QUANTUM PHYSICS: HISTORICAL REVIEW AND CURRENT DIRECTIONS

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Abstract

For several decades in the 20th century quantum physics has produced lively discussion and serious debates. The authors summarize early foundational work establishing quantum physics prior to 1930 and briefly consider the need for an epistemological shift in our classical philosophy of science. A further evaluation is made regarding egregious interpretations surrounding recent applications in quantum mechanics and their bearing on science and theology. Finally, a creationist framework is entertained to provide scientific insights and constrain ideas deduced from modern physics.

Introduction

In a recent article in *Christianity Today*, Allen Emerson reports the qualms of his theological friend regarding apparent conclusions derived from quantum mechanics.[1] Others, such as author Dave Hunt, are beginning to express their concern also.[2] Is a common sense view of the universe slipping away? Is the "new physics" paving the way toward pantheism? Will we be able to know or have certainty about anything? Let us first take a brief look at the foundations leading to what is called Quantum Physics.

The following list in Table I will begin helping us to understand some of the details in the development and interpretations involved in Quantum Physics. This list could be embellished with additional contributions, but it serves to represent some of the people and events from which modern physical concepts have been derived.

Max Planck derived a new mathematical relationship, $E = h\nu$, from his radiation formula fitted to blackbody radiation curves. Albert Einstein was later credited with demonstrating the discrete or particle-like nature of light, photons, from the photoelectric effect. Following the chain of this development, Compton's experimental results were interpreted as illustrating the particle nature of light when interacting with electrons. This is a brief outline which is generally used to convince us of the particle nature of electromagnetic radiation.

A parallel development began with N. Bohr's model for the hydrogen atom which tended to explain hydrogen's emission spectra in terms of a planetary electron, about a proton, within select or quantized orbits. These orbits were determined through the "quantization" of the electron's angular momentum.

After Bohr, the next critical step came with L. de Broglie's prediction that matter possesses wave properties, $\lambda = h/p$. This concept was regarded as the corresponding principle to Einstein's photon theory, as well as a better rationale for Bohr's atomic orbits of radius, r in terms of the number (n) of electron wave lengths, $n\lambda = 2\pi r$. After this, the work of Heisenberg, Born, Jordon, Bohr, Pauli, Schrodinger and others provided the mathematical formalism which has been commonly used in quantum mechanics. Beginning with such classical forms as matrix theory, wave propagation, Fourier analysis, etc., new relationships were developed which included the concepts $E = h\nu$ and $\lambda = h/p$ in the mathematical scheme.

A short time later, the wave nature of the electron was apparently confirmed by the electron diffraction experiment of Davisson and Germer. The "new physics" appeared theoretically and experimentally complete around 1930. From this point on, quantum physics would find much use in specific applications to various problems. The debate, however, continues regarding

Table I. Summary of Historical Developments in Quantum Physics

Planck and Blackbody Radiation (1900)
Development of mathematical formula satisfying experimental data for blackbody radiation; purported to indicate that light is radiated in "quanta" of energy, $E = h\nu$ (E = quantum of energy; h = Planck's constant; ν = linear frequency).

Einstein and the Photoelectric Effect (1965)
Theoretical explanation of photoelectric effect in terms of quantum energy; used to support particle nature of light (photons).

The Bohr Atom (1913)
Modification of Rutherford's atomic model proposing that electron orbits are selected due to quantized angular momentum, $L = nh/2\pi$ where n = 1, 2, 3, . . . n. Also included idea that electromagnetic radiation from the atom results from jumps between electron orbits, $E_2 - E_1 = h\nu$ where E_1 and E_2 are orbital energies of the electrons.

The Compton Effect (1922)
Experiment involving scattering effects of photons interacting with electrons; used to confirm particle-like nature of light (billiard ball behavior).

DeBroglie and Matter Waves (1923-4)
Theoretical proposal that matter has wave-like behavior, $\lambda = h/p$. (λ = wavelength of electron or other particle; p = particle momentum).

Heisenberg, et al. and Matrix Mechanics (1925-7)
Development of matrix mechanics in quantum physics, uncertainty principle, probability interpretation, etc.; also foundation of what has been called the Copenhagen interpretation of quantum theory.

Schrodinger's Equation (1926)
Development of wave mechanics in quantum physics following de Broglie relationship; mathematically equivalent to matrix mechanics.

Davisson and Germer Experiment (1927)
Electron interaction with nickel crystal producing apparent diffraction patterns; purported to confirm de Broglie relationship.

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the proper physical and philosophical interpretation quantum physics is to be awarded.

At present among creationists, Dr. Thomas Barnes has been a significant opponent of some of the standard quantum mechanical interpretations. In his book *Physics of the Future,* Dr. Barnes discusses the photoelectric and Compton effects, and the Bohr atomic model. His quotations of such men as Lorentz, Poincare, and Ives generate serious reconsideration of the particle nature of light.[3] Barnes further develops an electronic model of the atom in contrast to the Bohr model.[4] Atoms are thought of as high Q oscillators whose wave properties are characterized in terms of electronic resonance.[5]

In deference to Dr. Barnes, we confess our partiality to mechanical models. However, the profound concept which underlies some of his work is the maintenance of *real particles with resonant characteristics* (whether electrical or mechanical). Resonance is a classical concept which, in this case, can be used to simultaneously relate mass or charge to frequency and therefore wavelength. Although we do not wish to prematurely depreciate or exalt Dr. Barnes's atomic model, we believe that maintaining a view of the atom as a *real* resonant oscillator is sound. A proper interpretation of such oscillators could possibly contribute to sweeping away wave-particle dualism or abstract probability approaches in atomic modeling. Even Planck and Schrodinger expressed such an emphasis somewhat in their respective work speaking of oscillators and resonance. Indeed, Schrodinger himself had discussed the Compton effect completely in terms of wave phenomena.[6] However, our main emphasis is that quantum physics proper should be first seen as an extension of classical physics and not as something wholly different mathematically or philosophically.

Basic Mathematical Relations

The following includes a few common mathematical presentations, found in many physics texts, regarding Bohr's atomic model, [7,8] De Broglie's [9] relationship, and Schrodinger's time independent equation. [10,11]

(A) Bohr, using Rutherford's basic atomic model, equated the appropriate electrical and mechanical forces in the planetary model of hydrogen:

$$\frac{mv^2}{r} = \frac{e}{4\pi\epsilon_0 r^2} \tag{1}$$

where m = mass of electron, v = velocity of electron, r = orbital radius of electron, and ε_0 is a constant (permittivity of free space). Equation (1) is employed to arrive at expressions for both v and r. Combining the kinetic and potential terms for electron energy (E_t) we obtain

$$E_T = \frac{-e^2}{8\pi\epsilon_0 r} \tag{2}$$

Using Bohr's proposition $L = mvr = nh/2\pi$ and the idea that changes between electron orbits were accompanied by a specific quantum of energy $E_2 - E_1 = h\nu$ we obtain the general relationships:

$$r \sim n^2h^2 \qquad v \sim 1/nh \qquad E(h\nu) \sim 1/n^2$$

The integer n, which was Bohr's principal quantum number, was equivalent to individual values in the set of series numbers for the Ryberg formula:

$$\nu = R(1/n_j^2 - 1/n_k^2) \tag{3}$$

Bohr's formula for frequency took on the same form with a physical meaning for the Ryberg constant:

$$R = \frac{me^4}{8\epsilon_0^2 h^3} \tag{4}$$

The integer n becomes the selection number for a specific orbit, and the constant, R, has been physically derived.

(B) After de Broglie introduced his proposition it was shown to be mathematically equivalent to Bohr's selection rule. De Broglie's relation is:

$$\lambda = h/p = h/mv \tag{5}$$

If, as de Broglie indicated, the radius of the electron encircling the nucleus is determined by a unit wavelength then,

$$\begin{aligned} 2\pi r &= n\lambda \\ 2\pi r &= nh/mv \\ mvr &= nh/2\pi \end{aligned} \tag{6}$$

Equation (6) is known as the Bohr selection rule. De Broglie's idea about the electron was of course much different than Bohr's, but the former tended to give an explanation for the selection of orbits. It also tended to explain a mechanism for electron stability in terms of standing waves instead of moving charges, which would continually radiate energy and fall toward the nucleus.

(C) The following derivation shows how the time-independent form of Schrodinger's equation can be obtained from the classical wave equation using de Broglie's relationship.

$$\frac{\delta^2\psi}{\delta x^2} = \frac{1}{v^2}\frac{\delta^2\psi}{\delta t^2}, \qquad \psi = \psi(x, t) \tag{7}$$

Equation (7) is the classical wave equation and ψ is generally referred to as the wave function. Classically it is represented as a wave with magnitude dependent upon location and time, ψ (x, t). The quantum approach will result in a localized waveform. which is to imply particle-like behavior. The standard solution for this equation may be expressed by separating the time (t) and space element (x) by using ψ (x,t) = ψ (x) ψ (t). If we take ψ (t) = $e^{-i\omega t}$ where ω is the angular frequency, the function (or particle) moves as a wave in time, then:

$$\frac{\delta^2\psi(x)}{\delta x^2} = -\frac{\omega^2}{v^2}\psi(x) \tag{8}$$

Understanding that $\omega = 2n\nu$, $v = \lambda\nu$,and using $\lambda = h/p$ and, $p^2 = 2m(E_T - V)$ derived from the total energy [kinetic and potential (V)] of a hypothetical atomic system $E_T = p^2/2m - V(x)$, then:

$$\frac{\delta^2\psi(x)}{\delta x^2} = -\frac{4\pi^2p^2}{h^2}\psi(x)$$

$$\frac{\delta^2\psi(x)}{\delta x^2} = -\frac{4\pi^2}{h^2}\cdot 2m(E_T - V)\,\psi(x)$$

$$\text{or} \qquad \frac{h^2}{4\pi^2}\frac{\delta^2\psi(x)}{\delta x^2} + 2m(E_T - V)\,\psi(x) = 0 \tag{9}$$

Equation (9), which is called the time-independent Schrodinger equation, is a) for one dimension only and b) developed considering the potential as a function of position alone. Of course much more is involved in the derivation of the complete time dependent form of Schrodinger's equation as well as the rest of quantum mechanics. However, what is important to note is that the previous equations, being developed prior to 1930, can be consistently derived from the formalism of classical physics with appropriate modifications.

In conclusion to these simple exercises, it was our intention to demonstrate the dependence of quantum mechanics upon the foundation of classical physics. Even in more recent times, for example, John Wheeler in a discussion on quantum gravity stated:

> No one today knows how to get quantum theory as quantum theory without having at the start the mathematical guidance of what we call 'classical' theory.[12]

It is a respectable opinion that when distilled down to the fundamental ingredients quantum physics (1930) = classical physics + ($E = h\nu$) + ($\lambda = h/p$). By saying this we do not mean to minimize the profound mathematical work of others involved. We also recognize that spin, perturbation theories, approximations, and further developments have contributed to the intricacy of quantum mechanical approaches. However, we believe that the historic mathematical progression has been consistent with classical scientific epistemology as opposed to some of the philosophical interpretations attending quantum physics.

New Directions of Quantum Mechanical Interpretations

The previous sections dealt briefly with quantum physics in the past. We shall now deal with some philosophical concepts concerning the interpretation of science and reality which have been attributed to quantum mechanics. It is here we think that many make offensive "quantum leaps."

An excellent article in *Scientific American* by Bernard dEspagnat discusses a number of experiments which bear on quantum mechanical predictions.[13] Before discussing dEspagnat's conclusions refer to Table II for some definitions of concepts involved.

After several conferences in the early 30's, the debate concerning reality and quantum mechanical interpretations had focused primarily on two men and their views: Bohr and Einstein. Later in 1935, Einstein, with Podolsky and Rosen, laid down a final challenge to quantum mechanical interpretations in what is known as the EPR paradox. Einstein and his colleagues stressed that unknown factors or hidden variables existed so that quantum mechanics must be an incomplete system. If we could discover the hidden variables we could once again return to a deterministic explanation of atomic phenomena.

The EPR paradox can be illustrated using the following example: Let two particles interact in such a way that some of their properties are correlated i.e. spin. Once the particles are separated and the spin, etc. analyzed for one of them, we could perhaps automatically conclude something specific about the same property of the other particle (again representing a deterministic view of reality).

Table II. Definitions of Terms

Determinism
Belief that all activity is fixed or determined by a continuous sequence of cause-effect relationships.

Einstein Separability
Specifically: The idea that matter or information cannot be transmitted faster than the speed of light; generally: the observer is separate, distinct and does not influence that which is observed.

Inductive Reasoning or (Induction)
Interpretation of limited information, i.e. experimental data, to form general conclusions about reality.

Positivism
Belief that only empirical observations have real meaning and that conclusions beyond observables should be disregarded; extended in the present sense to infer that only what is experienced is real.

Realism
Belief that all things have separate or objective existence apart from human observations or experience.

In 1964 John Bell developed a mathematical relationship which assisted in bringing the EPR experiment into the laboratory. This relation, called Bell's inequality, could be used to calculate the results of correlated properties which differed from quantum mechanical predictions.

DEspagnat lists the experiments which were carried out in the 70's regarding the EPR paradox. Five of seven experiments have been reported as confirming the predictions of quantum physics. Most of these experiments dealt with the polarization of photons, but one experiment employed pairs of protons. Not only did dEspagnat evaluate the results of these experiments, he anticipated the philosophic conclusions related to the potential results of the Alain Aspect experiment (1982) while still in progress. The results of the Aspect experiment are apparently "making waves" both in the scientific and theological communities.

This experiment has been reported to show that correlated photons, after separation over some distance, affect one another almost instantaneously (transferring information about the property or situation of one to the other faster than the speed of light). The Aspect experiment was uniquely designed so that no correlation could exist unless an action-reaction response traveled faster than the speed of light. If the experimental instrumentation is sound, and the measurements sufficiently correct, then certain principles of relativity may be called into question.

We believe that dEspagnat has done an excellent job in assessing the Aspect experiment, particularly before the results were recorded. In his evaluation of the assumptions concerning the experimental method, he examines 1) realism, 2) inductive reasoning, and 3) Einstein separability. He suggests that Einstein separability is the faulty assumption within the experimental framework (a conclusion not at all displeasing to many creationists).

On the other hand, many popularized science books such as *The Tao of Physics*,[14] *The Dancing Wu Li Masters*,[15] and *Taking the Quantum Leap*[16] use a number of these experimental results to emphasize a positivist (related to solipsism) or pantheistic view of re-

ality. For example, Fred Wolf states:

> A quantum solipsist says: I am the only reality. Everything out there is in my mind. To change reality, that is, to change objects into different objects, I need to change my mind. To the extent that I am able to do this, so appears the world as I see it.'

Zukav states:

> Photons do not exist by themselves. All that exists by itself is an unbroken wholeness that presents itself to us as webs (more patterns) of relations. Individual entities are idealizations which are correlations made by us. . . . The new physics sounds very much like old eastern mysticism.[18]

DEspagnat mentions this sort of thinking and explains that positivism in physics has been replacing the notion of realism in our day:

> A number of philosophers, who can collectively be called positivists, have rejected the realistic viewpoint. The positivists do not assert that the world external to the mind does not exist; they merely dismiss as meaningless any statement about an external reality that does not refer directly to sensory impressions. In the 20th century some radical positivists have had an appreciable, if indirect, influence on the thinking of theoretical physics.[19]

Although dEspagnat concedes that the rejection of Einstein separability may "represent a step toward philosophical positivism," a realistic view of a cause-effect universe could remain intact. The tragedy of an encroaching positivist view in science, however, is well represented in his statement as follows:

> If the refusal to seek underlying causes of observed regularities is applied consistently, it trivializes the entire scientific enterprise. Science is reduced to a set of recipes for predicting future observations from a knowledge of past ones. Any notion of science as the 'study of nature' is impossible; nature is a phantom. One can imagine a physics grounded on positivist principles that would predict all possible correlations of events and still leave the world totally incomprehensible.[20]

The previous quote confirms why creationists realize that our philosophy of science must begin with and follow divine revelation. A rejection of realistic views hardly seems warranted and actually appears to be a case of attempting to use science to prove nonscience, or possibly nonsense.

How might this affect theology? Again Wolf states:

> The first case of quantum consciousness may have been Moses. When he asked, 'who are you?' of the presence felt at the burning bush, the answer: I am that I am.' Moses then recognized that within him, the god voice spoke as Moses. And from that moment onward, humans began to control their destiny.[21]

No space is necessary to elaborate on this absurdity to serious students of Scripture.

When theology is the topic discussion, there should be no doubt as to the authority of God's Word in the matter. However, our philosophy of science must also be consistent with epistemological foundations set forth in the Scriptures. We do not affirm this position, of course, merely to set forth some unique personal view of Christian dogma. We do so because this is what is true.

Whatever quantum physics brings to light regarding the physical universe, we have every confidence that its correct understanding will be constrained by theology proper. Positivism being humanistic is inherently uncertain. Only revelation provides a real basis for understanding. In the following evaluation of the Genesis account, we consider the creation of matter and light. Quantum physics provides a mathematical framework for the phenomena. However, are matter and energy mutually exclusive in form, two shades of the same thing, or do they fit "hand in glove," so to speak? This exercise may yield a fruitful reflection upon our scientific models for particles and waves, as well as interpretations affecting both physics and cosmogeny.

Biblical Considerations in Cosmogeny

As creationists we approach the creation account of Genesis 1 and 2 as truthful and factual history and interpret it as such. Further, we accept the Bible's claim to divine authorship and look to the Scripture as the only revelation of God's will for man, and it is the only adequate source for the explanation of origins. We also believe that any accurate implications from sound approaches in quantum physics may have already been anticipated within in the canon of Scripture. The question of origins is answered with a true cosmogeny which shines forth:

> . . . We are taken back to that point which the human mind will naturally revert and in reference to which it asks: What was the beginning of things?' This solemn and pithy statement gives man the information: the beginning was made by God in His creation of heaven and earth. As far as this world is concerned, it simply had no existence before this time.[22]

The Early Earth

The origin of the earth is expressed in Genesis 1:1. Moses, the author of this account, used the Hebrew word *bara* which in this particular verb form means, without exception, creation ex nihilo.[23] In itself *bara* does not necessarily preclude the use of pre-existing material because of the use in Isaiah 65:18. However, as Leupold notes: ". . . When no existing material is mentioned as to be worked over, no such material is implied."[24] Thus, man sees the staggering exercise of divine omnipotence through the creative word of God. In this context, *bara* means to create out of nothing, but not in a final state. The Genesis account reveals God like a potter who begins with raw clay on a wheel and shapes and forms that clay into his creation; the raw unfinished universe is molded into the finished brilliant universe and verdant earth.

One important aspect of the creation week was the work of the Holy Spirit of God as expressed in Genesis 1:2: "and the Spirit of God was *hovering* over the waters" (NIV). The Hebrew root is *rkph* and in this verse can be translated "hovering, flying, fluttering."[25] This word is used in Deuteronomy 32:11 of the mother eagle who hovers over the nest of young eaglets "to warm them, and develop their vital powers . . ."[26] Similarly, the Holy Spirit ". . . moved upon the deep, which had received at its creation the germs of all life, to fill them with vital energy by His creative breath of

life."[27] The author of Genesis is apparently saying that God started with a raw, unfinished creation and will now begin to shape and form that creation into a finished, organized creation. The work of the Spirit in verse two as expressed in the term "hovering" is "a vibrant moving, a protective hovering."[28] Leupold expresses this particular activity of the Holy Spirit as follows:

> From all other activities that are elsewhere ascribed to the Holy Spirit we conclude that His work in this case must have been *anticipatory* (our emphasis) of the creative work that followed, a kind of impregnation with divine potentialities. The germs of all that is created were placed into dead matter by Him. His was the *preparatory* work for leading over from the inorganic to the organic.[29]

Another commentator from the previous century expresses a similar interpretation:

> It was not the self-development of powers inherent in matter. The creative movement was made by the will of God; . . . Through the whole of the Old Testament, "The Spirit of God" is represented as the great agent in imparting vital energy and action (cf. Ps. civ. 3) both to animals and plants; and thus, as he is represented to have brought His immediate influences to bear upon "the void and formless'" world, by working on the dead or discordant elements, the action must be considered as having consisted in combining, arranging, and ripening them into a state adapted as being the scene of a new creation. . . .[30]

Henry Morris has the same understanding of the "hovering" work of the Spirit and says this: ". . . In modern scientific terminology, the translation would probably be 'vibrated.'"[31] Morris goes on to add: "If the universe is to be energized, there must be an Energizer. If it is to be set in motion, there must be a Prime Mover."[32]

Morris and the above commentators are saying that the matter created by God "in the beginning" was then given properties by the "hovering" of the Spirit which prepared it for the further molding and shaping of God's creation that would occur as revealed in Genesis 1 and 2. Although the exact nature of the work of the Spirit cannot be known, we believe that the interpretations of the above writers are true to the Scripture and fit the context of the passage.

The State of Early Earth

The earth is described in Genesis 1:2 "Now the earth was formless and empty." The word "formless" is in the original language *tohu* and "empty" is the word *bohu*. The word *tohu* refers to the original state of creation as it was after God brought it into existence by His spoken Word. It was "formless" or "unformed"[33] in the sense that God had yet to put it into His desired final shape and form.[34] Weston Fields says the following concerning the meaning of *tohu:*

> . . . When God was done with his creation work in relation to the earth, it was not *tohu*. It was *tohu* in the purest sense only for a short period on the first day of creation. All during the creation week it became less and less *tohu,* as the light appeared, the firmament was made, the land was divided from the sea, the plants and animals were created, and the sun, moon and stars were made. Finally, by the time Adam was created on the sixth day, the earth was in the state God had planned it should be. It was *completed;* it was now *formed* and *filled!*[35]

The word "empty" *bohu* is listed under the "emptiness" entry in the lexicon[36] and means merely that the earth was without dwellers.[37] The earth therefore ". . . must be peopled with all kinds of inhabitants or beings . . . "[38] God then had created the earth in its original state and in the remainder of the creation week he would shape and mold earth until it was formed, and filled with inhabitants.

Light

The text of the Genesis is clear in placing the creation of light from the earth as preceding the creation of the sun and stars. The original language of the translation "Let there be light'" is quite forceful using the imperative and could be translated "become light'" with the resulting effect "and there was light," which more literally could be translated "became light."[39] The point of the passage seems to be that light was first created on the earth and later appeared in the rest of the universe. Lange brings this out in the following:

> . . . In the fact of the first illumination of the earth the author presents the fact of the birth of light generally in the world, without declaring thereby that the date of the genesis of the earth's light is also the date of the genesis of light universally. But we may well take the birth of light in the earth (or the earth becoming light) *as the analogue whereon is presented the birth of light in heaven*. (Our emphasis.)[40]

Light originated in conjunction with the development of earth or matter and then at God's command light appeared in, or emanated within, the rest of the universe in response to His word.

This brief examination of Genesis 1:1-2 shows that the universe was created in an unfinished state and through the working of the Holy Spirit, God began to complete His work. Genesis reveals that light originated on the earth and later appeared in the rest of the universe.

Consideration of Creationist Position

As creationists, we are confident that we can make some general assertions regarding both quantum mechanical discoveries and interpretations before a maze of metaphysics clouds the issues.

I. *Matter was constructed with resonant characteristics*
Matter, in its construction phase was apparently infused with vibrational energy by the action of the Spirit (Genesis 1:2). Resonant characteristics were a part of this construction of matter before the embellishment of the heavens and the earth. The incorporation of vibrational characteristics within matter was most likely both integral and preparatory to the production of light (Genesis 1:3).

II. *The Universe exists apart from human existence*
Contrary to conclusions which could be derived from an extreme positivist view, the *existence* (with a tangible purposeful cause-effect nature) of the universe is not a function of human observa-

tion. God was clearly creating a real and *good* universal order before human occupation.

III. Human activity influences the universe

God constructed man in such a way that his behavior influenced the destiny of things associated with the earth (Genesis 1:26-28) and apparently all of creation-including the universe (Romans 8:20-22). It is in this sense that we are interconnected with the universe, both physically and spiritually (which includes moral responsibility).

Although some of these ideas may seem simple or obvious to the Christian mind, they may need to be stressed to the scientific world.

Conclusion

In our effort to outline the fundamental development of quantum mechanics we have stressed a need for careful reflection of representations supporting this area of physics. We believe that this development was (and is) consistent with our classical epistemology of science.

We also conclude that positivist and pantheistic views regarding modern physics are not only antichristian by nature, but they corrupt and destroy the discipline of science. In reality, this new shift in philosophy might appropriately be termed "mystical positivism."

Finally, we are confident that a creationist interpretation may fully incorporate current scientific findings related to quantum mechanics. We further suggest the possibility that 19th century theology has qualitatively proposed a unified relationship between matter and energy prior to the development of modern physics. The basis of such a proposal was the reasonable conclusion from a literal Genesis.

Other concepts could conceivably be added or derived from our previous discussion. For instance, instead of "the big bang" the primordial universe might actually have experienced "the big flash" with all light emanating from a formless earth of unknown initial dimension.

Finally, to answer the concerns of Emerson's friend, I only need borrow words from the philosophic trilogy of Dr. Francis Schaeffer. We have no need to fear anything because God is there; nor do we need to escape from reason as some have done— because He is there and He is not silent!

Acknowledgements

The late Francis Schaeffer discussed positivism in a sense slightly different than was presented in this paper. We chose to use a definition which was more strictly consistent with the scientific sources used. However, we wish to acknowledge Dr. Schaeffer's clear insight and predictions, prior to the 70's, regarding the death of science (in the cultural sense) following moral decline in the West.

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QUOTE

A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it.

Planck, Max. 1968. Scientific autobiography and other papers, Greenwood. New York pp. 33-4.