# A call for the return of the physical to physics: A skeptic's view

*What one does not put into the equation will not finally be given by the mathematics.* James Franck


## Abstract

A strong skeptical viewpoint is required to ensure that mathematical derivations in the theories of physics have a well-defined physical basis. Several examples are cited to show that such an atmosphere of critical analysis existed in the past century during the developmental years of modern science. These methods are then applied to three, highly mathematical disciplines of physics; quantum theory, the unified field theory, and elementary particle theory. Quantum theory is shown to be an inconsistent theory of nature, while all three are found to be deficient in their physical foundations.


## 1. Introduction

The accomplishments of ordinary physicists pale by comparison with those of the mathematician. Entire universes can be created for the simple reason that mathematical formulae allow them to be. For the same reason particles can travel at speeds faster than light or backwards in time. The descriptions of these models in scientific journals are not presented as computational abstractions, but as mathematically viable concepts with well-defined physical meanings.

The mathematicians of today have nearly unrestricted freedom in their interpretation of natural phenomena. They are not required to justify the connection between mathematical abstraction and physical reality so long as their equations express some kind of relationship, real or imagined, between physical variables. For most academic pursuits freedom is a commendable state. However, in the case of physical theory it can lead to highly questionable results.

## 2. The skeptical viewpoint

The study of physics was not always conducted so freely. Although the development of modern science in the early 1900's occurred in a vibrant atmosphere of proposal, counter proposal, and change; there was an unspoken policy of the need to analyze not only every aspect of a theory, but its underlying assumptions as well. Publications and verbal accounts provide vivid descriptions of the struggles that took place. To illustrate, a heated discussion between Bohr and Shroedinger is reproduced below which presents arguments that are highly skeptical of the quantum mechanical model of a radiating atom.[1]

> As Heisenberg recalled, Schroedinger especially attacked the idea of sudden quantum jumps. Schroedinger believed that the idea of quantum jumps was bound to end in nonsense. He reminded Bohr that according to his (Bohr's) theory, if an atom is in a stationary state, the electron revolves periodically but does not emit light, when, according to Maxwell's theory it must. Next the electron is said to jump from one orbit to the next and to emit radiation. Is this jump supposed to be gradual or sudden? If it is gradual, the orbital frequency and energy of the electron must change gradually as well. But in that case, how do you explain the persistence of fine spectral lines? On the other hand, if the jump is sudden, Einstein's idea of light quanta will admittedly lead us to the right wave number, but then we must ask ourselves how precisely the electron behaves during the jump. Why does it not emit a continuous spectrum , as electromagnetic theory demands? And what laws govern its motion during the jump? In other words, the whole idea of quantum jumps is sheer fantasy.

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1 J. Mehra, in P. Lahti & P. Mittelstaedt (eds.), *Symposium on the Foundations of Modern Physics*, (NJ: World Scientific, 1987), p. 42.

Schroedinger objected to Bohr's physical interpretation of the emission and absorption of radiation because physical clarity and visualizability are being sacrificed in favor of mathematical description. The inability to visualize a mathematical description also motivated Wolfgang Pauli in his criticism of Hermann Weyl's theory of gravitation that appears below.[2] Both passages well illustrate the genuine concern of many physicists of the time to get at the truth and in the process to understand how nature functions rather than merely describing its behavior.

> There is a physical-conceptual objection which should not be forgotten. In Weyl's theory we continuously operate with the field strength in the interior of the electron. For a physicist this [the field strength] is only defined as a force on a test-body, and since there are no smaller test-bodies than the electron itself, the concept of the electric field strength in a mathematical [space-] point seems to be an empty, meaningless fiction. One should stick to introducing only those quantities in physics which are observable in principle. Can it be that we are following a completely false track when using the continuum theories for the field in the interior of the electron?

Weyl responded, saying that fields interior to the electron could indeed be assigned a qualitative meaning. Still his theory has not been accepted, nor did it lead to any new results. Did this mean that Pauli was right, the skeptical viewpoint would prevail, and thenceforth test charges were used with caution? In fact the opposite has occurred. Weyl's method for conceiving scientific theories, without significant physical restriction, has become the norm.

Briefly stated this means that it is unnecessary to define the precise basis, or underlying concepts of what one theorizes. A mathematical theory begins with the approximations of two known physical states, A and B, and uses mathematics to show that state A is related to or can be transformed into state B. It is unimportant what precedes state A or what physical processes occur during such a transformation. Only the mathematics, equating the endpoints of a physical change, need be justified. This accounts for the popularity of transformation theory as a format for theoretical description.

Dirac originated the idea of searching for equations that are invariant under transformation. His most important accomplishments came as a result of finding them by, as he put it, "playing about with equations"[3]. Though a master of mathematical logic, he did not lose sight of the need for realism in the formulation of a theory of nature. He recognized that the equations had come first and their physical interpretation afterwards, and in the process the "physics" had been assigned secondary importance. By realizing

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2 In J. Mehra and H. Rechenberg, *The Historical Development of Quantum Theory*, Vol. 2, (NY: Springer Verlag, 1982), p. 278.

3 *Archive for the History of Quantum Physics*, interview with P.A.M. Dirac, May 14, 1963, p. 19-21.

the insufficiency of mathematical methods Dirac differs from nearly all other theoreticians. Indeed he became increasingly critical of the highly mathematical nature of quantum theory until late in life he stated[4],

> The present form of quantum mechanics should not be considered the final form . . . . It is the best that one can do up till now. But one should not suppose that it will survive indefinitely into the future. And I think that it is quite likely that at some future time we may get an improved quantum mechanics in which there will be a return to determinism and which will, therefore, justify the Einstein point of view.

Unlike most critics of quantum mechanics, Dirac understood the theory very well. He had after all formulated many of its fundamental ideas, even developing the formalism to express it with. Nevertheless he did not hesitate to question the ultimate significance of his work in its relation to the absolute. If one wishes to discover truth in scientific theory then nothing can be held back to be protected from scrutiny. <u>All logic must be questioned and all concepts placed in doubt</u>. With this in mind, let us reexamine some of the established concepts of physics.

3. Field singularities

One questionable physical description that appears in both the classical and quantum theories is best illustrated by the following question: What is at the same time everywhere and nowhere? This may appear to be a trick question, a play on words, or a joke. Unfortunately it isn't any of these. It actually describes a physical model used by all physicists, a model that is included explicitly in every theory that can be expressed mathematically and is implicit to the rest. It refers to the field singularity. Because the non-existence of singularities in nature is a well known fact, it would be understandable if mathematicians had compensated for them in some way or had asked how their presence influences physical concepts. In fact this has not happened, nor is it likely to happen. The validity of the singular field as a particle model is not questioned at all in mathematical theories, rather it is taken as a fundamental assumption.

The only way to determine what influence singularities have on mathematical models is to find a way to remove them and then compare the differences. Of course if they are completely removed from all theories of physics, there would be nothing left; no physics and no mathematics. However, by introducing the idea of internal structure the point source can be eliminated and the concept of field retained. For lack of a better analogy particle structure will be conceived of as a continuously circulating body of fluid similar to a water-filled balloon; whose internal circulation is constant for a free particle, but adjusts in response to the presence of other particles. Time is included as an internal parameter to account for internal motion, so structure will be expressed in terms of the three spatial dimensions and time. Following Pauli, the internal fluid is declared

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4 In N. Mukunda, *The World of Bohr and Dirac*, (Wiley Eastern Ltd., 1993).

unobservable due to the unavailability of a test charge to measure it with. Particle behavior will be described therefore in terms of two space-time continuums, one that is observable and another that is unobservable.

Armed with this rudimentary concept of structure let us reconsider two of the examples given in the introduction, parallel universes and time reversal. In quantum theory the wave function describes all that can be known about a particle and the eigenvalues are an infinite set of real numbers, discrete or continuous, representing all that is observable. The idea of parallel universes arises because the wave function permits multiple experimental outcomes or possibilities to an observation. Simply stated, multiple choices equals the possibility of multiple universes. Because the mathematical logic of a theory may be questioned, but not the physical foundations of that logic; no other choice is available.

Now let field singularities be removed from the quantum mechanical model of matter by introducing the idea of an unobservable particle structure. The parallel universe argument topples like a house of cards. The multiple possibilities represented by wave functions can now be expressed in terms of internal, hence unobservable adjustments that particle structures make as they interact. Similarly a particle going backwards in time may be replaced by a particle whose internal "fluid" circulates in a direction contrary to that of other particles. In other words, it would have an opposed intrinsic time, rather than an opposed time parameter.

This exercise demonstrates that the mathematical formalism of quantum theory may be assimilated into a valid physical theory by simply including as its central hypothesis that singularities do not exist. The precise form of such a theory remains of course to be determined. However observables, which are ordinarily given as the primary requirements of a scientific theory, instead become guidelines for theoretical analysis.

4. Field geometries

There have been attempts in the past to avoid the use of singularities. When Einstein published the general relativity theory in 1916 it opened the door to a multitude of continuum theories attempting to express matter in terms of either a unified field or the curvature of space-time. There are, however, little known objections to these models that are even more fundamental than the gravitational and electromagnetic phenomena they attempt to describe. For example, if one wishes to describe matter in terms of the curvature of space-time then with reference to what is the curvature measured? For "even if a situation requires the use of curvilinear coordinates, the physicist will faithfully erect at every point a Cartesian frame of unit vectors for reference."[5] Thus the suspicion arises that the unit vectors represent a fundamental Euclidean space-time which serves as

5 M. Bunge, *Problems in the Foundations of Physics*, (NY: Springer, 1971), p. 50 ff.

a back drop for the representation of all natural phenomena; and curvature does not refer to space-time itself, but to the measurement of a physical variable, the gravitational field potential, relative to space-time.

There are other difficulties with continuum theories as well. General relativity theory originated as an attempt to formulate *local* laws. The motion of particles can then be described continuously in terms of a field geometry. However, the need to enforce a specific *global* behavior in the solutions of the field equations, cosmologically speaking, requires modifications in the original equations. Therefore a consistent development of general relativity theory requires the possibility of going back and forth between the local and global points of view. Why do mathematicians avoid this issue?

Transitional viewpoints are not easily describable mathematically or conceptually. Theorists generally try to avoid, or ignore situations of this type (and thus far they have), because their mathematical freedom is severely restricted in the process. However, when physical inconsistencies are ignored it reduces the significance of a scientific paper to no more than a mental exercise. This is like constructing castles in the air; they are beautiful, but highly impractical.

5. Particle physics

Elementary particle theory is the most visible branch of physics. The facilities cost billions of dollars and require hundreds of operating personnel. Theoretical methods and objectives are equally inflated. One hundred or more authors may be listed on a single paper and due to its high visibility Nobel prizes often become an objective of research activity. Perhaps because of all the attention they receive, particle physicists seem to believe that they are involved in a search for the truth that is highly significant and independent of worldly concerns[6]. Do the seemingly noble objectives of these physicists make huge expenditures of money, time, and human resources justified? One critic had this to say.[7]

> It is unproblematic that scientists produce accounts of the world that they find comprehensible; given their cultural resources, only singular incompetence could have prevented members of the [particle physics] community producing an understandable version of reality at any point in their history . . . . given their extensive training in sophisticated mathematical techniques, the preponderance of mathematics in particle physicists' accounts of reality is no more hard to explain than the fondness of ethnic groups for their native language.

These are probably not ideas being discussed at Stanford, Brookhaven, or CERN; yet they are valid concerns for those of us who are bewildered by the seemingly endless number of elementary particles and theories to account for them. Unless these arguments

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6 See, for example, L. Lederman & R. Teresi, *The God Particle: If the Universe is the Answer, What is the Question?*, (NY: Dell, 1993).

7 Andrew Pickering, *Constructing Quarks*, (Edinburgh UP, 1984), p 413.

are satisfactorily addressed by the establishment they will forever remain a source of doubt and mistrust to the outside world.

6. Concluding remarks: Hypocrisy in science

A hypocrite is someone who claims to be something he isn't. Scientific theories can be hypocritical if they define a concept by using a variation or corruption of the same concept, a sort of redundancy of determination. When that happens, the theory's foundations interfere with its logical development leading to highly illogical conclusions. In other words, hypocrisy in science is like measuring distance with a rubber band.

Of all the scientific disciplines hypocrisy is most evident in quantum mechanics. This is because first of all it defines atomic structure by using the antithesis of structure, a singularity, as its theoretical model. Due to the experimentally verified impenetrability of matter, however, particles cannot be singular. (Even photons deflect from each other.) And secondly, an ambiguity is introduced since the same mathematical point designates a particle's physical location (position), and its physical essence (structure). Although position and structure are independent physical concepts, quantum theory treats them equivalently. In a scattering experiment, for example, no distinction is made between deflection due to the size and shape of the particles as opposed to deflection due to their relative position and momentum. The wave function lumps both contributions together.

This means that quantum theory is a physically inconsistent theory of nature. To remove the inconsistency it is necessary to admit that <u>quantum theory cannot distinguish between structure and position</u>. More simply stated, quantum theory quite literally cannot see the trees for the forest[8]. Due to this fundamental ambiguity indeterminacy may be interpreted equivalently as 1) delimiting position measurements, 2) a result of the physical extension of particles, or 3) a combination of both.******

In general relativity theory, it was noted, the curvature of space-time is defined as an observable relative to Euclidean space-time. However, <u>observable space and observable time are absolutes</u>, and are therefore disallowed by the special theory of relativity. If unified field theories are to remain consistent in the sense of special relativity theory they must be defined within a background space-time that has *no* observable properties. Aside from this, it too must address the problem of the singularity before it can be considered a legitimate scientific theory.

Finally, in elementary particle theory we see a claim to be searching for the truth when on the surface it appears to be nothing more than a particle classification scheme, a zoology of the microcosm. If something more profound exists then the burden of proof is upon particle physics, not the layman who is forced to support it.

There is little chance that the skeptical views voiced here will be heard, much less addressed. This is understandable since they are not new concerns, and so they have been

8 Translation: Quantum mechanics extrapolates measurements taken at the level of the ensemble to the level of the single particle by neglecting particle structure. *****

ignored before. It seems that criticism is only permitted during the formation of a theory and then to a select few. After dissemination a kind of crystallization takes place that is for all practical purposes irreversible.