Physics needs nothing less than a Renaissance – On the relation between physics and philosophy

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Abstract. In this article, the fundamental inconsistencies of the mainstream theoretical physics has been analyzed in detail. It has been shown that relativity and quantum field theory have an array of fundamental problems in postulations, methodology, theory, experimental verification and philosophy. The modern theoretical physics represented by relativity and the standard model of particle physics has come to a dead end. To get out of the impasse, physics community must give up the theological pursuit of a theory of everything, return to scientific philosophy, logic, methodology and scientific mission. Physics needs nothing less than a renaissance.

1. Introduction

The modern theoretical physics has witnessed a history of more than one hundred years, if take the publication of Einstein's theory of relativity as the onset. After one hundred years of diligent work of thousands of theoretical and experimental physicists, the situation is still far from being satisfactory and encouraging. Many fundamental issues in theoretical physics, such as the divergence problem, the incompatibility of general relativity and quantum theory, the difficulties related with GUT and TOE, and the many issues with the so-called theories beyond the Standard Model, are still outstanding and defy easy solution. We can ask a legitimate question: Are the scientific logic, philosophy and methodology of the classical physics all obsolete? Why are there so many fundamental inconsistencies in theoretical physics of 20th century? Why is modern theoretical physics running into a dead end? A scrutiny of the edifice of modern theoretical physics reveals that the ultimate reason for the multitude of unsolvable fundamental inconsistencies of the theoretical physics is the shift of philosophy. The reason is that the contemporary theories, that were developed mathematics-first, in order to give mathematical descriptions of phenomena discovered in the early 20th century; and then philosophy of physics was made to confirm these theories. It is a shift from scientific philosophy and methodology to mythological and theological philosophy and methodology. To drive the point through, let us look at the fundamental problems of the theoretical physics of 20th century in comparison with the classical physics.

2. The modern approach to the microscopic physics is incorrect

The microscopic world beyond the atomic level denies easy access at the current level of technology. We know much less about nuclear structure than atomic structure. We do not even have a thorough survey of the nuclear reactions of some 2000 isotopes and their products. There is nothing similar to the periodicity of the chemical elements that could be spelled out from the data of nuclear reactions.

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The general trend of binding energy per nucleon shows some important features incompatible with contemporary nuclear physics:

1) The binding energy from H1 to He4 is a monotonic steep line. It would imply that hydrogen could be easily converted to deuterium, tritium and helium. If that is the case, hydrogen would not be as stable as deuterium and tritium. This is opposite to the facts.
2) Lithium is at a local minimum of the binding energy curve, which means that lithium would be able to either fission into helium or fusion into carbon. This is opposite to the facts.
3) U233, U235, U236 and U238 have nearly identical binding energy, but there is a world difference in their stability. U238 is a stable isotope with a half-life of about 4.5 billion years, but U233. U235, U236 are all fissionable isotopes. The binding energy curve, however, says that U238 should be the least stable and U233 the most stable of the uranium isotopes, which is exactly opposite to the facts.
4) The helium nucleus is extremely stable even in nuclear explosion. It indicates that the helium nucleus must have some kind of crystalline structure. We do not have a slightest idea about such structure responsible for the extremely high stability of helium.

These inconsistencies indicate that our understanding of nuclear structure and binding energy is flawed. To answer these questions, we need to have a broad database of nuclear reactions, but we do not. The reason that we can rationally speculate about the atomic structure is that over the centuries, alchemists and chemists accumulated an enormous database of chemical reactions that eventually led to the discovery of the law of definite proportion, the periodicity of the elements and the octet rule. It is not conceivable that any sensible nuclear structure could be discovered without a similar experimental database of nuclear reactions of the isotopes. The entrance to the nuclear level is paved by experimental nuclear physics and nuclear chemistry.

Unfortunately, the pioneer physicists in the early 20th century followed a wrong path. Instead of studying the structure of the nuclides, they were engaged and endeavored in the study of the "structure" of nucleons (protons and neutrons). We know that the proton and the electron do not decay, meaning they do not have structure as far as the experimental evidence go. The quark model presents a "structure" of proton, but have individual quarks and gluons theoretically "confined", forbidden to be detected individually. Quantum chromodynamics predicts that the proton decays, but experimental results show that the lifetime of proton is at least 10^{32} years, which is 22 orders of magnitude longer than the lifetime of the Big Bang universe. The proton does not decay in fact. The idea of a proton consisting of a few parts is not philosophically wrong, but it is not experimentally supported. The idea of a massless photon consisting of massive particles B^0 and W^0, however, is philosophically and logically wrong and absurd. The neutron does have a structure and it decays, but neutron is not a fundamental particle. It is wrong to treat the neutron and proton on the equal footing in a so-called "isospin space".

Since the pioneers had led the theorists through a wrong entrance, their students naturally followed suit and kept working on the "analytical continuation" of the theories of their teachers. To get out of the theoretical maze, we have to try a new approach: Start to explore the structure of the nuclides instead of the structure of the nucleons. We must build a database of nuclear reactions of some 2000 isotopes. The experimental survey of the nuclear isotopes may also lead to discovery of new fission and fusion materials that might eventually solve the energy crisis, and possibly lead to invention of portable fission and fusion reactors. The discovery of coal made it possible to revolutionize the industry with the steam engine; the discovery of petroleum made it possible to revitalize the industry with internal combustion engines and aviation vessels. The discovery of new fusion fuels might lead to realization of controlled thermonuclear fusion. The solution of energy crisis may not be in the design of sophisticated Tokamaks or laser ignition devices but in the discovery of new fusion fuels. Whoever first takes this new approach and re-appropriates the resources to experimental nuclear physics and nuclear chemistry and material science would be the first to jump out the abyss of theoretical physics of 20th century, and emerge as the world leader in science and technology.

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3. It is impossible to understand the microscopic world through collisional experiment

The only nuclear phenomena we can observe directly are the radioactive decay and the fission and fusion reactions. Mass spectrometry can measure masses of the nuclides and tell us the number of protons and neutrons contained in the various nuclides. None of these experimental data indicates how the nucleons behave and move in the nuclear force fields. As a result, we have no idea of exact form of the nuclear force. We can only reason that it must be strong at short distance to overcome the inverse square law that governs the electric repulsion between protons. Thus far, the best theoretical guess is the Yukawa potential, but it is a static potential not dependent on velocities of the nucleons. A static force is not a complete one because it cannot explain the propagation of the nuclear interaction. The Yukawa potential cannot be directly verified experimentally.

Without direct knowledge about the nuclear force, we must resort to indirect ways of exploring the nuclear force. What measures do we have? There are three experimental techniques for microscopic studies: a) spectroscopy; b) mass spectrometry; c) collision of particles. Spectroscopy and mass spectrometry are not effective tools of exploring the nuclear force. Collision is the only measure we have for studying nuclear physics. However, collisions do not carry direct information about the force field either. One has to speculate and guess the force field indirectly from cross sections of particle collision experiments. The differential cross section $d\sigma/d\Omega$ is supposed to be related to the interaction force (potential) and the wave functions of the scattering particles by:

$$\frac{d\sigma}{d\Omega} = \left| f\left(\mathbf{q}^2\right) \right|^2 \tag{1}$$

where $\mathbf{q}$ is the momentum transfer, and $f\left(\mathbf{q}^2\right)$ is called the *scattering amplitude*:

$$f(\mathbf{q}^2) = \int \Psi^\dagger V(\mathbf{r}) \Psi d^3\mathbf{r} \tag{2}$$

where Ψ is the wave function and $V(\mathbf{r})$ is the interaction potential function. The integration is carried over the entire volume of interaction. If we know the potential $V(\mathbf{r})$, we can obtain the force by taking the negative gradient of $V(\mathbf{r})$. Unfortunately, we do not know $V(\mathbf{r})$, nor the wave function Ψ. Our job is to speculate $V(\mathbf{r})$ and Ψ based on Eqs (1-2) and the measured differential cross section $d\sigma/d\Omega$. Namely, we have to determine the integrand in Eq (2), given the values of the definite integration ($d\sigma/d\Omega$). But this is an impossible task. There is no way we could determine the form of the integrand given the value of a definite integration! For example, if we are given the shape and measurements of a solid, we can determine its volume by integration. But we could not do the reverse. We could not determine the shape and the measurements of an unknown solid given its volume. For the same reason, it is simply impossible to determine the form of the interaction potential $V(\mathbf{r})$ and the wave function Ψ given the experimental data of the cross section ($d\sigma/d\Omega$). The whole business of particle physics is to speculate the form of certain interaction potential (or the Lagrangian) from the experimental data of collisional cross sections measurements. To make the speculating job a little easier, many restrictions are subjectively imposed on the forms of the interaction Lagrangians and the wave functions, the most important being the requirement of symmetry. The theorists love to preach about aesthetic beauty of various symmetries as a law of nature. Honestly, it is not a law of nature. It is merely a subjective measure to reduce the work of speculation and legitimize it.

Now let us look at the speculative nature of particle physics from experimental perspective. The reason that we know gravitational and electromagnetic forces very well is because we can study movements of objects such as planets and particles in gravitational and electromagnetic fields. We never (or rarely) use collisional process to understand gravitational and electromagnetic forces. I challenge my colleagues to see if it is possible to design a collisional experiment for discovering Kepler's laws, Newton's law of gravitation, Coulomb's law, Biot-Savart law, Ampere's law and Faraday's law. Suppose a boy discovers a deep cave in a dark forest. He uses a collision experiment to explore the cave by throwing stones into it. He might discover something such as the depth of the cave, and see some birds and bats flying out, but he could not figure out the shape of the cave, where the underground river runs into, and what mines are buried underneath, based on the observational data of birds and bats flying out of the cave. Similarly, we can learn something about the microscopic world by collision experiments, but we could not discover e.g. the octet rule and periodicity of chemical elements, nor the crystalline structure of the nuclides. The lack of effective methods makes experimental particle physics highly speculative. As the energy scale of experimental physics gets higher and higher, the processes get more and more complicated and indirect. Interpretation of the data becomes a guessing game. The experiments are usually designed according to some speculative theories and selection rules. It predefines the cyclic speculative nature of experiments.

In cosmology, the speculative nature is also evident in both theoretical and experimental aspects. Almost all interpretations of the observational data in astrophysics are dependent on the speculative theoretical model, specifically, the GR-based standard model of cosmology or the Big Bang theory.

4. Science versus aesthetics

Science is not associated with aesthetics in any definite way. The sense of beauty is subjective but the physical world is objective. Classically, beauty was not a theoretical requirement nor criterion.

In theoretical physics of 20th century, however, esthetic consideration has become a fundamental rule and criterion. Steve Weinberg [1] stated: “the consensus in favor of physical theories has often been reached on the basis of aesthetic judgements before the experimental evidence for these theories became really compelling. I see in this the remarkable power of the physicist’s sense of beauty acting in conjunction with and sometimes even in opposition to the weight of experimental evidence.” Edward Arthur Milne [2] stated “(If a paper) evokes in us those emotions which we associate with beauty no further justification is needed.” Paul Dirac [3] advocated: “The research worker, in his efforts to express the fundamental laws of Nature in mathematical form, should strive mainly for mathematical beauty.” Werner Heisenberg [4] p. 68 made his point explicitly: “If nature leads us to mathematical forms of great simplicity and beauty we cannot help thinking that they are ‘true,’ that they reveal a genuine feature of nature.” Anthony Zee [5] wrote: “My colleagues and I, we are the intellectual descendants of Albert Einstein; we like to think that we too search for beauty.” “Physicists developed the notion of symmetry as an objective criterion in judging Nature’s design”.

The above-mentioned figures are numerous and important enough to establish a faith. Their teachings served as the beacons for the younger researchers in their long voyage in the dark. The personal successes of these milestone figures, many of them being Nobel laureates, were more than convincing to convert the young physicists to the faith of beauty.

What is disturbing is that the mainstream theoretical physicists of the 20th century actually can reach consensus in favor of physical theories before the experimental evidence becomes compelling. It means that even when the experimental results show the opposite, they can still claim that their theories are correct based on consensus about aesthetics. Such doctrine with their established authority definitely holds a psychological sway of the experimentalists in their data measurement and data processing. It will keep them refrained from publishing negative results against the consensus of established authorities who might also serve as judges to evaluate their work. The consequences of opposing established authorities can affect their publication, promotion, continued funding, tenure decision and the candidacy for sought-after prizes. It poses a tremendous pressure on physicists in a society of “publish or perish”.

The first standard of beauty the modern theoretical physicists established was symmetry. In the early stage of quantum mechanics physicists believed that the parity was conserved. It is called the “parity conservation law”. The faith in parity conservation was broken in 1956 when Tsung Dao Lee and Chen Ning Yang [6] showed that parity conservation was untested in the weak interaction. In 1957 Chien-Shiung Wu et al. [7] found a clear violation of parity conservation in the beta decay of cobalt-60. The CP-symmetry (simultaneous charge conjugation and parity) was then believed to be preserved by all physical phenomena, but that was later found to be false as well. The current faith in the theoretical physics community is that the CPT (simultaneous charge conjugation, parity transformation and time reversal) is conserved, although there is no way to prove its general validity.

In quantum field theory the above discussed "symmetry" is generalized to mean that the theory remains invariant under certain transformation. The first such symmetry is the Lorentz invariance in special relativity. It has been adopted by particle physicists as a general requirement in constructing their theories. But such requirement is baseless. If we examine the physics course *Mathematical Physics,* we find that it includes the most important equations in physics: Laplace equation, Poisson equation, the equation of heat conduction, equation of radioactive decay, wave equation, Legendre equation, Bessel equation and Schrödinger equation. None of these equations is Lorentz invariant except the wave equation of electromagnetic field. Some of these equations are of fundamental importance. The equation of heat conduction is directly related to the second law of thermodynamics. The equation of radioactive decay is a description of nuclear interaction. The Schrödinger equation is the foundation of quantum mechanics. In comparison, the wave equation does not have such fundamentality. The wave equation describes the movement of water, string, sound, light etc., but does not have the fundamental significance of Schrödinger equation, heat conduction and radioactive decay. Lorentz invariance is a special characteristic of electromagnetic wave equation only. Even the acoustic wave equation does not obey Lorentz invariance. How can we insist the special mathematical characteristic of electromagnetic wave equation to be a general requirement of all physical laws? The exponential function e^x has a special characteristic: $\frac{d^n}{dx^n}(e^x) = e^x$. Can we require all other functions to satisfy the relation $\frac{d^n f}{dx^n} = f$? The number 2 has a special characteristic: $2+2=2\times 2=2^2$. Can we require any other number x to satisfy the same relation $x+x=x\times x=x^x$?

The symmetry of Lorentz invariance is further generalized to gauge invariance in the gauge field theory proposed by C. N. Yang and R. Mills, and criticized by Pauli [8]. Earlier on Pauli came up with the gauge field equation and then discarded it. When he heard Yang talking about it in 1954, he participated in the talk and kept asking Yang about some problems arising in the gauge field theory. Yang could not respond to Pauli's satisfaction. It turned out that the gauge invariance did not allow any particle to carry mass, in blatant opposition to the reality. To save the gauge field theory, an almighty Higgs particle, nicknamed "God particle", was proposed to give the particles masses through a mysterious mechanism called "spontaneous symmetry breaking". The absurdity can be easily understood philosophically: Is the Nature symmetrical or non-symmetrical? If the Nature is symmetrical, why would theorists have to resort to spontaneous-symmetry-breaking to rescue a theory of symmetry? On the other hand, if one assumes the so-called "spontaneous symmetry breaking" to be the way the Nature is, which means that the Nature is essentially non-symmetrical, on what grounds then should the laws of physics be required to be symmetrical in the first place?

We can examine the mechanism of "obtaining mass through the God particle" from a logical point of view. The proton and the electron are stable particles. They do not decay. Even the most speculative theory that proclaims proton decay admits that the proton has a life time of at least 10^{32} years, which is 22 orders of magnitude longer than the lifetime of the Big Bang universe. In contrast, the lifetime of the God particle is as short as 10^{-22} seconds according Standard Model. Logically, the action of "obtaining mass" should not take longer than the lifetime of the God particle. After that moment, the God particle would decay into something else (whatever that might be we do not and need not know) and the proton would have obtained mass. Since the decayed God particle no longer exists, the proton should now have mass without being helped by the God particle. The mechanism of "spontaneous symmetry breaking" is a transient "first push", so to speak. Once the mass has been obtained, the behavior of the proton and electron should be described without the presence of the God particle, just like Newton's classical physics does not include God in his equations. Once the Solar System obtained the first push by God, He no longer interfered with the movements of the planets. The movement of the Solar System can be described by Kepler's three laws and Newton's law of gravitation without presence of God. In contrast, the Higgs field or the God particle must be omnipresent in the Lagrangian of the Standard Model of particle physics. How can the God particle with a lifetime of 10^{-22} seconds be omnipresent and co-exist with a proton or electron having a lifetime at least 10^{32} years?

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The classical standard of beauty was different from that of modern theoretical physicists. Classically, a theory is considered beautiful if it satisfies the *reality standard*, i.e., if it agrees with the measurable reality, and the *simplicity standard*, i.e., its metaphysical hypotheses such as its postulated laws of nature and its mathematical presentation are simple. The 20th century theoretical physics satisfies neither criteria.

Let us first examine the reality standard. Quantum electrodynamics yields infinitely large mass and charge of the electron, which directly violates the reality. The practice of renormalization simply throws the infinities away. It amounts to equalizing infinity to zero. Paul Dirac [9], [3] regarded renormalization "mathematically ugly". Ugliness is not beauty.

The standard model of cosmology or the Big Bang theory predicted the mass density of our universe to be 30 times greater than the experimentally measured value, a discrepancy great enough to falsify the Big Bang theory. The theorists then chose to ignore the physical fact and declared that 97% of the matter was "dark matter". The serious problem was politically transformed into a great "discovery of dark matter" and a reason for further funding. The prediction that deviated from the observed value by a factor of 30 was ugly; the political trick of turning an ugly discrepancy into a great discovery is uglier. Simply put, the 20th century theoretical physics does not measure up to the reality standard of classical beauty, and therefore must be fixed by additional metaphysical hypotheses, which is at odds with the simplicity standard.

Let us now look at the simplicity standard. Isaac Newton [10] said: "Truth is ever to be found in the simplicity, and not in the multiplicity and confusion of things." Ernest Rutherford believed that a good theory should be comprehensible by a bartender. Theoretical physics of 20th century does not measure up to the simplicity standard either. Theorists love to use Einstein's field equation $G_{\mu\nu} = \frac{8\pi}{c^4} T_{\mu\nu}$ as an example of simplicity and beauty. It looks simple only in the appearance. Actually, it is one of the most complicated equations in physics. It is a rank-2 tensor equation, having six independent second-order partial differential equations. These equations are highly non-linear since the quadratic terms of the partial derivatives are involved. Adding the complications of the boundary conditions and initial conditions, it is a nightmare to physicists as well as mathematicians. No wonder Einstein himself failed to find a solution to his own field equation. Later on, Schwarzschild and Kerr found the solutions to Einstein's field equation under the simplest boundary conditions for fields of objects with spherical symmetry, static or rotating with constant low angular velocity. The time dependence is eliminated because the system is assumed to be static. Any deviation from such simple boundary conditions, or any involvement of time dependence, would leave Einstein's field equation unamenable to mathematical analysis. It is also the reason that all cosmologists are stuck with the fundamental assumptions that the universe is homogeneous and isotropic: you simply couldn't do business otherwise. I myself tasted the complexity of Riemann geometry in the calculation of the Riemann curvatures of Schwarzschild metric and Kerr metric [11], [12]. It took me months and the scratch papers literally piled up to more than a foot high. I also tried to find a rotational transformation between these two metrics [13]. I could only do it for low angular velocity, and the calculation was quite complicated. No one has carried out any calculation with general relativity for strong fields or more complicated boundary conditions and initial conditions than that of the Schwarzschild and Kerr solutions.

Particle physics is by no means simpler than general relativity. The complexity is manifested by the number of elementary particles. There are a few hundred species in the particle zoo or particle botanical garden. Even Enrico Fermi [14] had a problem with so many elementary particles: "If I could remember the names of these particles I would have been a botanist." The whole game of particle physics was about classification and categorization of the few hundred elementary particles using group theory. The highly celebrated result is the quark model which reduced the number of elementary particles to 62, still far too many to be "elementary". Another manifestation of the complexity of the Standard Model is that it has 19 free parameters to be determined by data fitting. Fermi would not have liked so many free parameters in a model. He made a comment in a chat with Freeman Dyson: "With four free parameters

I can fit any data into an elephant; with a fifth, I can make its trunk wagging." No statistician with common sense can make any sense of a mathematical model with 19 free parameters.

The complexity of the Standard Model is also evidenced in the page long Lagrangian having some 170 terms [15]. Each term is quite complicated by itself. The individual terms may involve second order partial differentiation and summation over four-dimensional coordinates. A sum over a single index gives 4 terms, and 16 terms if summing over two indices. One has to make all kinds of assumptions and approximations in order to conduct any calculation.

Some more adventuristic theories are more complicated than the Standard Model. The supersymmetry (nicknamed SUSY) hypothesizes that the fermions and bosons are super symmetrical. Stephen Hawking [16] described the complicatedness and complexity of the theory: "No one has the patience needed to calculate whether these theories were actually completely finite. It was reckoned that it would take a good student two hundred years, and how would you know he hadn't made a mistake on the second page?" Is such "super symmetrical" theory super beautiful?

The supersymmetry was later on married to the string theory to become the superstring theories, which were claimed to be candidates for a Theory of Everything (TOE). The superstring theories all need 10 dimensions with 6 of them "curled in" a tiny space at the scale of Plank length (1.6 x 10^{-35} m). There are five different competing superstring theories on the table. It is conjectured that these five superstring theories might be the projection of an 11-dimensioned theory onto the 10-dimensioned subspaces, but no one could prove such conjecture because the theory is super complicated. The superstring theory is anything but simple. It does not measure up to the classical simplicity standard of beauty.

All in all, imposing "beauty" or "symmetry" on physical laws is baseless. On the other hand, it makes perfect sense to make your theory beautiful and set evaluation criteria. As mentioned above, classical criteria of beauty are agreement with reality and simplicity. See also section 2.3.3 of the article of Styrman in chapter 1 in this volume.

5. Resonances are not particles

Before quantum field theory was in its full swing, the physics community knew only a few stable fundamental particles (proton, electron and photon) and unstable particles (neutron and mesons). The number of "fundamental particles" skyrocketed since "resonances" were identified as particles. The zoo of "particles" expanded to include a few hundred animals. Even the most positive positivists could not reconcile themselves with such divergence of the particle zoo. The supersymmetry theory would double the number of elementary particles by assigning each particle with a super partner, called *sparticle*. Something must be done to reduce the number of species of the elementary particles. The quark model came into being to answer the call. In the Standard Model the number of "fundamental particles" reduces to 62: 18 quarks, 18 antiquarks, 6 leptons, 6 antileptons, 8 gluons, 3 vector bosons, photon, graviton and Higgs boson (the God particle). The number of "fundamental particles" is reduced, but 62 does not seem to be "elementary" either. The key issue we have at hand is whether or not the resonances are really "particles".

The resonances are the peaks at certain energies in plots of differential cross sections, which are interpreted by theorists to be particles. Such interpretation was responsible for the explosive expansion of the particle zoo.

The resonance peaks in the plots of differential cross sections simply indicate that the interactions are more likely to take place at these energies. It is far from convincing that these resonance peaks are particles. The only argument supporting the particle claim is Einstein's mass-energy equivalence. If such argument is valid, we can convert the energy spectrum into a mass spectrum. If the peaks in the mass spectrum are particles, what are the plateaus between the peaks? The plateaus have probabilities not much less than that of the resonance peaks. We may have to accept the inconvenient picture that there is a continuum of particles.

Einstein's concept of mass-energy equivalence is shown to have many inconsistencies in [17]. Mass is a measure of the quantity of substance contained in an object, while energy is a measure of motion or state. They are related but not equivalent. Proportionality is not equivalence. Even if we take Einstein's formula $E=mc^2$ at its face value, it does not lead to the mass-energy equivalence.

For half a century the whole shell game of particle physics is about construction of mystical diagrams of these resonances with group theory. When you can categorize everything into a few groups and arrange them in certain diagrams of symmetry, it will look impressive and mysterious. Mystery fosters holiness. The diagrams of symmetry seem to suggest something natural, and the beauty of symmetry is a vindication of the diagrams when absorbed by human psychology. The modern particle physicists have presented a few diagrams of symmetry, such as the diagrams of the spin 0 meson octet and singlet, the spin 1 meson octet and singlet, the spin 1/2 baryon octet, and the spin 3/2 baryon decuplet. The diagrams of symmetry helped to justify the identification of resonances as particles. If the resonances are not particles, the particle physics could be a great joke. All the issuing problems of particle physics, such as quark confinement, charge quantization, fine tuning, naturalness, super symmetry, extra dimension, gravity-gauge duality, and et cetera, are mute.

6. Theory-Of-Everything

A Theory-of-Everything (TOE), or ultimate theory, or final theory, which would hopefully unite all the forces and describe all phenomena in the physical world, has long been a dream of astrologists, alchemists and scientists. The early thinkers like Democritus and Archimedes wanted to describe the working of nature, or the working of God, with a single theory of everything. Since the Renaissance, the TOE dreamers included prominent scientists like Laplace, Kelvin, Hilbert and Einstein. Their pursuits of TOE all failed. Einstein spent thirty years searching for a "unified field theory". After Einstein's failure the dreamers of a final Theory-of-Everything started to follow a different approach – quantum field theory.

After the unification of the weak and electromagnetic interactions, it was widely believed that, as the energy of collision got higher and higher, the strong interaction and the gravitational interaction could be brought to the eventual unification. In defense of the Superconducting Super Collider (SSC) project, Steven Weinberg [18] commented in his book *Dreams of a Final Theory*: "No one can say whether any one accelerator will let us make the last step to a final theory. … Whether or not the final laws of nature are discovered in our lifetime, it is a great thing for us to carry on the tradition of holding nature up to examination, of asking again and again why it is the way it is." Another major proponent of Theory of Everything was Stephen Hawking. He told the readers of his popular science books that the Theory of Everything should be found around the turn of the century, and he believed that it should be the M-theory. When no such thing showed up 15 years into the 21st century, Hawking admitted in 2015 that general relativity and quantum theory were incompatible.

The most adventurous effort in pursuing TOE is the superstring theory. The superstring theory is frustratingly abstract, i.e., hard to be related to physical reality. No one could even explain the physical meaning of the extra dimensions. The mathematics is so complex that it might take 200 years of calculation to find out if the theory is divergent [19]. Moreover, at least five competing superstring theories have been proposed. The embarrassing trouble seemed to be alleviated in 1995 when Whitten [20] conjectured that the five different versions of string theories might be different presentations of the same theory if the eleventh dimension is introduced. No one could actually prove such conjecture. With the eleventh dimension added, the "string" becomes "membrane". The "superstring theory" evolves into a "membrane theory", or "M-theory", the complete structures of which has yet to be discovered.

The M-Theory is not the only proposal for a "theory of everything". A "loop quantum gravity" (LQG) was developed by Ashtekar [21] and Smolin and Rovelli [22]. In LQG the space-time is fundamentally discrete and quantized. Both the M-theory and LQG have their fundamental issues. For M-theory, the extra dimensions have no empirical support. No experimentally verifiable physical quantity is predicted by the theory. The major issue with LQG is the radical proposition of discrete space-time. Super string theory so far remains mathematicians' exercise, not accepted as a part of the "Standard Model". A Nobel laureate (1999), Martinus Veltman [8] made a concluding remark in his book *Facts and Mysteries in Elementary Particle Physics*: "The reader may ask why in this book string theory and supersymmetry have not been discussed… The fact is that this book is about physics, and this implies that the theoretical ideas discussed must be supported by experimental facts. Neither supersymmetry nor string theory satisfy this criterion. They are figments of the theoretical mind. To quote Pauli: they are not even wrong. They have no place here."

The absurdity of the idea of "Theory of Everything" can be easily understood philosophically without getting into technical details. The concept of "Theory-Of-Everything" is based on the assumption that the search for scientific knowledge has come to exhaustion in the current generation. History testifies exactly the opposite. The search for scientific knowledge never reached exhaustion by any generation, and will not by the future generations. Each time we think we know more about Nature, we realize that there are much more and much deeper things to be discovered. Science would never stop advancing. If the final "Theory-of-Everything" is found, the science would be dead, but science will never die. We welcome a theory that unifies the currently known forces if it is theoretically sound and consistent, but that would not be a "final theory of everything".

More than two thousand years ago, Euclid established plane geometry. It is so beautiful, rigorous and systematic that it is still used by modern human beings in their scientific and engineering practices. A physicist of about the same time was Archimedes. Euclid and Archimedes were certainly among the most intelligent scientists in human history, but if they believed that they had found the final theory of everything, or believed in its existence, they would be philosophical dwarfs.

Laplace was one of the mathematical giants in history. Among his contributions to science are Laplace equation and Laplace transformation. He believed that "it would be able to embrace in a single formula the movements of the universe and those of the tiniest atom; and for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes" [23]. We know how naive Laplace's optimism was.

Newton and Maxwell were two giants in physics. They would be philosophical dwarfs if they believed that they had found the final Theory of Everything. Newton did not even have a good understanding of electromagnetism. Maxwell did not have any idea about radioactivity and nuclear force. Newton and Maxwell were not among the believers of Theory-of-Everything. Any modern scientist would be philosophically naive if he believes that his generation has completed the search of scientific knowledge of nature.

If we open our eyes to look at the broader scientific landscape, we see many outstanding fundamental issues that we don't really understand. We do not really know how life was developed from the primitive "organic soup". We do not know why atoms are happy when they have eight electrons in the outmost orbits and why the helium atom is stable with only two electrons. We do not know the electrons obey Pauli's exclusion principle. We don't know why uranium 235 is explosive while uranium 238 is stable. The proponents of the "Final Theory of Everything" do not seem to understand the greatness and depth of Mother Nature. Our posterities would laugh at our ignorance and presumption like we laugh at our ancestors who did not know even the freshman physics while claiming that they found the final Theory of Everything.

The progress of knowledge of the mankind parallels the growth of an individual human being in many ways. When I was about to graduate from elementary school, I was puzzled why there were math courses in the middle school. We had learned all the four arithmetic operations – addition, subtraction, multiplication and division. What else were there that I had not learned? My question was immediately answered as soon as I entered the middle school and started algebra and plane geometry courses. The same sense of completeness recurred in my senior year of high school. I had learned algebra, trigonometry, plane and solid geometry, analytical geometry, physics, chemistry, biology, history, geography, philosophy and politics! I felt like I was a wizard. What else were there that I did not know? My sense of completeness was dismissed after entering college, and never returned back again for the rest of my life. I gradually understood that even if I exhausted all the college courses and all books in the libraries I would still not have exhausted the scientific knowledge. The sense of completeness is a measure of naivete and ignorance.

The human intelligence has experienced a similar process of growing from young ignorance to matured modern science. In the primitive time when the mankind knew very little about the Mother Nature, almost all extraordinary natural phenomena were ascribed to the behavior of Gods, and that was the time when the various astrological and theological Theories-of-Everything flourished in the different centers of civilization. Whence a theory was established as a religious doctrine, it became a "final" theory that did not allow any challenge or revision. Any slightest change would be condemned as heresy. The notion of "Final Theory-of-Everything" is astrological and theological, not scientific. After the Enlightenment and Renaissance, the human intelligence became matured enough to establish a real science in modern sense. The more the mankind knows about the nature, the more scientists realize that there won't be the end of scientific search and research. The more we know, the more we realize that there are more we do not know. Smart and talented students may have reasons to be overconfident and even presumptuous towards classmates or colleagues. But try to be humble towards Mother Nature.

Strange enough, the physics community seems to have forgotten historical lessons in the last few decades and indulged in the great effort of searching for a final Theory-of-Everything that claimed much of the scientific research resources and manpower. The spending in such big science is not, and cannot be, justified scientifically.

7. Mathology

The singularity problem of general relativity is quite embarrassing. To save the credibility of general relativity, M.D. Kruskal [24] argued that the singularity can be eliminated by an appropriate choice of good coordinate system. He proposed a coordinate transformation to transform the coordinates (r,t) into his abstract mathematical coordinates (u,v). The transformation was a 1-2 mapping. As a result, a single point (r,t) is mapped to two points on his u-v plot. He thus obtained two families of curves. He then identified the two families of curves as two universes. Kruskal thus created an additional universe by a mathematical transformation. His mathematics also created the white hole, the worm hole etc. In Kruskal's theory, the time reduced to merely a mathematical parameter having no physical significance. His "time" was measured by a new topological time *v* in Kruskal's theory. Kruskal's concept of multi-universe set the first example of mathematical creationism. The reason for Kruskal to keep both families of curves was "completeness of geometry". Math created multiverse.

Kruskal set the first example of mathematical creationism by creating a multiverse through coordinate transformation. Since then, theorists have adopted the practice as self-evident principle to take mathematical characteristics of functions and equations as physical laws of Nature. Mathematical characteristics (such as topological completeness, Lorentz invariance, gauge invariance, etc.) are endowed with supreme status over the classical physical laws (such as the conservation laws of mass and energy) and scientific logic (such as causality). Theoretical physics research has become mathematical exercise, having nothing to do with the physical world. I call such practice *Mathology*.

Mathematics is only a tool to explore and express the laws of nature. It is not a tool to create universes and to manufacture the laws of physics. Mathematics is beautiful, but the physical world is even more beautiful.

8. Scientific test versus religious testimony

The Renaissance in 17th century brought about scientific revolution. Scientists like Francis Bacon, Galileo, Descartes, and Newton established physical science following an approach distinct from the medieval religious teachings. A scientific theory would not be accepted unless tested by independent experiments and engineering practices. The natural laws were discovered by observing the physical world, not manufactured or ordained by theoreticians or theologians. A single negative observational result or a single logical paradox was enough to falsify a theory, in much the same way as a single hole was enough to capsize a boat. Max Planck, quoted in [25] p. 7, said: "Experiment is the only means of knowledge at our disposal. Everything else is poetry, imagination." Albert Einstein [27] p. 271 said: "The only source of knowledge is experience." "Pure logical thinking cannot yield us any knowledge of the empirical world; all knowledge of reality starts from experience and end in it. Propositions arrived at by purely logical means are completely empty as regards reality. Because Galileo saw this, and particularly because he drummed it into the scientific world, he is the father of modern physics—indeed, of modern science altogether." He [28] also said: "Experience naturally remains the sole criterion of the usefulness of a mathematical construction for physics."

Experimental verification distinguishes science from religion. Religions rely only on faith and testimony to hold a doctrine. Religious testimony does not require uniqueness. If a Buddhist monk narrowly escapes a car accident, he immediately jumps to the conclusion that he was saved by Buddha. A scientist would not be so sure that he was saved by Buddha unless he could prove that he was not saved by Jesus, Allah, Laozi or any other possible mighty gods, and that he would not survive if no god was around, based on the uniqueness requirement. Equally important is repeatability of the experiments. Scientific evidence must be repeatable by many independent experimentalists at different places and different times, while religious testimony does not require repetition. You don't need to repeat the car accidents a dozen times to prove that Buddha saved you. Religious testimonies are biased by dogmatic attitudes, where the pet theory or doctrine is considered unconditionally true. Only the positive stories confirming the orthodox doctrine are told. Negative stories that do not confirm the orthodox doctrine are hidden or dismisses as failure, heresy, speculation, bad quality, etc.

The experimental test of modern physical theories is becoming more and more like religious testimony. The particle physicists spent enormous amount of money and manpower searching for the God particle. The electron-positron collider (LEP) in CERN searched for it in the 1990s. They found nothing. Fermi Lab searched for the God particle from 1995 to 2011. They found nothing. Both of these experiments were considered failures because they did not support the Standard Model. In 2015, the LHC group announced that they found something around 125 GeV that might be a God particle. It was immediately welcomed and endorsed by the theoretical community as a positive result.

From experimental point of view, the negative results of LEP in CERN and the Fermi Lab should have equal statistical weight as the positive result of LHC. But such is not the culture of the particle physics community. The negative results that do not confirm predictions of the Standard Model would be considered failures. Only positive results confirming the Standard Model would be considered successes. If the LHC result were negative, it would have been dismissed as another failure, and the process of verification would be continued until some positive results show up and confirm the theory. Repeating the experiment means further investment of another billion dollars and ten years of hard work of thousands of researchers. Funding may be granted for repetition only when the previous results are negative.

The same attitude is held in macroscopic physics. The Big Bang theorists predicted a mass density of the universe 30 times greater than the observational value, a discrepancy great enough to falsify the theory. But the embarrassing blunder was dismissed politically. It was declared that the problem was not with the theory, but with the experiment and observation. The theorists declared that 97% of total mass was unobservable "dark matter". And yes, people did get substantial funding to search for the dark matter. Suppose I am a fortune teller, and I predict that you have a dollar in your pocket. It turns out that you have only three pennies in it. I immediately tell you that the rest 97 cents are "dark money". What would you make of my fortune telling theory? Will you give me more money to search for your missing dark money?

The biased evaluation is stipulated in Eddington's philosophy: "One should never believe any experiment until it has been confirmed by theory." It suffocated experimentalists' spirit of independent checking. An indirect and biased "experimental evidence" without repeated verification is at most a religious testimony, not scientific evidence.

Besides the biased attitude, there are technical challenges to experimental verification. The energy scale needed by the particle physicists to test the Grand Unified Theory (GUT) is as high as 10^{16} GeV which requires an accelerator bigger than the Solar System. It is way beyond the ability of the mankind. The Theory-of-Everything requires an energy 1000 times higher, in a scale of 10^{19} GeV (known as the Planck energy scale). To reach the Planck energy scale and test the Theory-of-Everything and quantum gravity, the accelerator needs to be as big as the Milky Way and the detector needs to be as big as the planet Jupiter. If a theory is not experimentally testable, is it a scientific theory?

There are theories that are not experimentally verifiable even in principle. The theories with extra dimensions or discrete space-time are not experimentally verifiable. The "phenomena" in other universes are not observable by experimental physicists. The theorists believe that they know exactly what is going on in other universes and in higher dimensions without any help of experimental physicists.

The departure of modern theoretical physics from the conviction that physics must be based on physical reality instead of human imagination is the most fundamental shift of philosophy that is responsible for much of the shift of physics paradigm, and for the infiltration of mythology and theology into science.

9. Hypothology

Positing a hypothesis used to be a very serious business in classical physics. A hypothesis must be theoretically and logically sound and verified by numerous independent experiments before accepted as a valid postulate. In the 20th century, however, it has become a trend to build a theory by piling up hypotheses to fit experimental results or to patch up loopholes of the previous hypotheses. Allow me to coin a term *hypothology* for such practice. The Standard Model of particle physics serves as an example of how many hypotheses are employed to build a model. The Standard Model of particle physics inherits all postulates and hypotheses of quantum electrodynamics, including 1) the marriage of special relativity and quantum mechanics, 2) second quantization which requires creation and annihilation of particles as a fundamental principle or rule, 3) the construction of Lagrangian based on Lorentz invariance, 4) The mediation of interaction by virtual photon that does not obey the conservation laws of energy and momentum; 5) Feynman diagram that allows time to go backward, and 6) renormalization that drops an infinity from a divergent result to yield a finite one. In addition to these hypotheses of quantum electrodynamics, more hypotheses are added along the way: 7) There is a neutral particle of zero mass called neutrino to preserve the conservation of mass and energy; 8) The resonances are particles; 9) The hadrons are made of quarks with fractional charges; 10) There are three gauge bosons W^+, W^-, and W^0; 11) There is a neutral field with a weak isospin singlet particle B^0; 12) The Z^0 particle and the massless photon are mixtures of the massive B^0 and W^0; 13) The weak interaction is mediated by W and Z bosons; 14) The strong interaction is carried by gluon, which is responsible for binding quarks together to form hadrons; 15) The quarks are assumed to be confined to avoid infinities; As a result, no individual quark is supposed to be detectable; 16) The theory must have the symmetry of gauge invariance that forbids the particles to have masses; 17) The elementary particles must obtain masses from the God particle by spontaneous symmetry breaking. This list is far from being exhaustive, but long enough to make the point. The Standard Model is a magnificent building founded on a stack of hypotheses. Most, if not all, of these hypotheses are not *independently* verified or verifiable. If any of these hypotheses is false, the logical link is broken and the whole building will collapse.

One might argue that we have enormous amount of experimental data accumulated over decades. Are these not sufficient to vindicate the Standard Model, although we are not able to verify each hypothesis independently? The answer is "NO". Let me explain why each individual hypothesis needs to be verified independently with an example. A Taoist theory is built upon a few hypotheses:

1) Every human has a body and a soul;
2) If the soul leaves the body temporarily, the person will be sick;
3) If the soul leaves the body too long, the person will die;
4) The sickly person can recover if the soul is called back to the body.

In my childhood the soul-calling practice was a quite popular method among the villagers in China to treat their sickly family members. An older member of the family would go to places where the soul of the sick could be possibly scared off his or her body by animals or ghosts, and call the name of the sick to come home. Most patients would eventually recover, with or without treatment by a physician. The experimental evidence was strong enough to bear out such a theory. However, there was no direct and independent experimental evidence to prove any of the above listed individual hypotheses. The villagers simply accepted the numerous final results (recovery of the sick persons) as proof of the whole basket of hypotheses. A small percentage of patients would die due to bad physical condition and weak immune system. The tragic results would be interpreted as the evidence that the soul was completely lost. Either way the astrological theory was proved to work, and the practice was sustained.

Many experiments in modern physics are similar to the astrology of the villagers. People usually celebrate the "experimental evidence" of a great theory built upon more than a dozen hypotheses without being able to show independent verification of the individual hypotheses. The experimental evidence of the God particle and the gravitational wave from some remote binary black holes are such indirect "evidences" which are supposed to bear out the whole basket of hypotheses.

Classical physicists needed hypotheses as well to figure out the deeply hidden laws. Isaac Newton made a hypothesis that there was an attractive force between any two objects that is inversely proportional to the distance squared. The hypothesis was quite logical. If there was no attracting force between the sun and planets, there would be no reason for them to stay together for millions of years, and it was quite logical to believe that such force must get weaker and weaker as the distance becomes greater and greater. The only thing in Newton's hypothesis that could not be reasoned out with common sense was the quantitative aspect of it: The inverse square law. It was arrived at by comparing the theory with the empirical laws discovered by Kepler.

When a classical physicist discovered a fundamental inconsistency in his theory, the first thing he would do was to stop and think if the hypothesis was correct before going any further. The modern theorists, however, usually make additional hypothesis to patch up the theoretical loopholes.

An important hypothesis in Standard Model is the principle of gauge invariance. It turns out that the gauge invariance forbids any particle to have mass, in blatant opposition to reality. It is a direct proof that the hypothesis of gauge invariance is invalid. Instead of doubting the hypothesis of gauge invariance, the theorists keep on proposing more hypothesis – the spontaneous symmetry breaking – to rescue the hypothesis of gauge symmetry. The elementary particles are then able to obtain masses through the God particle, they say.

We see the same practice of rescuing a hypothesis with new hypotheses in cosmology as well. General relativity was built upon a few hypotheses, which resulted in a famous singularity problem. To solve the singularity problem, Kruskal proposed a coordinate transformation which led to the creation of multi-universes and worm holes for time-travel. The Big Bang cosmology has a famous *horizon problem* that the speed of expansion of the universe would be hundreds times greater than the speed of light, in direct contradiction against relativity upon which the Big Bang cosmology was built. According to the Big Bang Theory, the decoupling epoch was at the age of 300,000 years since its birth, but the radius of the universe was expanded to 70,000,000 light years by then. The average expansion speed was about 230 times of the speed of light. To solve the horizon problem, Allen Goth hypothesized that the universe had gone through an inflation phase shortly (about 10^{-36} s) after the Big Bang, and the inflation stopped at about 10^{-33} s. The universe inflated from microscopic size to macroscopic size during this short time interval of 10^{-33} s. The speed of inflation was more than 20 orders of magnitude greater than the speed of light in the inflation. The absurdity is immediately evident logically: How can you fix the horizon problem that has an expansion speed 230 times the speed of light with a hypothetical theory that requires an inflation speed 20 orders of magnitude greater than the speed of light? You cannot cure my headache by simply smashing it!

Einstein proposed a world model based on his general relativity with additional hypotheses. He hypothesized that the universe was finite, homogeneous and isotropic. A finite universe would collapse due to the gravitational interaction. To cure the problem, Einstein further proposed a hypothetical cosmological term. It amounted to a universal repulsive force proportional to the distance. One would not feel the repulsive force if he was close to the mass, but would feel the strong repulsion if he was far away on the edge of the universe. The idea was astrological and absurd. Einstein then disowned the cosmological term and gave up his world model. The Big Bang cosmologists picked up Einstein's cosmological term and further hypothesized that the radius of the universe is imaginary to allow an open universe. Based on these hypotheses, the Big Bang theory predicted a cosmological mass density of about 10^{-26} kg/m^3 to keep the universe asymptotically flat. The predicted mass density was 30 times greater than what was observed by astrophysicists. The discrepancy was great enough to falsify the Big Bang Theory. But amazingly, the problem was politically "solved" by an additional hypothesis that the missing 97% of theoretical mass was the "dark mass". The great blunder was politically turned into a great discovery and a reason for additional research funding! If the logical inconsistency of a theory is allowed to be rescued by additional hypotheses, that theory is not falsifiable, and therefore, not scientific.

As noted earlier, Enrico Fermi used to say: Given four free parameters, I can fit any data into an elephant; given the fifth, I can make the elephant wagging its trunk. I have a corollary to Fermi's law: Give me four hypotheses, I can create a creator; Give me the fifth, I can make Him endorsing my theory.

Physics should be a scientific discipline to discover the laws of the Nature, not a game of hypotheses-piling. The laws of Nature can only be discovered, not manufactured or hypothesized. A theory built upon a multitude of hypotheses is a mirage.

10. Interpolation versus extrapolation

If we know the values of a function at two points of the argument, we can predict its value at a point between these two points using interpolation. Interpolation is an effective tool in science and engineering if the physical processes can be described by continuous and well behaving functions. Extrapolation is a prediction of the function value outside the range defined by the end points. If the function is well behaving and the point of prediction is not too far from the end points, the extrapolation may make sense. Extrapolation is used in science and engineering with caution. The farther away the prediction point is from the end points, the less reliable or more risky the extrapolation is. If the extrapolation goes too far, it can be way off target and senseless.

Weather forecasting is a good example of extrapolation. The meteorologists can predict the weather tomorrow, even next week, with reasonable accuracy. But no meteorologist can sensibly predict the weather next year even next month. I used to explain the difficulty of extrapolation with an everyday experience to my students. Seeing a falling leaf passing the window of the classroom, I asked them: "suppose I videotape the movement of the leaf passing the window with highest speed and record every moment of the movement of the leaf, can you predict where it will land on the ground, and figure out where in the tree it was falling from?" Nobody said he could. Nor could I. Although it is a pure kinematic problem without involving thermodynamics and electrodynamics, it is impossible to predict the trajectory of the leaf due to its complicated shape, the changing of the wind, etc.

If we compare the task of predicting the fate and the origin of the leaf based on our observation of its history when it passes the window to the task of predicting the fate and the origin of the universe based on human observation over the span of human history, which one is more difficult? The movement of the leaf is only a kinematic problem, but the cosmology involves kinematics, dynamics, thermodynamics, electrodynamics, nuclear physics, chemistry, biology and so on. The complexity of the kinematics of a falling leaf is not a comparison of cosmology. The universe contains enumerable galaxies with billions of stars over a spatial span beyond what our telescopes could reach, but the falling leaf is but a small object that we can closely examine with our naked eyes. If we compare the time span, it is equally impressive. It takes a leaf a few seconds or minutes to complete its course of falling from the branch to the ground. Our job is to predict the fate and origin of the leaf at its origin and ending moment based on the observable history which is about one tenth of the whole process of falling. In comparison, the history of the Big Bang universe is supposed to be about 14 billion years, while the recorded human history is only 7000 years. The effective scientific research did not start 700 years ago, which is only 50 billionth of the Big Bang history. Plus, our observation has been mostly within the Milky Way, the Solar System and the Earth, a miserably small corner of the Universe. How likely is it to figure out what was going on 14 billion years ago and what is going to be at the end of the universe, presumably to take place some billions of years later at the Big Crunch?

We have a historical example of extrapolation. In 1787, Jacques Charles discovered that, for a given mass of an ideal gas at constant pressure, the volume was directly proportional to its temperature. It was called Charles' law or gas law. If the linear relationship is extrapolated to the lower temperature all the way to meet the temperature axis, the volume would be zero. Since nothing could have negative volume (they did not have the mind of 20^{th} century's theoretical physicists who would probably propose negative even imaginary volume and mass), they believed that was as far as the shrinking could go. It turned out that the linear gas law for all the gases met the temperature axis at the same place, -273ºC. This temperature was then believed to be the lowest temperature of the universe, called the absolute zero, which was set to be zero degree in Kelvin temperature scale. However, if the temperature of a real gas is lowered, the linear gas law breaks down at certain point when the gas is condensed into liquid. Namely, there is a phenomenon called phase transition that interrupted the linear process and extrapolation. If the temperature is further lowered, the liquid will be frozen to solid – another phase transition. Scientists have grown to realize that one could not assume the extrapolation to work indefinitely. The linear relationship may become non-linear or be interrupted by phase transitions if the extrapolation runs too far.

The modern cosmologists seem to have forgotten the historical lesson, or just conveniently choose to forget. They apply the thermodynamic relationships obtained under the conditions in the labs on Earth to the whole process of their Big Bang. The extrapolation has it that the universe was a geometric point some 13 billion years ago according to the linear Hubble's law. No phase transition is supposed to intervene. (The "phase transition" of inflation was latter assumed for different reasons.) When the Big Bang cosmologists use such extraordinary extrapolation to shrink the whole universe to a size of the Plank length, 10^{-35} m, the density of the universe was 10^{93} g/cm^3, which was to be compared to the density of Mercury, 13.56 g/cm^3, and to that of a neutron star, 10^{14} g/cm^3. The temperature at Big Bang was said to be 10^{32} kelvin, which is to be compared to the temperature of the center of the Sun, 10^7 kelvin. The pressure was believed to be 10^{15} N/cm^2, or 10^{14} (100 trillion) atmospheric pressure. How can one believe our universe can smoothly shrink to such a baby universe with unbelievably high density, high temperature and high pressure? Suppose you squeeze a tank of nitrogen gas with high pressure, can you expect it to shrink smoothly and indefinitely all the way to Planck size without any phase transition? Our Solar System were formed due to gravitational attraction from a nebula. Has the nebula shrunk to a point of Planck size? Will it shrink to a point of Planck size? But the cosmologists use thermodynamics without any worry to yarn a spectacular story of genesis of our universe, and stories of multiverses.

The problem with the extrapolation over 13 billion years is manifested in the "prediction" by the Big Bang theory of the mass density of the universe. The mass density is an important parameter which determines the eventual fate of the universe. If the mass density is too high, the gravitational force will eventually pull the expanding universe back, and the universe will die in a Big Crunch. Such universe is said to be *closed*, with a positive curvature of space-time. If the mass density is too low, the universe is *open* and would expand forever. Such universe has a negative curvature of space-time. There is a critical value of mass density at which the curvature of space-time is zero, meaning the universe is flat. This theoretical mass density is about $5x10^{-30}$ gram/cm^{-3}. It cannot be accurately determined because it depends on the accuracy of the Hubble constant, which is not accurately known. Whether the universe is closed or open depends on the mass density. A mass density parameter Ω is then defined as the ratio of the mass density of a model to the critical mass density. If $\Omega = 1$, the universe is flat. If $\Omega < 1$, the universe is curved and open. If $\Omega > 1$, the universe is curved and closed. Whatever universe a model has, it must produce a universe that is asymptotically flat at our time because that is what we observe at the present. It is an extremely rigid constraint on all the cosmological models. The rigid constraint requires Ω to be extremely close to unity, with an allowance of 10^{-58} deviation. If Ω deviates from 1 by 10^{-40}, the universe would not survive for more than one second. The extreme high sensitivity to certain parameter of a mathematical model attests the extremely high instability of the model. That is what you get from extremely long range extrapolation to predict the phenomena billions of years in the remote past and future based on our incomplete knowledge of the physical world obtained in but a few thousand years.

In general, the farther away a phenomenon, spatially or temporary, the less accurately we know. We know every detail about the Vietnam War, but not as much detail about the War of Roses, even less about the War of Peloponnese. We have only mythological knowledge about the Trojan War from Homer in "Iliad" and "Odyssey". The modern cosmologists seem to have a different logic: The farther away spatially and temporary a phenomenon is, the better they know. Their cosmology could not explain many phenomena at present that we witness every day, such as the formation of new stars and the extraordinary brightness of the quasars, but have no problem at all to predict the spatially and temporary remote phenomena. They can calculate exactly what was going on 13 billion years ago at every split of a second. They predict with confidence how the enormous mass and energy was created from nowhere out of nothing in the "first" 10^{-43} second, how an "inflation" at the a speed 20 orders of magnitude greater than the speed of light was turned on at the instant 10^{-36} seconds after the Big Bang, and turned off at 10^{-33} seconds, never mind whoever did this and why and how, we don't need to know, they tell us. It reminds me of a fortune teller who could not advise me what stock to buy today, but confidently informed me that I was an incarnation of a prince of Sung Dynasty, and would retire as a prime minister in my later years.

11. Contradictory Epistemology

One of the most impotent achievements of the Renaissance was the establishment of scientific epistemology. Scientists believe that the Nature is understandable through experimental investigation and logical reasoning, and human knowledge will advance forever, although we could never exhaust the scientific knowledge. Namely, there is no final theory of everything. Everything in nature can be studied experimentally. If a theory is not based on observation of real physical world and its predictions cannot be verified experimentally, the theory does not belong to science. It belongs to theology or mythology.

The modern theoretical physicists have shifted the classical epistemology to contradictory mythology. On one hand, they hold that the world is not understandable whenever encountered inconvenient questions such as: How could the enormous mass and energy be created *ex nihilo*? What was before the Big Bang? Who was turning on and off the inflation and why? How are things like in other universes? What does it look like in the extra dimensions? Their standard answer to these inconvenient questions is theological: These questions are beyond human understanding. Hell for those who ask such inconvenient questions.

On the other hand, their agnosticism does not prevent them from doing mathematical exercises in other universes and extra dimensions. They even claim that they are very close to finding the final Theory of Everything about this universe and inaccessible other universes. Their self-contradictory epistemology simply means this: If there are questions about the incredible postulations and conclusions of their theories and they could not answer, they claim that these questions are beyond the human understanding; If, however, their theories have produced incredible predictions, which are beyond reach of human intelligence, say, in the remote past or remote future, or in the other universes or in the extra-dimensions, they claim that they are intelligent enough to understand and predict.

12. The Mission of science

The mission of science is to promote the progress of human civilization, to provide theoretical tools for scientists and engineers in their applications. Failing to provide theoretical tools for other branches of science, physics would not be considered as a *fundamental science.* Moreover, the applications of physical theories in technological and engineering activities also serve as ultimate tests of the correctness of the theories. If a theory works when applied to technology and engineering, it is a solid proof that the theory is correct, at least approximately. However, if a theory does not work when applied in technological and engineering practices, the theory is incorrect or irrelevant.

Newton's classical mechanics including his theory of gravitation was immediately applied to the various technological and engineering activities since its establishment, ranging from the building of houses and bridges, manufacturing of machines and tools, to ship building and military engineering. It has been applied over the centuries up to the modern era. The design of scientific instruments, transportation, aviation and space science all depends on the working of Newtonian mechanics. The broad applications helped to establish physics as a fundamental science, and educated the society of the importance of it.

Likewise, Maxwell's theory of electromagnetic fields and waves was almost immediately (about 30 years later) applied to telecommunication. It has truly started the second industrial revolution considering the importance of electronics in modern society ranging from electronic devices and instrumentation in all walks of life, the computerization of the whole landscape of industry, to the internet based global information system.

Thermodynamics was developed during the first industrial revolution and responsible for the invention of steam engine. Quantum mechanics promoted the research in material science, especially in the research of semiconductors. Without the broad application, no public support could be motivated, certainly not at the scale that the modern physics research has enjoyed in the last few decades. Physical science has a clear mission – to provide theoretical guidance and tools for other branches of science to better fulfill their missions. Namely, the mission of physics is to provide theoretical foundation for science, technology and engineering.

The modern theoretical physics community seems to have forgotten the mission of physical science. Most theorists do not seem to be concerned about the application and usefulness of their theories. They are more interested in finding a Theory-of-Everything, in building a Babel tower, in determining whether an astronaut would be torn into spaghetti or baked into a hamburger if some day he is falling into a remote black hole while traveling to other galaxies to attend a weekend party. They seem to have much less interest in helping nuclear physicists to develop a practical fusion device, or any application in material science. Some theorists believe that finding applications is not their job, but the job of those working in the applied sciences. The theoretical physics has become an isolated and closed club having no interaction with the rest of scientific community. Even nuclear physics, which is the hometown of particle physics, is not benefitted from the theories of the Standard Model of particle physics or the theories beyond the Standard. General relativity fostered modern cosmology and the study of black holes. There is no generally accepted cosmological theory standing out, because all models have inconsistencies. The black hole research remains controversial. Stephen Hawking used to be one of the leading figures in black hole research. He declared in 2015 that the black hole research was the greatest blunder of his life. Many astrophysical phenomena are interpreted according to the Big Bang theory and black hole theory, which filled up the decades-long publications in astrophysics. These interpretations may have to be reinterpreted in the future when physics community decides to abandon the Big Bang theory. The theoretical physics community has been claiming and celebrating big breakthroughs every year, but the rest of science remains intact. If you knock out or change the foundation of a building, it will collapse or shake violently. If a building remains intact when something is changing dramatically, that thing must not be the foundation. It could only be decoration.

It is frustrating to see that neither particle physics nor cosmology has helped any of the other branches of science and technology. The theorists love to say that the internet system was invented by the experimental particle physicists. True it is, but the spin-off cannot be employed to dismiss the fact that particle physics does not help other branches of science. Invention of internet was not included in the goal of any proposal of high energy experiment. The fact that particle physicists have nothing to speak of except the spin-offs testifies that the main mission of particle physics has nothing to do with the rest of science. It has failed the mission as a "fundamental science". Alchemists spent hundreds of years to invent the elixir of life, which led to some advances in chemistry as spin-offs, but it does not justify the mission of elixir making.

Application of a fundamental science is not only a noble mission of theoretical physics, but also the ultimate test of the theory. It is also the ultimate justification of the financial support from the society. If the theoretical physics community can help to find any application of their theories, it will be more eloquent and convincing by far than any argument of reductionism and the rosy promises that the huge investment in the big science will help to find a Theory-of-Everything and to understand God's mind.

13. Shift of paradigm or shift of science?

The theoretical physics of 20th century is dramatically different from the classical physics in fundamental postulations, logic, philosophy and experimental verification. Many classical concepts are considered inappropriate and obsolete by main-stream modern theoretical physicists:

1) The classical space and time are reduced from the most fundamental physical quantities to mathematical variables not more significant than Kruskal's coordinates *u* and *v*. The classical space and time are mutually independent, and independent on velocity and observer. In modern theoretical physics, however, space and time are mutually dependent, and dependent on velocity and observer. The classical time is the common argument of all functions of changing processes, be it physical, chemical, biological, geological, historical or political. Time never goes back, and there is no origin or end of time. In theoretical physics of 20th century, however, time has origin in the past and may end in the future. Time can go backwards to the past. The classical space and time are continuous, homogeneous. The most adventuristic modern concept of space and time can be discrete. The classical space is three dimensional, while the modern space can have more than three dimensions. The classical space and time are both real, but the modern space and time can be imaginary. Hawking's time is two dimensional and has shape, with one dimension imaginary, and he believed that the imaginary time was more real than the real time.

2) The other two fundamental quantities in classical physics are mass and charge. The fundamentality of mass and charge is manifested in the fact that mass, charge, space and time form the basic unit system MKSA because all other quantities in physics can be defined in terms of these four quantities. These quantities are fundamentally independent from each other. Mass is a measure of quantity of the substance, inertia, and its gravitating strength. Charge is a measure of strength of electromagnetic interaction. Mass and charge of a particle are constants. Energy is a measure of movement or state in which the particle is pertaining. Energy is defined and measured by the four fundamental quantities, and is essentially a different quantity from mass. In relativity, however, mass of an object is dependent on velocity. Modern physics holds charge invariant while mass variable. Standard Model of particle physics stipulates that elementary particles must obtain mass through God particle but charge does not need to be obtained through any almighty particle.

3) Classical physics holds some laws fundamental. For example, the mass conservation law (the first law of thermodynamics), the momentum conservation law, the energy conservation law, and the second law of thermodynamics cannot be violated, and have never been found violated. Since no mass and energy can be created or destroyed, creationism is a direct antithesis to science. In theoretical physics of 20th century, however, the mass conservation law, the momentum conservation law and the energy conservation law have all been violated. Energy and mass are now considered the same thing mutually convertible, which allowed creation and annihilation of particles. Creation and annihilation are stipulated in the standard procedure of what is known as the Second Quantization of quantum field theory. In the adventuristic *quantum bubble theory*, Stephen Hawking claimed that in a tiny volume of 1 cubic centimeter there were 10^{143} baby universes created per second, all connected to our

universe through wormholes. Each baby universe would soon gain the same productivity [28]. This impossible birth rate is to be compared to the explosion of a nuclear bomb that sends about 10^{23} molecules per cubic centimeter per second to the sky, but these molecules are not created. It was in existence before the nuclear explosion.

4) Classical physics holds some logic inviolable. For example, a part of a thing is always less than the whole. Causality is also an inviolable logic. In theoretical physics of 20th century, however, no logic is inviolable. The violation of causality has become a fashionable and fascinating idea spoon-fed into the young minds through sci-fi movies and popular writings. The mass of a particle can be less than the mass of the parts making up the particle. For example, the massless photon is assumed to be a linear combination of massive particles B^0 and W^0 in the electro-week theory of the Standard Model.

Failing to explain the dramatic deviation of modern theoretical physics from the classical physics, the theorists always shrug their shoulders with the same old excuse: “It is a shift of paradigm. You cannot judge modern theory with classical theory and logic.” A shift of paradigm it is, but more than that: It is a shift from science to mythology and theology. History has witnessed a shift of paradigm in the Renaissance when the astronomical paradigm shifted from Ptolemy’s geocentric theory to Copernicus’ heliocentric theory, which triggered the shift of paradigm from medieval theology and mythology to scientific pursuit of knowledge by experimental investigation, logical reasoning and mathematical analysis. Four centuries later, the theoretical physicists of 20th century started a backward shift of paradigm from science back to medieval theology and mythology, from science to agnosticism that doubts theory and logic of classical science. It is anybody’s prerogative to espouse himself to certain faith or paradigm, as long as the taxpayers do not have to carry the heavy burden of their whimsical theories and experiments. No taxation without explanation. The tax payers have justifiable reason and right to expect such “shift of paradigm” being beneficial to science and society. Science is not about building a Tower of Babel that has nothing to do with the society. Science has its noble mission – to advance human civilization.

The physicists in the beginning of 20th century were like a group of Boy Scouts looking for a secret book containing all secrets about the Nature. No one knew where the secret book was hidden and along which road one could find it. The boys had to guess the direction at each crossing. One single mistake in their decisions was enough to lead the boys farther and farther away from the secret book. After a number of crossings, they forgot where they were coming from and lost their way to get out of the woods. We physicists are much luckier than the boy scouts. We know exactly where we were coming from and what approaches we followed to the present state of theoretical abyss. If we want to get out of it, we can simply go back to the starting point – physics before second quantization and renormalization, or physics before relativity. We can do it only if we have the guts to admit that theoretical physics of the 20th century is in fundamental trouble. That is exactly what the trouble is: the mainstream physics community dare not to face the harsh fact that theoretical physics has run into a dead end. We have set an example in our recently published theory of unification of gravitational and electromagnetic forces of how the theoretical advances can be made without violating fundamental laws of mass and energy conservation and classical logic of causality. Our unification theory provided a natural answer to the problem of action-at-distance, derived the gravitational wave equation and the solution. The theory predicts that the gravitational wave propagates with speed of light. The detail is given in Appendix A.

The deviation of modern theoretical physics from the classical physics is not merely a shift of physics paradigm, it is a shift of philosophy, a shift from science to theology and mythology. From the above discussions of about a dozen issues we see the importance of philosophy. Any philosophical mistake would lead to a totally wrong direction of the research of the whole physics community. Over the last century, the theoretical physics community enlisted the best physicists and mathematicians, from Einstein to Hawking, without being able to avoid running into a theoretical abyss of contradiction and absurdity. It was not because these theorists were weak in physics or mathematics, but because they were confused in philosophy. They forgot the scientific philosophy hardly earned since Renaissance by our pioneers with their wisdom and martyrdom. To get out of the theoretical abyss, we must reinstall the scientific philosophy. Philosophy matters, it matters a great deal.

Physics needs nothing less than a new Renaissance.

Acknowledgements
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Appendix A: Classical unification of gravitational and electromagnetic fields
Unification of gravitational force with other forces has been a dream of physicists since the beginning of the 20th century. Einstein first started searching for a unification theory, joined by rest of physics community for a whole century along the approach of general relativity and quantum field theory, without any success. The reason is that general relativity and quantum field theory are incompatible, both having fundamental inconsistencies.

Recently, we have developed a classical theory of unification of the gravitational and electromagnetic forces in 2018 [29] and presented it in a series of international conferences. A book on this theory has been published recently [30]. Our unification theory is mathematically rigorous and complete without any *ad hoc* hypothesis. The only postulation of the theory is the generalization of Newton’s law of gravitation to include a dynamic term to explain the propagation of gravitational wave and answer the historical question of action-at-distance. It turns out that this generalization alone is sufficient to develop a whole dynamic theory of gravitation. The theory takes exactly the same form of Maxwell’s theory of electrodynamics, which predicts that the gravitational wave propagates with the speed of light.

An important discovery in our unification theory is the Wang’s Law which states that the total linear momentum of the gravitational field transmitted into the space is conserved.

The logical and natural explanation of the propagation of the gravitational wave offers an answer with mathematical rigor to the historical question of action-at-distance. Moreover, our unification theory has revealed the secret of the inverse-square law that governs both the electrodynamic and the gravitational interactions. It turns out that the inverse square law is the result of the conservation of the total static and dynamic fluxes as expressed in Gauss’ Law and the newly discovered Wang’s Law. The Gauss’ Law says that the total energy transmitted into space is conserved, and Wang’s Law says that the total momentum transmitted into space is conserved. The unification theory of gravitational and electromagnetic forces shows explicitly that the two interactions are propagating through the same universal medium ether.

The unification of gravitational and electromagnetic forces would have enormous and profound impact on physical science in many ways. For over a hundred years, the physics community has been educated to believe that any possible future theory unifying gravity with other forces would have to be built upon general relativity and the Standard Model of quantum field theory. Our unification theory shows that the unification of gravitational and electromagnetic forces could be done beautifully and naturally within classical framework without resorting to general relativity and quantum field theory. The simplicity, rigorousness and completeness of our unification theory are so compelling that it leaves no doubt on the correctness of the classical approach. It will certainly shake the confidence of physics community in the paradigm of theoretical physics of the 20^{th} century. We can ask a legitimate question: Are the scientific logic, philosophy and methodology of the classical physics all obsolete? Why are there so many fundamental inconsistencies in theoretical physics of 20^{th} century? Why is modern theoretical physics running into a dead end? A scrutiny of the edifice of modern theoretical physics reveals that the ultimate reason for the multitude of unsolvable fundamental inconsistencies of the theoretical physics is the shift of philosophy. It is a shift from scientific philosophy and methodology to mythological and theological philosophy and methodology. To drive the point through, let us look at the fundamental problems of the theoretical physics of 20^{th} century in comparison with the classical physics.

Appendix B: Commentary

Reviewer A. Comment 1.
I appreciate your many well-motivated comments regarding the problems in contemporary physics, and I fully agree that physics needs a renaissance.

If I have understood correctly, your new gravitational theory should replace the general theory of relativity and serve as a solution for the unification of gravitation and electromagnetism. For such radical claims, strong experimental support should be given. How does the new gravitational theory handle well-known relativistic effects like, e.g., the effects of gravitation and motion on the frequency of atomic oscillators – and how does the new theory affect celestial mechanics and the current cosmological picture based on general relativity?

Reply: Is the unification theory meant to replace general relativity?
My unification theory is not meant to replace general relativity. It is meant to complete the theory of gravitation that Newton started and half-finished. The Newtonian theory is a static theory without a dynamic component. As a result, it cannot explain the propagation of the gravitational interaction, leaving a historical issue of action-at-distance which, at least partially, motivated Einstein to propose his general relativity.

My unification theory provided a natural answer to the problem of action-at-distance, derived the gravitational wave equation and the solution. The theory predicts that the gravitational wave propagates with speed of light. The whole theory is naturally unified with the electromagnetic theory. The unification theory has yielded an important discovery: Wang's Law which states that the total momentum propagated into the space is conserved. The classical theory of gravitation is now complete in the Newton-Wang formalism.

The many "achievements" claimed by General relativity cannot stand scrutiny. I have given an extensive and thorough analysis of the fundamental inconsistencies of general relativity in my review article [31]. In this article I have scrutinized the three crucial tests of general relativity (precession of planets, bending of light as observed in eclipse by Eddington's team, and the gravitational redshift). None of these big claims could stand scrutiny. Einstein's world model is known to be a failure, nor did he accept the notion of an expanding universe and the Robertson-Walker metric based on which the various brands of Big Bang theories were built.

Physicists are not responsible for explaining Einstein's claims and mistakes, and for reproducing these "relativistic facts". It is now a common knowledge that Einstein's relativity is incompatible with quantum theory. Requiring new theories to reproduce and repeat Einstein's claims imposes unfounded restrictions on the theoretical research. We would not need a "Renaissance" if the prevailing theory is correct. Physicists need to be spiritually emancipated from the confinement of the prevailing modern theoretical physics defined by Relativity and Quantum Field Theory. Such is the very meaning of new Renaissance of Science. My present article is dedicated to drive this point through.

Reply. About experimental evidence of the unification theory

The unification theory predicts that the gravitational interaction is propagated by gravitational wave with the speed of light. The existence of gravitational waves is now a common knowledge, and it is a solid experimental evidence of the unification theory.

Besides experimental evidence of gravitational wave, my unification theory has made a number of predictions (not hindsight confirmations) to be verified by experimental physicists: 1) The speed of gravitational wave is the same as the speed of light; 2) The dynamic component of the gravitational force between the sun and the planets is in the order of 10^{-14}. With the modern technology, it is possible to pursue experimental detection of the dynamic gravitational force if the project is properly funded. Namely, our unification theory can be experimentally vindicated or falsified; 3) The total linear momentum propagated into the whole space is conserved (Wang's Law). Since this is a new discovery, it can be verified or falsified with electromagnetic wave.

Inclusion of some postpositive calculations to confirm some of the existing experimental results would certainly help to convince the public of the values of the new theory. I am considering this as possible projects next, but I did not feel the compelling need partially due to my evaluation of the hindsight confirmations.

Reviewer B. Comment 1.

Quotes from your article: "The modern theoretical physics represented by relativity and the standard model of particle physics has come to a dead end." "general relativity and quantum field theory are incompatible, both having fundamental inconsistencies."

Then why are they still individually successful, including the relatively recent discovery of direct gravitational waves predicted by Einstein's General Theory of Relativity?

Reply.

If two theories are fundamentally incompatible, they cannot be both correct, even individually. At least one of them is wrong, or both are wrong. The main task of my article is to show that there are arrays of fundamental problems in both relativity and the standard model of particle physics. Specifically, the recent "discovery" of "direct" gravitational waves predicted by General Relativity is highly questionable. The signals they have detected is interpreted as the gravitational wave of a binary black holes. But the concept of black hole is exactly one of the fundamental inconsistencies of General Relativity. A black hole is the region within the event-horizon (EH) at which the metric tensor diverges to infinity. Infinite metric tensor means infinitely large gravity and curvature of space-time, which is absurd. Inside the event-horizon, the space becomes time and time becomes space. No one can make sense of such space-time interchange. A dark massive object in space is not necessarily a black hole in the sense of general relativity unless one can prove a) The gravity and the curvature of space-time on the edge of it are infinities; b) The space and time interchange inside the event horizon. Einstein never admitted the existence of black holes; nor does Steven Weinberg admit its existence. The most prominent star in black hole research, Stephen Hawking, admitted in his last years that the black hole research was the greatest blunder of his life. He also was one of the important figures who admitted that the theory of relativity is incompatible to the quantum theory. If the black hole does not exist, the whole story of a binary black hole and its gravitational wave is not credible. There are other technical problems including detection method, limit of instrumentation and data processing, which I have detailed in [32].

Reviewer B. Comment 2.

A quote from your article: "The logical and natural explanation of the propagation of the gravitational wave offers an answer with mathematical rigor to the historical question of action-at-distance. Moreover, our unification theory has revealed the secret of the inverse-square law."

One way of getting that law is from Gauss's law applied to the divergence relation between electric field and charge (in Maxwell's electromagnetism) and gravitational field and mass (in Newtonian gravitational theory).

Reply.
Gauss's law can only explain the static Coulomb's law and Newton's law, but not the dynamic Biot-Savart law. Our unification theory is the first time ever to give a general prove that the inverse –square law is an exact law, not an approximate empirical law.

Reviewer B. Comment 3.
A quote from your article: "A scrutiny of the edifice of modern theoretical physics reveals that the ultimate reason for the multitude of unsolvable fundamental inconsistencies of the theoretical physics is the shift of philosophy. It is a shift from scientific philosophy and methodology to mythological and theological philosophy and methodology."

I am not aware of such "mythological and theological philosophy and methodology". In doing a search through your paper I cannot find what you mean by "scientific philosophy"?

Reply.
I believe I have explained in this article the difference between scientific philosophy and mythological and theological philosophy and methodology, specifically in sections 7-11.

Reviewer B. Comment 4.
Quotes from your article: "We know much less about nuclear structure than atomic structure. We do not even have a thorough survey of the nuclear reactions of some 2000 isotopes and their products. There is nothing similar to the periodicity of the chemical elements that could be spelled out from the data of nuclear reactions."

What is meant by 'thorough'? See books and papers about nuclear physics to understand what we know. The Pauli Exclusion Principle, however, has been applied as an aid to understanding both atomic and nuclear physics. See [24] pp. 308 – 330 for statement and application (*via* the Hartree theory) of the Principle to multielectron atoms and thus a kind of *building up* approach to the electron structure for the Periodic Table of the elements.

Reply.
The Hartree-Fork theory is a self-consistent-field method to determine the energy levels of large atoms with many electrons. It is a mathematical method to deal with many-body problems of atomic structure, but not the nuclear structure. My statement "we know very little about nuclear structure" sounds shocking, but that is the unfortunate fact. We do not know the nuclear force as a function of interaction distance between nucleons. Currently the best guess is the Yukawa potential. But it is far from the real nuclear force in many ways: a) It is a static potential without any dynamic component; b) No one knows if Yukawa potential applies to the strong force or to the weak force, or to both? c) Does Yukawa potential apply to the quarks and gluons? If not, what is the force between the quarks and gluons? Our lack of knowledge is also evidenced by the fact that our understanding of the nuclear interactions is not much better than it was after WWII, in spite of numerous publications and textbooks on nuclear physics. The reason is that much of the research resources and manpower have been dedicated to the study of the structure of the nucleons instead of the structure of the nuclides (more than 2000 nuclear isotopes). What I advocate is to have a thorough survey of the nuclear reactions of all the isotopes, find their half-lives and products, and see if we can identify some regularity or even periodicity, in much the same way as the chemists did over centuries. Without such accumulation of experimental data base, I do not see how we can understand the questions that I raised in the following paragraphs. Experimental nuclear physics and nuclear chemistry are the entrance door to the sub-atomic physics.

Reviewer B. Comment 5.
Quote from your article: "It is impossible to understand the microscopic world through collisional experiment."

A 'collisional' (scattering) experiment was first used by Rutherford and his students to determine that the Thomson (or 'plum pudding') model of the atom was incorrect. Consistent with the experiment (manner of deflection of alpha particles sent through gold foil) the atomic model was modified so as to be more like a 'planetary' system (but with the central object consisting of a concentrated positive charge, instead of the Thomson model with its spread-out positive charge). Later information about the nuclear force can be understood through scattering experiments, as described in [33] item 3 on p. 511. In medical physics and nuclear engineering, scattering experiments have been used to better understand the nature of microscopic entities in order to provide more adequate shielding. Scattering experiments elucidate aspects of the microscopic world at the level of molecules, atoms, and nuclei.

Reply.
If you read through this paragraph, you can understand that my point is not "the collisional experiment is useless", but "the collisional experiments is not capable of revealing the form of the nuclear force and other physics in the nuclear world." True, collisional experiments do give us some information about nuclides, but far from enough. For instance, Rutherford's experiment defeated Thomson's plum pudding model, but Rutherford's model assumes that the nuclide is a hard ball, which is not the modern concept of the nucleus. However, Rutherford's experiment does not reveal anything about the nature and the form of the nuclear force. (The scattering takes place at the surface of the hard ball.) The physics community can keep on conducting more sophisticated collisional experiment, but the collisional experiments will not yield the true form of nuclear force. My statement is based on the observation that, even with our good understanding of the gravitational force and electromagnetic force, it is impossible "to design a collisional experiment to discover Kepler's laws, Newton's law of gravitation, Coulomb's law, Biot–Savart law, Ampere's law and Faraday's law", as I stated in the issuing paragraph.

Reviewer B. Comment 6.
Quote from your article: "The whole business of particle physics is to speculate the form of certain interaction potential (or the Lagrangian) from the experimental data of collisional cross sections measurements. To make the speculating job a little easier, many restrictions are subjectively imposed on the forms of the interaction Lagrangians and the wave functions, the most important being the symmetry requirements."

There are always rational restrictions as part of a scientific approach. Otherwise problems would be overdetermined, irrelevant information would be incorporated, and progress would be hampered." The conservation laws (such as those pertaining to Energy, Momentum, and Charge) have been of major importance in understanding Nature. The value of those mentioned are seen from variety of texts used to teach introductory courses of physics; both algebra- and calculus-based. Lagrangians are (and continue to be) a useful approach to generating conservation laws via the use of Noether's theorems. This is true both in classical and quantum physics. See, e.g., Goldstein, Poole, and Safko, *Classical Mechanics,* 3rd edition. Symmetry requirements (such as that of anti-symmetry) on the wave function pertaining to electrons moving around the nucleus as well as to nucleons within it enable us to better understand and verify our model of the atom and of the nucleus. See comments above with references to [33].

Reply.
You are right in that the idea of symmetry are spoon-fed and preached into the young minds through "variety of texts used to teach introductory courses of physics; both algebra- and calculus-based". But this is exactly where the problem is. The physics community is teaching the students to take the

aesthetics as the most important consideration in evaluating the existing and newly proposed theories. I have criticized this in detail in section 4, "Science versus aesthetics".

True, theorists need to make some "rational" assumptions and restrictions to keep the research going. The key is, are the needed assumptions and restrictions "rational"? For example, Renormalization assumes that the divergent mass and charge of electron can be "normalized" to a finite value by throwing away an infinite amount. Is it rational? Dirac regarded such practice mathematically ugly. The hypothesis of gauge invariance forbids all particles to have mass, in blatant contradiction to the reality. Is such hypothesis or restriction rational? The Standard Electroweak theory assumes that the massless photon is a linear combination of the massive particles B^0 and W^0. Is such hypothesis rational?

Reviewer B. Comment 6.
Quote from your article: "Lorentz invariance is a special characteristic of electromagnetic wave equation only."

No; it also applies to the spacetime, proper velocity, and momentum-energy four-vectors; assuming we mean the same thing by "Lorentz invariance".

Reply.
This is the logic of my argument: I listed almost all the equations in the course of mathematical physics. Among these equations, only the wave equation of electromagnetic wave has Lorentz invariance. The argument has nothing to do with how widely it was imposed as a general requirement to other physical processes. The broad application of Lorentz invariance is exactly what I challenge in this article. Simply because it is widely imposed does not mean it is logically justified and correct. A thorough discussion of the Lorentz invariance deserves a lengthy article or a book, which is not adequate for our short exchange of comments here. You and the interested readers are invited to reference [34], [13], [17].

Reviewer B. Comment 7.
Quote from your article: "I could only do it for low angular velocity, and the calculation was quite complicated."

Use of differential forms tends to make it easier to treat the field equations; in case you haven't used that mathematical approach.

Reply.
If you have a global rotational transformation compatible with relativity, I am all ears.

Reviewer B. Comment 8.
Quote from your article: "No one has carried out any calculation with general relativity for strong fields or more complicated boundary conditions and initial conditions than that of the Schwarzschild and Kerr solutions."

Einstein's theory of General Relativity has been confirmed through some of its (not-necessarily-exact) solutions in a variety of tests: bending of starlight and other electromagnetic waves by a massive body, gravitational redshift of light emitted from a massive body, precession of the perihelion of the planet Mercury, gravitational lensing (which has been used to detect exoplanetary systems), indirect detection of gravitational waves (Hulse and Taylor), and direct detection of gravitational waves (LIGO observations).

Reply.
The fallacies of all these crucial tests are analyzed in detail in [31]. You and the interested readers are cordially invited to comment and criticize.

Reviewer B. Comment 9.
Quote from your article: "Einstein's concept of mass-energy equivalence is shown to have many inconsistencies in [17]. Mass is a measure of the quantity of substance contained in an object, while energy is a measure of motion or state. They are related but not equivalent. Proportionality is not equivalence. Even if we take Einstein's formula $E=mc^2$ at its face value, it does not lead to the mass-energy equivalence."

Einstein's formula was derived by him in a short paper that followed his much lengthier one (both published in 1905). It explains a variety of phenomena as well as predicts others: Examples are: Why does the Sun shine? (fusion reaction), How much energy is emitted in the fission of Uranium 235? How much energy in the form of gamma radiation results from the collision of electrons and positrons (e.g., in PET scans used in biological applications). How much energy is required to collide to protons in order that the result is the production of three protons plus an anti-proton?

Reply.
What you stated here is an orthodox statement of the mass-energy relationship. The issue is again more profound and involving than could be easily presented here in our short exchange of comments. Once more I cordially invite you and the interested readers to read and criticize [17]. I can only list some of the conclusions from the article: 1) Einstein's mass-energy relationship is not derived from special relativity, but a choice from three different possible options; 2) The famous formula $\mathrm{E} = \mathrm{mc}^2$ has not been verified experimentally either by the binding energy curve or by the nuclear reactions; 3) The creation and annihilation have never been directly observed, although it is stipulated in the standard formalism of quantum field theory. In clinic PET scan practice, no annihilation is directly observed. It is simply *believed* that an annihilation has taken place within the body of the patient and emitted two gamma photons. The fact that the gamma photon has an energy of 511 keV does offer some support of such belief, but it is not a solid proof.

Reviewer B. Comment 10.
Quote from your article: "We do not know why atoms are happy when they have eight electrons in the outmost orbits and why the helium atom is stable with only two electrons. We do not know the electrons obey Pauli's exclusion principle."

The antisymmetry of the wave function for electrons, for example, is used to explain the Pauli exclusion principle. See earlier remarks about [33].

Reply.
The reason why the Pauli exclusion principle needs to be explained is that it is an imposed hypothesis (The term "principle" hallows a hypothesis to something like a "law"). The quantization condition in solving Schrödinger's equation allows the n^{th} atomic orbit to accommodate n^2 states, while the periodic table requires each orbit to accommodate $2\mathrm{n}^2$ electrons. To close this theoretical gap, two hypotheses are added: 1) The electron has a spin *1/2* with two states (Dirac later on explained electron's half spin with his spinner theory, but the concept of spin is far different from the popular concept of the spinning of a particle. The meaning of quantum mechanical spin is out of the scope of our discussion here); 2) A quantum state as defined by *n, l, m* and *s* could contain only one electron (Pauli exclusion principle). The two added hypotheses amount to replacing the mystery of octet rule with the mystery of the exclusion principle and the spin. What is less mysterious is pretty much a matter of personal taste. To my taste, Pauli's exclusion principle is not less mysterious than the octet rule, which remains a mystery that we do not quite understand.

Reviewer B. Comment 11.
Quote from your article: "We don't know why uranium 235 is explosive while uranium 238 stable."

It was a sufficient level of knowledge that enabled humans to create "atomic bombs" and nuclear power plants!

Reply.
I know that this level of knowledge enabled humans to create atomic bombs and nuclear power plants, but this does not prevent humans to seek an answer to the question of why uranium 233, 235 and 236 are explosive while uranium 238 is stable. Humans knew how to make bombs centuries ago, but it did not prevent chemists from studying the chemical composition of gunpowder. Humans knew how to use fire tens of thousands of years ago, but it did not prevent chemists and physicists to study the chemical composition and spectra of the plasma of a fire. We have the ability to make nuclear bombs and nuclear power plants, but we do not understand the nuclear force and physics behind these. The status quo of the mainstream particle physics, especially the physics of strong force, is far from being satisfactory.

Reviewer B. Comment 12.
Quote from your article: "Kruskal set the first example of mathematical creationism by creating a multiverse through coordinate transformation. Since then, theorists have adopted the practice as self-evident principle to take mathematical characteristics of functions and equations as physical laws of Nature."

No; physicists generally seem to recognize that *mathematical characteristics* are not the same as *physical laws*. Math is (as one example) a concise description (when properly interpreted) of physical laws. For example, Lorentz invariance can be used as a mathematical description of the fact that the speed of light has the same value in either of two inertial frames of reference.

Reply.
I agree with your general statement that *mathematical characteristics* are not the same as *physical laws*, which seems to echo my statement that "theorists have adopted the practice as self-evident principle to take mathematical characteristics of functions and equations as physical laws of Nature". Your example of Lorentz invariance, however, does not support our consensus. The constancy of speed of light is not a physical fact, but a consequence of the Lorentz transformation. Instead of giving a lengthy philosophical argument over the constancy of speed of light, allow me to share with you that even Einstein's general relativity is not consistent with the constancy of speed of light. According to Einstein, the light travels along geodesics in the gravitational field: $ds = 0$. The Schwarzschild solution to Einstein's field equation reads:

$$ds^2 = \left(1 - \frac{2GM}{rc^2}\right)c^2dt^2 - \frac{1}{1 - \dfrac{2GM}{rc^2}}dr^2 - r^2\left(d\theta^2 + \sin^2\left(\theta\right)d\varphi^2\right)$$

Assuming the space to be isotropic： $d\theta = 0, d\varphi = 0,$ we have

$$ds^2 = \left(1 - \frac{2GM}{rc^2}\right)c^2dt^2 - \frac{1}{1 - \dfrac{2GM}{rc^2}}dr^2$$

Since Einstein demands $ds = 0$, the speed of light in gravitational field is given by

$$v = \frac{dr}{dt} = \pm\left(1 - \frac{r_s}{r}\right)c$$

Where c is the speed of light in Minkowski vacuum, $r_s = 2GM/c^2$ is the Schwarzschild radius. It shows clearly that the speed of light in gravitational field is not constant. At the Schwarzschild radius, the speed of light is zero. When the radius approaches zero, the speed of light approaches infinity.

The problem with the constancy of speed of light are reflected in many other aspects, such as with the global rotational transformation and with the famous clock paradox. I have commented this in the previous replies, and I have given the relevant references.

Could we hold the constancy of speed of light in general relativity and abandon Einstein's proposition that the light travels along the geodesics in gravitational field? Well, that will invalidate the important prediction of the bending of light by gravitational field and the gravitational lensing effect. Either way would jeopardize the credibility of General Relativity.

Many more examples are given in this section to explain how modern theorists "have adopted the practice as self-evident principle to take mathematical characteristics of functions and equations as physical laws of Nature".

Reviewer B. Comment 13.
Quote from your article: "From experimental point of view, the negative results of LEP of CERN and the Fermi Lab should have equal statistical weight as the positive result of LHC. But such is not the culture in particle physics community. The negative results that do not confirm the predictions of the Standard Model would be considered failure. Only positive results confirming the Standard Model would be considered success. If the LHC result was not positive, it would be dismissed as another failure as well, until some positive result coming up to confirm the theory. Repeating the experiment means further investment of another billion dollars and ten years of hard work of thousands of researchers. Funding may be granted for repetition only when the previous results are negative."

What is a "positive" result? The Michelson-Morley experiment did not detect a <u>mechanical</u> ether. But that does not mean it was dismissed as a "failure". For Michelson it was a failure. But others took it as a "positive" result in the sense that, to within an experimental error of a certain fraction of a "fringe", it showed that no such ether was detected.

Reply.
Allow me first to mend your last sentence: The null result of Michaelson-Morley experiment did not show that no ether was detected, it just showed that no relative velocity between the Earth and the ether was detected.

Apparently, you are trying to avoid facing the fact that "If the LHC result was not positive, it would be dismissed as another failure as well, until some positive result coming up to confirm the theory". I believe I have made it very clear here as to what is a "positive" result. A positive result is a result that confirms a theory of authority to be tested, specifically, the Standard Model of particle physics.

Michelson's era was a time when the experimentalists could still be able to conduct independent experiments. Much of that spirit of independence is now lost, as evidenced by the detection of the God particle and the detection of gravitational wave. The reason for Michelson to be disappointed about his "null" result was because he was misled by the notion that the ether is an absolutely static medium of the universe. But we have no reason to believe an infinitely large medium to stay absolutely static. A more reasonable notion is that the ether is a fluid capable of local movements like any other fluid. If the local ether is co-moving with the Earth or the Solar System or the Milky Way, then it is not surprising that Michelson and Morley could not detect any relative velocity of the Earth with respect to the ether. I myself have spent two years in conducting a first-order ether drift experiment, and confirmed the null result of Michelson-Morley experiment [35]. The null result of our ether drift experiments only proves that there is no detectable relative velocity between the Earth and the local ether at the current level of technology, but does not disprove the existence of ether.

Nowadays the concept of ether seems to be a synonym of obsoleteness and ignorance. But the modern concept of vacuum goes much farther than the concept of ether. The incredible modern "vacuum" is said to be filled up with dark matter and dark energy that is 30 times more than the "ordinary matter". The Big Bang cosmologists also propose an absolute coordinate system fixed with the universal Cosmic Microwave Radiation (CMR). The ether is excommunicated and exiled, but the heresy is rediscovered and exploded. According to Stephen Hawking's quantum bubble theory, from every cubic centimeter of our space there are 10^{143} universes created every second from the vacuum. The classical ether does not have such incredible power.

Reviewer B. Comment 14.
Quote from your article: "Isaac Newton made a hypothesis that there was an attractive force between any two objects that is inversely proportional to the distance squared."

Newton "feigned" no hypothesis. I refer to that because you are using the term "hypothesis" to carry a different (modern) meaning of the term. See Newton's *Principia* for details.

Reply.
I believe I share your feeling. If your point is that the assumption of a gravitational force is not much a hypothesis because it is so natural an assumption, then we are on the same page. As a matter of fact, the following text in this paragraph does exactly the thing to explain the naturalness of Newton's assumption. The reason I use the word "hypothesis" is to show the difference between the classical physicists and the modern theorists in their attitudes in proposing a hypothesis. And yes, at the time when Newton proposed the existence of a gravitational force, it was a bona fide hypothesis. In science, physicists do need to make hypotheses to formulate a theory to organize the experimental results and provide deeper and broader understanding of our observation. My point is, a hypothesis must be theoretically reasonable, logically sound and consistent, and must be independently tested and verified after its proposition.

Reviewer B. Comment 15.
Quote from your article: "Einstein proposed a hypothetical cosmological term. It amounted to a universal repulsive force proportional to the distance. One would not feel the repulsive force if he was close to the mass, but would feel the strong repulsion if he was far away on the edge of the universe. The idea was astrological and absurd."

No. It was in keeping with the evidence at the time.

Reply.
Both Einstein and I feel the cosmological term is illogical. No evidence supports a repulsion force linearly proportional to distance. Not then, not now, nor will there be any such thing in the future.

Reviewer B. Comment 16.
Quote from your article: "How likely is it to figure out what was going on 14 billion years ago and what is going to be at the end of the universe, presumably to take place some billions of years later at the Big Crunch?"

To what extent? We do have knowledge of what took place after the so-called Big Bang (for which we have no knowledge).

Reply.
I do not know what is your idea of "reasonable extent". To get some feeling of the "extent" of the extrapolation, let us look at some well-known examples of modern cosmology. As I stated in the article: "They can calculate exactly what was going on 13 billion years ago at every split of a second. They predict with confidence how the enormous mass and energy was created from nowhere out of nothing in the "first" 10^{-43} second, how an "inflation" at the a speed 20 orders of magnitude greater than the speed of light was turned on at the instant 10^{-36} seconds after the Big Bang, and turned off at 10^{-33} seconds, never mind whoever did this and why and how, we don't need to know, they tell us." All this despite the fact that their prediction of the current mass density is 30 times of what is observed. The relative error of their prediction is as huge as 3000% off if there is an observed value to compare with, but is as small as 10^{-58} if there is no observational data to compare with, since nobody was there observing 13 billion years ago. The literally unbelievable accuracy speaks of one thing: the Big Bang cosmology is extremely sensitive to the theoretical mass density that is the mathematical manifestation of the extreme instability of the theory.

Reviewer C. Comment 1.
You declare that your theory unifies gravitational and electromagnetic fields, but you have not explained e.g. how gravitational potential affects atomic clocks. Does your theory explain this and how? Or do you believe that the effect of gravitational potential on atomic clocks is a hoax?

Reply.
I cannot say that the observations on "gravitational effect on clock" are all hoax, but the interpretation based on general relativity is hoax. Neither Newton's theory nor my unification theory predicts time dilation due to the difference in gravitational potential.

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