matter. It is no wonder that no philosopher of science is satisfied with the Copenhagen interpretation of physics.

Much has already been written about the controversial aspects of Copenhagen interpretation. It should be noted that fundamental concepts are never directly observable. Heisenberg was surprised but, I presume, accepted Einstein's opinion : "It is the theory which ultimately decides which is observable"."Operational physics can never lead us to the *understanding and comprehension* of physical phenomena. Can we find irrational numbers which occur in many physical laws through operational processes ? No observation can be satisfactorily explained unless we have a corresponding theory and unless we understand the pertaining theoretical concepts, hypotheses and postulates which are seldom amenable to direct straightforward verification. Neither Schroedinger's ψ-function nor Ritz states are directly observable. If we believe in *only* operational physics, we would inevitably come to conclusions which can hardly be considered as "sane" physics. If we deny the existence of objective reality, we shall come to the bizarre notion of Bohr and Wheeler that a phenomenon does not exist unless and until one has observed it. It might satisfy operational physicists but certainly does not help us to *understand* physics. One would like to recall here the sarcastic remark of Einstein to Pais [8] : "Do you think that the moon does not exist unless we see it ?"

Positivism and operationalism can never lead us to the comprehension of physical phenomena unless we reinforce them with deeper physically meaningful ontological questions. Without such ontological basis one can never resolve the crisis which appears in physics and which advances our knowledge of the physical reality. Could we comprehend microphysics if we adhered to the ideas of Mach and Ostwald ?

Further, as I have discussed elsewhere [6], physics must not only be causal but also deterministic. How else can we comprehend the fact that with correct postulates we can come to observable results through deductive logic ? Why Nature should oblige us with causality if its elementary laws are erratic as stated by Pauli. The noted philosopher of science Sir Karl Popper rightly criticized that quantum mechanics tries to explain uncausal processes through causal arguments.

Anyway, no philosophical discussions and pertinent adverse criticisms of the presentday theoretical structure of quantum theory which had phenomenal success in predicting a vast domain of experimental results, although very crucial for the advancement of science particularly in times of crisis, will ultimately convince sceptics who solely rely on operational physics about the necessity of introducing new physics with an entirely different methodology.
What is needed is a physically satisfactory and mathematically consistent theory of Transquantum Physics, which alone can finally decide the controversy over determinism and indeterminism in physics.

It should also be carefully noted that one must distinguish between mathematical functions with which we try to describe physical phenomena and physically observable functions which represent some integral values of the mathematical functions, really speaking, a functional of mathematical functions and the precision and domain functions of the experimental set up, (for details see [7]).

Finally, before proceeding with quantitative theory which had already proved that one can derive Schroedinger and Dirac equations from deterministic theory, let me summarize here my own perception about the state of modern physics as we encounter now.

In my opinion Schroedinger and Dirac equations in their formal expressions* as well as linear quantum mechanical operator formalism are correct as linear approximations and so far as physical reality is concerned they are to be considered as satisfactory and extremely successful *recipes* to predict average properties of observables. "Spin" has been explained within the space-time framework as "intrinsic angular momentum" of the rotating vortical wave field of elementary particles. Quantum field physicists still concern themselves almost exclusively with Poincaré group and Lie groups and with linear transformation theory, in spite of the generally accepted principle of covariance for all continuous coordinate transformations. Perhaps this is because of the fact that the present quantum theory has not yet been reconciled with the general theory of relativity and the fundamental Poisson Bracket formalism of quantum theory becomes meaningless for generalized coordinates. Already in 1955 at the Bern Conference on Relativity Wigner discussed this question and came to the conclusion that the quantum theory is incompatible with the general theory of relativity. I think that this is due mainly to the fact that one takes Heisenberg's Uncertainty relation as a

*I say formal because neither ψ-function nor spinors represent the true wave field of the particle.

Principle of Nature. We have proved long ago that p_{op} of quantum mechanics represents not the physical momentum of the particle which is a function of space and time, but its representation in terms of the Fourier components of its wave field. As such the Uncertainty relation is the price of our representation and is not a principle of Nature. It expresses the well known relation between the coordinates of physical space and that of Fourier space.

Quantum electrodynamics undoubtedly had produced remarkable results. Nevertheless, not even the founders of quantum mechanics who initiated quantum field theory like Dirac, Heisenberg, Pauli, Jordan and others accept the present version of QED and QCD and all sorts of "subtraction physics". Perturbation theories are meaningless if the series do not converge. But the very practical success of QED indicates that one must be able to derive a physically and mathematically consistent theory of QED. In the past some authors, notably Pena-Auerbach of Mexico, had tried to get the results of QED from stochastic considerations without encountering the divergence difficulties. Even if such efforts succeed, it would not satisfy physicists because stochastic processes, however practically useful they might be, do not contain mechanics which essentially is a group of motion of *non-random* objects. I think its satisfactory solution would need an entirely new approach based primarily on the nonlinear differential equation for the elementary particle which should not be considered as a point particle, an unfortunate legacy of Newtonian physics. As shown before, the electron can be satisfactorily represented by a vortical wave field of finite dimension.

It appears to me that the presentday "elementary particle" theory, on the otherhand, is purely an *ad hoc* phenomenological approach. Some concepts which it had introduced might be useful in order to get a clue as to the physical nature of elementary particles. The present status of such a theory is similar to the important contributions of Mendeleev, Kekulé, Van't Hoff and others in the field of pre-quantum chemistry. It has not yet reached the stage of Moseley, not to speak of quantum chemistry of Heitler, London and Pauling which finally reduced chemistry as a branch of quantitative physics. Consistent physics and dynamics are still missing in modern

theory of elementary particles, apart from the inconsistencies of the pertinent mathematics.

I believe that every dynamical quantity should be described at least in principle as functions of four dimensional space-time manifold. Configuration space, complex Hilbert space, internal symmetries, fibre bundles, spinors, etc might be useful as mathematical techniques to obtain in a simpler and elegant way important physical results, but ultimately they have to be explained in the context of space-time if we are to understand physical reality. And to repeat, the business of physics is essentially to help us in understanding and in comprehending physical reality conceptually.

Quantum mechanics had taught us essentially two things about this physical reality : (i) Every particle shows both corpuscular properties in the sense of Newton-Einstein as well as wave properties in the sense of Huygens-Maxwell. They are both physical realities existing simultaneously. Both are the properties of the "thing" which we call a particle. (ii) The wave field alone can explain all the properties of a particle.

The ultimate physical reality, so far as we can extrapolate from our existing knowledge, is the energy density continuum, the so called "World Aether". But continuum is not amenable to measurement. Physical observables are nothing but manifestations of space-time topological distortions of this continuum. This is the main reason why elementary quantum of action plays such a significant role in microphysics. This continuum is more or less akin to vacuum of modern physics. I am glad to note recently that Schwinger [4] had also come to the same conclusion. He writes :
"The picture of an infinite sea of negative energy electron is now best regarded as a historical curiosity and forgotten. Unfortunately, vacuum fluctuation seems to have left people with the impression that the vacuum, the physical state of nothingness, is actually the scene of wild activity. For us the vacuum is the state in which no particle exists. It carries no physical property. It is structureless and uniform. I emphasize this by saying that the vacuum is not only the state of minimum energy, it is the state of zero energy, zero angular mo-

mentum, zero momentum, zero charge. Structure comes into existence when we disturb the vacuum, when we excite it".

If one desires to fulfill Einstein's vision of Physics, (supported by de Broglie, Schroedinger, von Laue and recently also by Dirac), one has to chalk out an entirely different approach. I think that the real physical wave field of matter, (the reality of which follows inevitably from Reninger's gedanken experiment, as I analysed elsewhere [1]), embedded in the 4-dimensional space-time framework could lead us forward to establish and vindicate Einstein's concept of physics and objective reality. I believe that space-time is likely to remain as continuum with the usual topology, even in the domain of Planck length. The singularities, topological properties of multiple connections, vacuum fluctuations, worm holes, (if they exist), and such other unusual properties are to be ascribed to the wave field itself rather than to space-time manifold. Philosophically it is hard to accept that space and time, as we comprehend them, would behave in such a curious way unless we deny the very concept of objective reality.

The concept of point particle as a physical reality has become a myth, an unnecessary and unacceptable extrapolation. All elementary particles have finite dimensions consisting of vortical fields whose energy are concentrated mainly in the domain of the Compton wave length of the particles.

Taking this wave field as a primary object to describe the elementary particles it might be possible to derive all their properties and the fundamental equations of classical and of quantum physics as special cases of nonlinear equations governing this wave field in perfectly deterministic ways.

So far such a deterministic theory have been set up for scalar and vector fields of a single particle interacting with an external field of electromagnetic type in Minkowski space. This showed that stable elementary particles represent vortical fields and the unstable "elementary particles" are nothing but eddies of the composite wave field when quantum vortices interact with one another within the domain of their Compton wave lengths creating turbulence. One can

understand at least qualitatively and also often quantitatively based on classical hydrodynamics and existing quantum theory many of the strange properties of electrons, e.g., Zitterbewegung motion of Schroedinger, velocity c of a stationary Dirac electron as well as the nature of symmetry of a collection of identical particles and even of the nature of nuclear forces. Our work on the fundamental solution of the so-called generalized wave equation [9] points out that this world aether moves with the velocity c and the perturbations of this continuum are nothing but Huygen's wavelets. Unfortunately, exact quantitative treatment of such interactions is not possible at the present state of our knowledge.

In order to overcome these difficulties in 1979 the author suggested a tentative programme for the formulation of a Universal Field Theory, [2].

I think the difficulties of modern quantum field theories arise from the hypothesis that a (point) particle interacts with all sorts of virtual particles which are also considered as point particles. It is totally ignored that these virtual particles do not exist *ab initio*. They are *created* when the field is excited and most often these exotic very shortlived particles are generated when electrons and protons undergo violent collisions. I think one should not incorporate these virtual particles in the original formulation of the field theory. It would be preferable to start from a manifestly covariant (for all coordinate transformations) partial differential equation for the wave of a particle rather than from its hypothetical Lagrangian and Hamilton's Principle with its attendant equivocal independent variables. The correct Lagrangian can be obtained from the proper differential equation.

This programme is based on the following hypotheses.

(i) The only fundamental stable particles existing *ab initio* are the electrons and protons. (We ignore here the recent conjecture of the finite life time of protons, an extraordinarily large number $\sim 10^{30}$ years compared to the age of the universe.) They are characterized by the following conditions.

(a) The hypothesis that the properties of any particle are completely given by a second order hyperbolic nonlinear partial differential equation (PDE) of its associated wave field. In the general case, this wave field is a nonsymmetric tensor field.

(b) The empirical physical fact that there are only two primarily given stable particles, electrons and protons. All other particles, including stable photons, are created when these primary particles are accelerated.

(c) The criteria of stability are given by the restriction that the wave field of a stable particle has a constant curvature, constant torsion and the same sense of torsion and circulation throughout space and time.

(d) Mass is related to the space-time curvature of the wave field, the circulation to the intrinsic angular momentum and torsion to the charge.

(e) When such a wave field is subjected to an arbitrary coordinate transformation, (kinematic equivalent to the phenomenological force of impact), the resulting nonlinear PDE governing the wave field becomes unstable and return to the equilibrium state in one or many intermediate steps. Quantum jumps are myths. Everything is deterministic. It is interesting to note here Schroedinger's article, Are there quantum jumps ? (see ref. [10]).

(f) The final stable states may represent the "primary" particles as well as any other stable particles like photons, neutrinos, anti-particles.

All these stable particles are also characterized by the facts that their respective wave fields have constant curvature and torsion as well as the same sense of torsion and circulation. They differ from one another in the magnitudes of curvature and torsion and in the sense of torsion and circulation.

(g) Discrete values of certain physical quantities -the so called quantized values- would appear as the eigen values of nonlinear operators.

(h) In the domain of high energy physics, particularly in the neighbourhood of collision cross sections, one might have to

give up the theory of affine connections and to consider nonlinear connections and path integral concepts of Eisenhart, Veblen, Schouten and other workers of classical differential geometry.

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