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Appreciation of the nature of light demands enhancement over the prevailing scientific epistemology

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ABSTRACT

Based on attempts to resolve the problem of various self contradictory assumptions behind the prevailing belief on *single photon interference*, we have analyzed the process steps behind our experimental measurements and named the process as the Interaction Process Mapping Epistemology (IPM-E). This has helped us recognize that the quantum mechanical *Measurement Problem* has a much universal and deeper root in nature. Our scientific theorization process suffers from a *Perpetual Information Challenge (PIC)*, which cannot be overcome by elegant and/or sophisticated mathematical theories alone. Iterative imaginative application of IPM-E needs to be used as a metaphorical *analytical continuation* to fill up the missing information gaps. IPM-E has also guided us to recognize the generic NIW-principle (Non-Interaction of Waves) in the linear domain, not explicitly recognized in current books and literature. Superposition effects become manifest through light-matter interactions. Detecting dipoles gets stimulated by multiple superposed beams; it sums the simultaneous multiple stimulations into a single resultant undulation, which then guides the resultant energy exchange. The consequent transformation in the detector corresponds to observed fringes. They neither represent *interference of light*; nor represent selective arrival or non-arrival of photons on the detector. Photons do not possess any force of mutual interaction to generate their redistribution. Implementation of IPM-E requires us to recognize our subjective interpretation propensity with which we are burdened due to our evolutionary successes.

Keywords: Non-Interaction of Waves (NIW); Nature of light**;** What photons are; Interaction Process Mapping Epistemology (IPM-E); Measurable Data Modeling Epistemology (MDM-E); Epistemology for science; Limiting velocity of particles; Running time as an immeasurable physical parameter.

1. INTRODUCTION

Let us start our journey by accepting that the concepts of the *structure of photons* and the *interference of indivisible single photons* are not yet resolved issues. Otherwise, our 4th biannual conference would not have succeeded in attracting almost sixty presented papers. The author firmly believes that the purpose of our theories is to help us visualize the invisible interaction processes that give rise to the data. Just the various successes of modeling data are not going to lead us to fully understand the cosmic system. This particular article will not directly dwell upon the issues of photons in details, which can be found in other articles of this volume. But the fact that these issues appear to be unresolved in the minds of many people, has inspired the author to write this article that proposes the need for the development of a rational strategy on how to do scientific thinking. The reader will find that the proposed Interaction Process Mapping Epistemology (IPM-E) provides a referent platform for both making iterative improvements of our theories and for enhancing our technology innovation capabilities.

However, sincere humility is called for on my part before writing about formulating a methodology of thinking, or epistemology, for doing science, since I have never been a student of either philosophy or the subject of logics! This is especially true when one reads some of the sayings of Newton, the father of Physics: "*I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.*" But, with the statement, "*If I have seen farther than other men, it is by standing on the shoulders of giants*",

Newton provides us with a profoundly important guiding tool to carry on the task of advancing science without feeling bewildered.

Unfortunately, the prevailing human culture and education train us to overlook the following. Any and all organized bodies of knowledge ever put together by human intellects, are necessarily incomplete as they have been formulated based upon insufficient knowledge of our cosmic system. The reason is that, since ancient time, for the necessity of successful evolution of each tribe, the tribal family had to invent and facilitate the development of social culture that systematically transforms our thinking to conform to the ruling family's viewpoint as long as it *works*, meaning, as long the culture allows the members to survive. Slowly, the unchallengeable god-culture evolved as a key tool to manage the large membership of the tribe. Perhaps, through millennia, we are thus genetically trained to develop the *messiah complex* and accept the concepts handed down by our hierarchy as the ultimate truth, especially, if it *works*. So, as we find the concepts of many Newtons and Einsteins are working brilliantly, our *messiah complex* accepts them as the unchallengeable final truths.

Today, we are both confused and fortunate because our guiding giants have been divided among themselves as there is some recognition that the advancement in our fundamental knowledge of nature has become stagnant while our technology is advancing quite rapidly, albeit, leveraging only the existing fundamental knowledge. First, our state of confusion: Our knowledge gate-keepers are consistent about promoting and holding on to the current consensus epistemology. This, of course, maximizes the economic benefits for the consensus-followers enforced on the society by the by hierarchy of our modern scientific enterprise. An enterprise that is obligated to conform to the socio-politico-economic reality! Thus, any concept that challenges Descartes-Einstein-Heisenberg foundation will not pass through the gates held by the gate-keepers. The assumption is that the final foundation of our scientific edifice has been laid! We are now allowed to find only those stones and bricks that can fit on to the existing edifice. Thus, physics has become another religion! We train our graduate students to publish with conformity or perish. We are consistent in our training tools to suppress their enquiring minds. Systematic suppression of enquiring minds slowly and undetectably becomes a functional tool for slow de-evolution of our human minds! This approach has been stifling the serious progress in fundamental physics for almost half a century. In the process of conforming to the socio-economic reality, we have become over confident about the finality of our mathematical tools invented from centuries past until the middle of the 1900's. We are now arrogantly telling nature how she ought to function and behave, instead of humbly keep on trying to discover the actual logics behind all the ongoing cosmic evolutionary processes, whether animate or inanimate.

Second, we are also fortunate. A good number of books have been written by several major leaders of the knowledge gatekeepers, and a few outsiders, on the subject that it is time for us to re-visit the very foundation of physics by questioning the foundational hypotheses [1-8]. We are also fortunate for another deeper reason. Biological evolution has given us enquiring minds to all of us as a dedicated segment of our brain. While our socio-political cultures over many millennia have been consistently training us to conform to the social rules and cultures set by the various tribal leaders of human societies, time and again, through ages, we have experienced that human social cultures and pressures cannot completely brainwash all the people, all the time, all over the world. We all just need to consciously bootstrap this biological endowment, the enquiring brain, to frame questions when we face problems to find solutions. We also know that framing the question determines the answer we can extract out of nature. In fact, this approach is the key tool in the arsenal of reporters who interview political leaders. When they fail to get the answer to a specific query, they rephrase the question depending upon the socio-political context. Whereas, scientists tend to hold on to their initially framed question about a particular problem of nature they have identified to explore. While this tenacious faculty has historically been found to be beneficial behind many successes, limitations are in general not underscored in our history books. So, scientists are generally not trained to be conscious about the root of their faculty of framing questions; neither do they try to re-frame their questions like the political reporters do.

Let us make a point using a historical example. Like a true scientist, never surrendering his enquiring mind, Einstein has been known to question all his life everything including his own theories. During the last decades of his life, he kept on working to formulate a unified field theory for the universe with which he would be more comfortable than his existing theories, as well as Quantum Mechanics (QM). He kept on diligently raising questions regarding the very foundational hypotheses behind the QM. He kept on asking question about the nature of light, "What are light quanta?"for almost fifty years, even though his hypothesis of *indivisible photon* has been universally accepted. However, Einstein kept on asking the same question with his favorite built-in answer- *quanta*. This is why we have initiated our conference series with the open ended question, "What are photons?" Einstein, of course, defied Planck, who originally found the *quantumness* in the nature of emission and absorption of EM waves. Planck firmly believed that photons, after emission as an energy quantum, evolve and propagate diffractively (Huygens-Fresnel principle) as a classical wave

packet. Semi-classical models for photo electric effects [9,10] do not require *indivisible quanta*. Yet, we are so conditioned over a century of *indivisible quanta* that we are extremely reluctant to entertain any other alternate concepts.

Preceding his 1905 paper on photo electricity, as Einstein was pondering on how to frame a theory; he brilliantly recognized the *quantumness* in the experimental data on photoelectric current. Had Einstein followed Planck's view of photons, he would have assigned the quantumness in photoelectric data on the electron binding energy and the optical frequency as the required frequency for stimulating the bound electrons. Then, he would have formulated a QM with a very different mathematical approach than what we have now! This was about eight years before Bohr's heuristic quantum theory and 20 years before the formal QM. Had Einstein reframed his question from *light quanta* to *electron quanta* (and its quantized binding energy), Quantum Philosophy would have been dramatically different! Thus, framing and reframing questions regarding the same problem at hand should be a critically important part of our scientific epistemology. Could there be some logical framework that can be used to iterate and reframe our questions in a logical, efficient and productive way?

The author certainly does not want to trivialize the staggering progresses brought about by modern science and technologies. On the grand scale, our concept for the universe has evolved from geocentric model to heliocentric model to center-less limitless universe with billions of observed galaxies. On the micro scale, we have learned to manipulate, create and destroy, from micron size biological molecules to sub-nanometric atoms to femto-metric nuclei to immeasurably small elementary particles. We have woven together fairly logically self consistent story how the magnificently large and beautiful galaxies are built out of the elementary particles and how the structures at all levels are evolving. We also have found the codes of conduct behind the complex biological lives; just four different molecules woven inside a pair of helical chain of molecules, have been guiding the entire biological evolution for almost four billion years. But, is this the end of the knowledge-extracting capability by the human species? Experience tells us that emulating a success path helps us achieve many more successes and much more rapidly. But, continued emulation of the same success logic is equivalent to controlled locomotion through the same rut. Does not this imply that we are effectively training our enquiring minds not to question the foundational hypotheses formulated by e Newton, Einstein, Heisenberg, etc.?

Just because a theory is working, validated by many observations, does not necessarily mean that the theory has captured the ultimate cosmic logics. Suppose we give a very smart five-year old child to solve a jig-saw puzzle of the global map, with the conditions that all the pieces must remain upside-down without showing the printed map segments to aid matching the pieces. Nonetheless, the child will very quickly solve separate segments of the world map, most likely, those of Australia, Madagascar, southern segments of India and Africa, etc. His progress after this will slow down severely. If we now invert his solutions to see the printed map side, most likely we will find that many pieces of the map are mixed up between different countries, even though they are fitting *perfectly*. This is because puzzle pieces consist of only a very small set of identifiably different shapes, except for the edges of the different countries. So, the uniqueness of the edge-pieces guide a child to quickly solve some segments of the world map correctly, but the pieces that go inside a country can be easily switched because some of them have identical shapes! When a very large and very complex system is built out of only a small set of basic rules completely unknown to us and we have access to solve only a few small segments, we may succeed in solving these segments by inventing a set of rules none of which may exactly coincide with the actual rules behind the original system. Modern complexity theory teaches this to us! To our current state of knowledge, the magnificently large and enormously complex universe is running under the guidance of only four forces. We have been solving small separate segments of this universe using human invented mathematical logics. So we need to be cautious in declaring that all of our working theories have correctly captured the final cosmic logics.

Modern precision measurements on the velocity distribution of stars in outer periphery of galaxies are not matching up with any of our existing gravitational theories. The power of mathematics still prevails today, even though its elegancy and symmetry are getting repeatedly called into question in many branches of physics as our measurements become more precise with our rapid technological advances! Astro-physicists are proposing many different solutions to the observed variety of deviation in rotational velocities of stars in the outer rims of galaxies (fig.1).

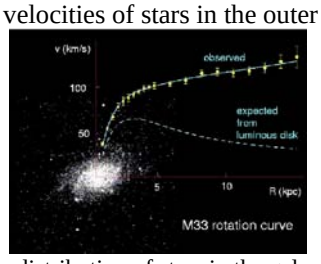

Figure 1. Measured and expected rotational velocity distribution of stras in the galxy M33 [from the web].

It is time for us to see deeper and higher, farther and further again, by following Newton, by standing on a high pyramid built over the shoulders of many more giants than Newton had the privilege to utilize, as we do today. All these giants have spent their lives developing theories that unlock the diverse working knowledge of the universe. The best way to carry forward their legacies is to respectfully stand on their shoulders to see farther, rather than limiting our vision by bowing down at their feet, out of messiah complex. But, for this, we need a deeper and articulated *bold purpose*. A *purpose* that is focused on discovering nature's actual reality rather than inventing them to please our pre-conceived model of the universe! Can this *purpose* be kept constructive rather than destructive by anchoring it to the collective self interest of sustainable evolution? We must get over with the belief that the *foundation of the scientific edifice has already been built.*

The question is how to frame a methodology of thinking (epistemology) that can be our everyday guide in consistently searching for the evolving and cycling realities behind all the cosmic logics (5,11). I am proposing that we simply re-energize the Interaction Process Mapping Epistemology (IPM-E) of our early days, which used to *stand on the shoulders* of the Measurable Data Modeling Epistemology (MDM-E). We need to re-vitalize IPM-E because over the last few hundred years, staggering successes provided by our mathematical tools, has created a culture that mathematics is not just a set of human invented tools, rather they constitute discoveries as if the creator is a mathematician and we have already found the foundational frame work [12,13]!

Section Summary: Section-2 elaborates the power of proposed IPM-E in appreciating that we are perpetually challenged to gather complete information about anything because of the measurement process available to us. It also helps us explicitly recognize the principle of non-interaction of waves, or the NIW-principle, which then tells us that the time-frequency Fourier theorem cannot be a general principle of nature. Section-3 summarizes the consequences of the NIW-principle in optical and quantum physics. Section-4 presents a brief history of how IPM-E, which used to be the basic approach for physics, got steadily replaced by the Measurable Data Modeling Epistemology (MDM-E) as mathematical theories steadily got the upper hand with the tremendous successes they brought in. Section-5 underscores that the reason for this drift lies with our deep propensity for subjective interpretation of the observable material universe, hard-wired by our biological evolutionary success.

2. IPM-E, THE "MEASUREMENT PROBLEM" & THE NIW-PRINCIPLE

Mathematical logics are the purest of all logical languages, so far, invented by humans. Over the centuries, our understanding about the working logics behind the macro and the micro universe achieved through the utilization of mathematical theories are undeniably enormous. So, it is safe for us to assume that the rules by which the universe is running must be very logical. Otherwise, our knowledge about the universe could not have reached the high level where it is now. Then we can safely assume that the invisible interaction processes that give rise to our measurable data, driven by the cosmic logics (rules), must also be logical and hence invariant. We must then learn to use this invariance as a referent platform to repeatedly and iteratively perfect our working theories through corrections and reconstructions. We have already underscored that our capability to intelligently and creatively emulate the various interaction processes in nature lie at the root of technology innovation, which has always been the key force behind successful evolution and advancement of humans over other species.

Let us now improve upon our methodology of thinking based upon our analysis of one of the most logic based poignant problems, the *Measurement Problem*, identified by the founders of the Quantum Mechanics (QM). We will find that while IPM-E, when used in conjunction with MDM-E, reveals deeper knowledge. But we have been neglecting its power for a couple of centuries!

2.1. The "Measurement Problem" [14]

How do we succeed in registering data in any experiment? Let us try to formulate the steps based upon our current experiences.

1. *Measurables Are Transformations:* We can measure only physical transformations.
2. *Preceded by Energy Exchange:* There are no transformations without energy exchange.
3. *Guided by Forces of Interaction:* Energy exchange, and consequent transformations, must be guided by an allowed force of interaction.
4. *Must Experience Physical Superposition:* Interactants must be within each other's sphere of influence to be able to interact under the guidance of an allowed force to exchange energy and undergo transformations. Thus, *all*

interactions producing transformations *must be local* in the sense that the interactants must be within each other's sphere of influence.

5. *Through Some Physical Interaction Process:* Although invisible, all transformations are preceded by some real physical interaction process. Our conscious and systematic attempts to understand & visualize these invisible interaction processes provide us with some extra logical tools to explore cosmic logics (reality). We have been significantly under utilizing this IPM-E tool.
6. *Always Requires a Finite Duration:* Transformations in the interactants from one specific state into another specific state requires "compatibility sensing dancing period" between them before the interactants can acknowledge the force of interaction and then exchange energy and then undergo the measurable transformation (transition).
7. *Impossibility of Interaction-free Transformation:* The above set of self-consistent logical arguments clearly imply that we cannot observe any measurable transformations unless the entities under study interacts with each other under the guidance of some allowed force operating between them.
8. *The NIW-Principle (Non-Interaction of Waves):* Physics has never formulated any theory supporting interactions between waves in the linear domain. Even QED analyses do not provide any measurable scattering cross-section between photons! The NIW-principle is known [15-18] but we ignore it. So, *interference of waves* is a misguided, yet well perpetuated concept, in most books and literature. This has been possible only because we have been trained to ignore the necessity of understanding and visualizing the interaction processes that give rise to the measurable data.
9. *Perpetual Information Challenge (PIC):* Our theory-constructing enterprise suffers from perpetual information challenge (PIC) from the nature. Fortunately, our genius scientists have been using their immensely creative imaginations to fill up the information void by constructing most plausible hypotheses to construct theories that match data. How do we gather quantitative and accurate information regarding the transformations experienced by our chosen set of interactants in an experiment? There are two fundamental limitations that always deprive us from gathering complete information about any entities we are studying. (i) First, we have not succeeded in constructing any instrument that has 100% fidelity in transferring all the quantitative data (information) it generates as secondary transformations induced by the primary transformations experienced by our chosen interactants. For example, the high frequency information regarding a photo current gets cut off by the slow time constant of the associated LCR circuit. (ii) Second, we have never succeeded in setting up an experiment where the interactants experience all possible forces that could introduce various measurable transformations in them. Besides, we most likely do not even know all the existing forces with exact mathematical relationships. When only one of all the possible forces facilitates the measurable transformations between our chosen entities, we certainly cannot gather all possible properties about the entities we are studying. We still do not know what an elementary particle is made of!
10. *Time-frequency Fourier theorem (TF-FT) cannot be a general principle of nature:* Item 8 above underscores that waves by themselves cannot interact with each other and re-distribute their energies either in time or in space. But, that is precisely what TF-FT implies. Yet, the theorem is based upon sound mathematical logics and validates observed data in many branches of physics. Thus, all branches of physics need to carefully investigate (i) where TF-FT is working and what wave-detector interaction processes are hidden there to match up with the data; and (ii) where we are applying the TF-FT incorrectly by creating wrong physical hypotheses in agreement with data. For example, optical coherence theory is based upon field-field correlation, even though they do not interact (NIW-principle). Thus, this field needs a careful iterative reconstruction as has been presented by the author [17-19]. The lesson is that mathematics is not physics, even though it is the best tool, so far.
11. *Information out of transformations:* Useful information is always limited by our subjective interpretation propensity. Modern literature and books [5] underscore *information* in our knowledge age as something that has gathered its own identity. From the points developed here for scientific experiments, we can clearly define information as articulate-able translation of the experimentally registered transformations by humans. In other words, information is what we make out of our observations and hence it is very subjective as it depends upon who interprets it. The objective part lies with the interaction potentials that exist dormant within the interactants and is determined by the allowed force of interaction between them. The interaction potential becomes manifest as measurables only when they are brought within each others' sphere of influence. Then a human or a computer agent must interpret the measured transformations into usable information based on their interpretation capacities. Our earlier point, the *Perpetual Information Challenge (PIC),* underscores that some agent-interpreted information out of some measured transformations can never claim to be 100% objective.

These are the roots behind our *Measurement Problem*, comprising of loss of some real and some unknown information about the natural entities we study. This PIC is imposed on us by nature. Unknown information can never be recovered by any elegant mathematical theorems! Only our creative imaginations and repeated iterative reconstruction of "working theories" can inch us forward towards real cosmic logics by filling the information gap. The summary of the above eleven points is presented as a compact logical flow chart in Fig.1.

2.2. Dissecting our theorizing process

We have just accepted that we can never gather all the information about anything through any set of experiment since the details of none of the interaction processes and those of the interactants are completely known to us, as yet. Our theorizing process, inspite of criticism presented so far, is the best process available. So, we must learn to improve our theorizing process. We must learn to dissect the steps, as per *reductionism*, so we can critically analyze each step separately to enhance our iterative progress. We divide the steps into: (i) *human logics* that frame hypotheses, (ii) *mathematical logics* that give a structure to refined hypotheses, which we then use to (iii) map (or discover) cosmic logics (our ultimate goal).

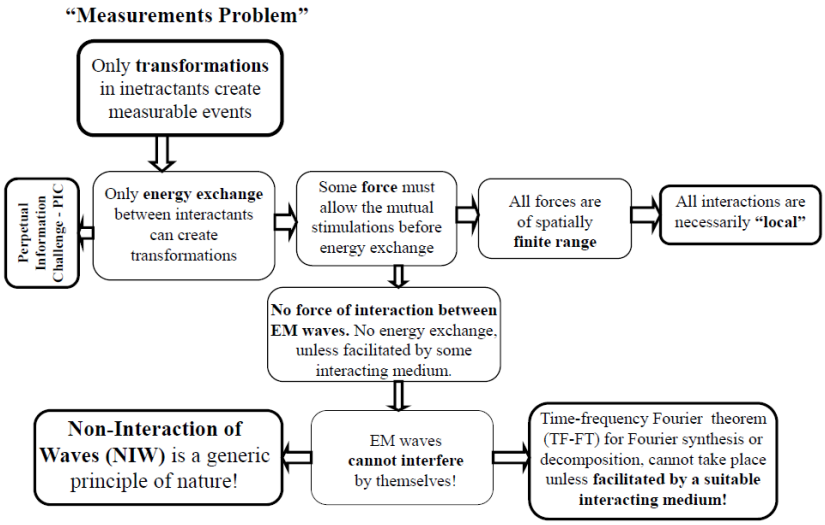

Figure 2. Logical flow diagram to appreciate the depth of the *Measurement Problem* that helps us appreciate: (i) Nature has imposed on us the *Perpetual Information Challenge (PIC)*. (ii) Nature's generic principle of *Non-Interaction of Waves* or the NIW-principle is still remaining unrecognized. (iii) Consequently, the time-frequency Fourier theorem (TF-FT) is cannot be a generic principle of nature.

1. We apply *human logics* to create some *hypotheses* to bring some *conceptual continuity* supported by *logical congruence* amongst several sets of different but related phenomena (and measured data). The hypotheses need to be directed towards visualizing the invisible interaction processes that our theory is intended to map.
2. The concepts and hypotheses that brought the logical congruence are then organized through *mathematical logics* into a defendable theory to match the measurable data.
3. When the theory appears to work extensively, we assume that it has captured some actual *cosmic logics* (rules or laws of nature).
4. When a broadly successful theory fails to accommodate other broadly successful theories, we need to critically revisit the foundational hypotheses of all the successful theories to ascertain whether unification is purely an unreasonable human esthetical demand, or we are still suffering from the perpetual information challenge defined earlier, requiring us to reconstruct the working theories from foundation up. We need to analyze which of the two components of *human logics and mathematical logics*, or their combination are holding us back from grasping the correct *cosmic logics.*

In spite of several major successful break-through in our modeling and predicting measurable data, the structure of human scientific thinking (epistemology) has been limping on basically unchanged! Historically, our scientific thinking

has been drifting between IPM-E & MDM-E, with modern bias towards MDM-E, driven by our love for the power of our mathematics, rather than keeping our focus on the main objective - the interaction processes in nature! In ancient times, we started intuitively with IPM-E. For our survival and well being, our forefathers needed to invent new technologies by learning to intuitively emulate interaction processes behind natural phenomenon. They diligently used their faculty of creative imaginations to understand and visualize the invisible interaction processes behind the phenomena of interest. They did not yet invent sophisticated mathematical theories; yet they succeeded in ensuring the sustained evolution of the human species through several million years. That is why we are here today!

With the invention of modern mathematics and its rapid development, our knowledge about the working logics of nature exploded within a few hundred years. We are now so blinded by the successes of our mathematics that we are ready to offer the crown of a mathematician to our creator [12,13]! We have almost completely forgotten that the key purpose of physics is to facilitate our understanding of the natural processes so we can emulate them to create more advanced technologies to assure our continued evolution, just as our forefathers did. The purpose of all human endeavors, including that of physics, is to facilitate the continuous and corrective evolution of a path for our consciously constructed purposeful evolution along with, of course, the entire biosphere. Instead, we have become so arrogant of our successes that we consider that the basic foundational structure of the edifice of physics is complete, and it must not be challenged any further. Yet, we have been ignoring the obvious lessons for re-thinking of our foundational hypotheses glaringly presented by our own successful mathematical theories. For example, our current foundational hypothesis about the manifest universe is that it is built out elementary particles even though the structure of most of the major successful mathematical theories is based on the concept of fields. Should we not then shift our focus from the many century-old *particle-paradigm* to some form of a *field-paradigm*?

3. CONSEQUENCES OF THE NIW-PRINCIPLE IN OPTICAL PHYSICS

Recall IPM-E helped us to re-discover the NIW-principle and consequent recognition that the time-frequency Fourier theorem (TF-FT) cannot be used as a generic principle of nature. Based on these realizations, we have presented improved interpretations of a good number of optical phenomena [18], the summary of which can be appreciated from the flow-chart shown in Fig.2 and abstracts below.

3.1. Impacts in Classical Physics

Spectrometry: Classical theory of spectrometry has been formulated based upon propagating a Fourier monochromatic frequency through passive linear spectrometer (grating, Fabry-Perot, etc.), which match up with most observed data. Unfortunately, Fourier monochromatic wave is a non-causal proposition as it exists in all space and hence violates the principle of conservation of energy. So, we have developed a causal theory by propagating the carrier frequency of a time-finite pulse [20]. We find that spectrometers functionally replicate the incident pulse into a train of N-identical pulses, N being the (grating slit number or the finesses number, with a characteristic periodic temporal step delay $\tau = \Delta / c = m / \nu$; where Δ is the path delay and m is the order of interference. So, all spectrometers have a characteristics time constant $\tau_N = N\tau$, which have been neglected by classical theory. When an incident pulse width in the limit exceeds this τ_N, our time-integrated pulse response function becomes identical to the classical CW-response function. We also found that our time integrated pulse response function can be expressed as a convolution of the CW-response function with the Fourier spectral intensity function (square modulus of the Fourier transform of the pulse envelope). This is at the root of classical assumption behind the time-frequency indeterminacy relation $\delta\nu\delta t \geq 1$. Since our formulation derives the pulse response function explicitly, knowledge of the envelope function clearly gives us an analytical expression for the fringe broadening due to a pulse. Thus, $\delta\nu\delta t \geq 1$ does not represent any indeterminacy of the carrier frequency. In our formulation $\delta\nu$ does represent a fringe broadening, but it is the spread of the energy due to the same carrier frequency; there is no indeterminacy!

Coherence: Coherence theory in current books and literature is presented as mathematical correlation (fringe visibility) between a pair of replicated and superposed fields under analysis. By virtue of the NIW-principle, fields do not correlate with each other. Light is never incoherent. It is the detectors' integration time that determines the registered visibility of fringes. If we can invent an atto second detector with complementary time resolved registration system, any and all light will give very high visibility fringes. Accordingly, based on IPM-E, we have re-defined coherence as a correlation function, as registered by detectors, but dictated by specific characteristics of light [19]. (i) *Spectral*

correlation (light with frequency variation). (ii) *Temporal correlation* (light with amplitude variation). (iii) *Spatial correlation* (light with independent multiple emitters). And (iv) *Complex correlation* (mixture of the above cases).

Polarization: We claim to be able to generate elliptically polarized light, with helically spinning E-vector, by collinearly combining two phase-steady orthogonally polarized light beams with 90^0 relative phase delay between them. Yet, when we superpose the same two beams on a detector array, we register uniform intensity without any interference fringes. Then we explain it by saying that orthogonally polarized light beams do not interfere! Then how do they generate orthogonally polarized beam? They do not. But, when material dipoles are exposed to such multiple beams, they do tend to create their own dipole oscillating vector that can carry out complex change in spatial orientation when the stimulating fields consist of different states of polarizations [21]. This picture is congruent with IPM-E.

Mode locking: All text books effectively accept time-frequency Fourier theorem (TF-FT) as a functional principle of nature, as if collinear superposition of a periodic array of laser cavity modes (frequencies), when in steady phase relation, will re-distribute their uniform energy into temporal array of pulses. This is the mode lock theory. But, the application of IPM-E reveals that it is the property of the intra-cavity mode-locking device that develops the oscillatory time-gating property under the influence of the phase steady periodic modes. Their dipoles linearly respond to the sum of all the phase steady E-vector frequencies and then change their physical characteristics based upon the square modulus of the linear sum of all the stimulated amplitudes. Yes, the mode phases must be locked (steady), but it is not the modes themselves that rearrange their energy in the time domain. Cavity energy is gated by the intra-cavity mode-locker [22].

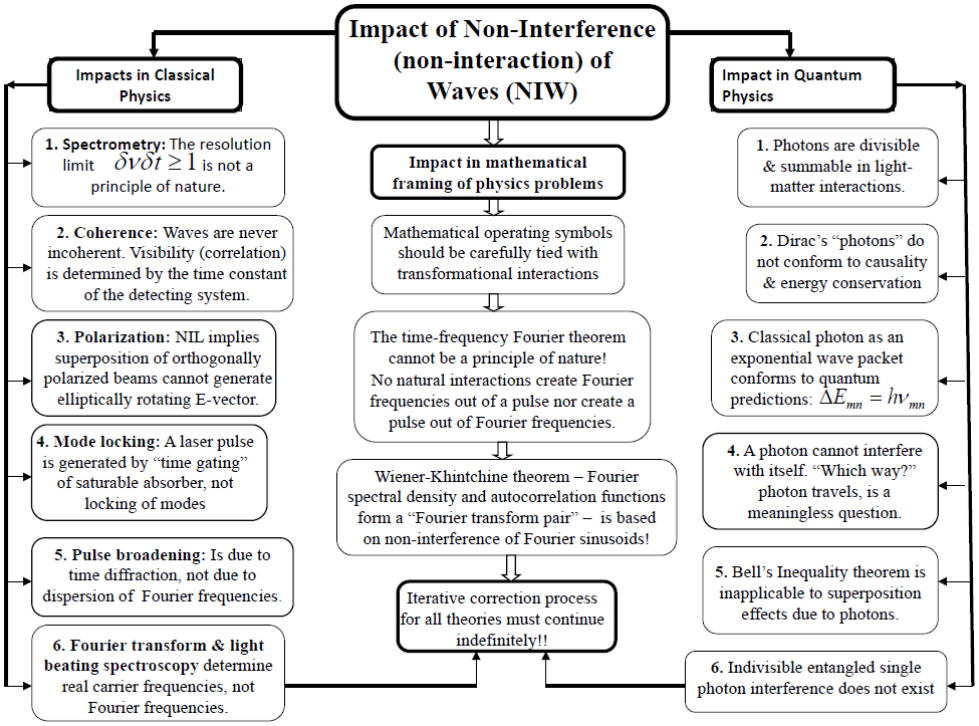

Figure 3. This logical flow diagram gives a summary of how many different optical phenomena and related concepts need to be corrected, modified and improved to match with light-matter (detector) interaction processes through which we gather the relevant data. Just data modeling is not sufficient; we must understand the interaction processes which will open up the process emulation and hence enhance rate of technology innovations further. We will present only very short summaries; the details can be found in references [17-22].

Pulse broadening: Let us consider again that we have we have a short pulse of width δt with a single carrier frequency. It is easy to appreciate that an N-slit diffraction grating will replicate an incident pulse into N-pulses with $\tau = m\lambda / c$ step delay along the m-th order diffraction beam. So, the original single incident pulse of width δt will approximately be broadened into a pulse of width $\delta t + N\tau$. Assuming that the grating is in free space, this broadening should be characterized as *diffractive stretching*, rather than *dispersive broadening*. So, when a pulse propagates through free space, it is stretched into a longer pulse along a higher order (non-zero) diffraction direction. Same kind of

diffractive stretching will also occur within a material medium, as long as the carrier frequency is a single one. If the pulse contains multiple carrier frequency, as for the case of a mode locked pulse containing comb-frequency, then the material dispersion in the medium will now add pulse broadening, which is different from diffractive stretching [23].

Fourier transform spectrometry (FTS) and light beating spectrometry (LBS): These two methods of spectrometry experimentally give different information about the frequency content of the light being analyzed**.** Consider the contradictory assumptions we make about these two methods. For FTS, we claim that different optical frequencies do not interfere, where as for LBS, they do! In reality, light never interferes! The difference is solely determined by the temporal response characteristics of the detector used in the two methods. Again IPM-E helps us discern the differences. For FTS, one uses slow time integrating detector placed at the output of a Michelson interferometer. If the light being analyzed has many carrier frequencies, one registers a variation in the visibility of the two-beam cosine fringes. The Fourier transform of the oscillatory component of the fringes, being the sum of the cosine intensity fringes due to each of the carrier frequency, yields the frequency information. For LBS, with a fast detector, one can register only all possible difference frequencies, not the absolute frequencies; this is dictated by the characteristics of the fast detector [19].

3.2. Impacts in Quantum Physics

In this paper, we will confine our discussions to those that are directly relevant to the NIW-principle.

In light-matter interactions, photon energies are divisible & sum-able [24]**:** The NIW-principle automatically guides us to appreciate that photon wave packets propagate through each other independent of each other's influence. This may imply that they are indivisible. However, since their propagation is guided by the Huygens-Fresnel principle (HFP) of diffractive spreading, any obstructing aperture in front of them makes them divisible into parts. We should note that HFP has been found to precisely corroborate theory and experiments for light propagation both in the macro domain (various characteristics of star light) and in the micro domain (nano photonics, plasmonic photonics).

To appreciate the sum-ability of their energy by detectors, we need to use IPM-E. Superposition effects become manifest as transformation of detectors in response to stimulations by multiple superposed beams on the same detector. The QM recipe for this transformation is given by the square modulus of the linear sum of all the dipole stimulations induced by all the waves. In the most general case, if there are n-waves, then, in general, there are n-amplitudes, n-phases, n-polarizations and n-frequencies. The number of variable physical parameters is 4n. Obviously a single indivisible photon would not succeed in delivering all these 4n variable information to determine the outcome. Thus, IPM-E guides us to appreciate, within the QM recipe that energies of photons are sum-able for detectors that can be stimulated by the incident photon wave packets.

Dirac's photon is not localizable: Since emission of light from atoms and molecules has been found to precisely follow the QM frequency relation $\Delta E_{mn} = h\nu_{mn}$, where ν_{mn} is a well defined frequency. Our mistaken classical concept (see **Spectrometry** in the previous section) required ν_{mn} to be defined as a Fourier monochromatic mode, and QM obliged with sophisticated mathematical theory. Unfortunately, Fourier mode is a non-causal proposition and it is not even necessary, once we recognize that photons are classical wave packets with their unique carrier frequencies [25]. We know from our pulse laser technologies and classical optics that light pulses can be constrained to occupy very small physical space and temporal domain with unique carrier frequency. Thus, Dirac's photon model adds more questions than resolving them.

Determination of which way photon travels destroys interference: There are host of publications that claim successful interference fringe can be generated only if we sacrifice the information about *which way* the photon traveled. We hope to have already convinced the reader that light beams (photons) do not interfere. So, "Which way?" is a physically irrelevant question. In an N-beam interference set up, all N beams must arrive on the detector with N-different phase, frequency, etc., information and deliver them to the detector, which will then determine the necessary transformation according QM recipe [26].

Relevancy of Bell's inequality theorem: It is generally believed that Bell's inequality theorem and consequent experiments have given a *decisive blow* to demand for locality of superposition effect [27]. Non-causal concepts like *delayed choice, teleportation* are now common. Unfortunately, Bell's theorem assumes photons are indivisible quanta and that single photons interfere by themselves. Since we have more confidence on our causal NIW-principle, we believe that Bell's *no-go theorem* is irrelevant in experimental observation of superposition effects, functionally determined by the detectors.

Can photons be entangled? If an isolated quantum entity emits a pair of photon wave packets, the quantum nature of the light emitting process will clearly impose all the necessary conservation laws and the emitted photon wave packets will acquire complementary properties during the emission process. So, one can describe them to be *entangled* during their birthing process. However, the energy packets after emission evolve as diffractively propagating and spreading wave packets as undulations of the space, we call Complex Cosmic Tension Field or C^2TF. These spatially separated linear undulations cannot influence each other [28]. In fact, if one folds one of them back on to the other using a mirror, they would not even perceive each other's presence because of the NIW-principle.

4. A BRIEF HISTORY OF SUBORDIANTION OF IPM-E TO "THEORY & MDM-E ONLY"

We have already underscored that "theory led MDM-E" approach is working, but we have abandoned the key purpose of physics – understanding and visualizing the invisible interaction processes. This has limited the rate of progress in fundamental physics and understanding nature much more deeply that we really are capable of. Let us try to understand our move away from IPM-E by using a few selective historical cases.

4.1. Early physics; up to 1850.

Ptolemy's (100-170) Geocentric model falls in the IPM-E domain, even though he tried to place humans at the center of the universe! Because, that is how the reality appeared to him then and it still does so to us today until we are exposed to diverse observations whose logical congruency demands a heliocentric model for our planetary system. However, our religious culture has succeeded in instilling in us some epistemological *Human-Centricity* in general and a bias towards mathematical *Harmony and Spherical Symmetry*. A "wiggle" in the motion of the Mars, as observed from the earth, was explained as secondary circular motion of Mars around an imagined center to match the observed "wiggle". Thus, a modern theoretician would have needed only nine *free parameters* to explain most of the easily observable planetary motions. It is the asymmetry and imbalance between diverse potential gradients around different particles that make the universe continuously evolve.

Copernicus's (1473-1543) appreciated the complexity in the observational data for our planetary system and introduced a better model with better mathematics. Guided by mathematics, IPME-and MDM-E started becoming synergistic tools for doing science. Slowly the Geo-centricity began to be replaced by Heliocentricity, but far from being universally accepted! More precise data were gathered by Tyco Brahe (1546-1601) and still the epistemology of *Homocentricity* prevailed! Kepler (1571-1630) formulated three empirical laws for the planetary motion that can be validated by meticulous observations; one of them being the elliptical orbits for the planets around the Sun. He thus assured the removal of humans from the center of the universe, & (ii) the importance of continuously advancing data gathering technologies. Kepler's meticulous work paved the way for Newton (1642-1727) to demonstrate the power and elegance of mathematics by proposing the famous inverse-square law of Gravitation! Differential Calculus easily and elegantly validated Kepler's three laws of planetary motions. MDM-E started to take a dominant role in physics. Newton struggled to explain how the Sun keeps a hold onto Earth at such an enormous distance. The concept about the vast cosmic space remained unsettled, as it is today, but the concept of ether as the space filling substance started emerging.

4.2. Beginning of modern physics; 1850 and forward

Let us fast forward by another century. Maxwell (1831-1879) showed that all the separately experimentally developed laws of electrostatics & magneto statics can be merged and presented together as a set of four differential equations, which, with some brilliant manipulation of the rules of calculus, proves that electromagnetic waves is a result of synthesis of electricity and magnetism. Light is a propagating wave. If it propagates through the vast cosmic space
Then it must be some complex tension field to sustain the propagation of the waves! After all, the velocity of light is determined by two measured properties of free space, $c^2 = 1/\varepsilon_0\mu_0$, the dielectric constant and the magnetic permeability! MDM-E and IPM-E appeared to be inseparable thinking tools. Michelson (1852-1931) initiated the efforts to detect ether earnestly. But his efforts to prove the existence of ether through optical interferometry turned out to be a failure.

4.3. Early 1900

During the last quarter of the 1800's and the first quarter of 1900's saw a very rapid shift in our scientific thinking. Skilful mathematical theory development supported by MDM-E, started effectively downgrading the synergistic need for IPM-E. Planck in 1900 applied his mathematical skills to model meticulously measured data on blackbody radiation and found an elegant mathematical expression implying that EM radiations are definitely exchanged (emitted and absorbed) by the blackbody cavity as distinct energy packets. Plank himself held on to his model of light as waves, explaining that it is only atoms and molecules that exchange energies in discrete packets. This was most likely inspired by Rydberg-Ritz empirical formula on atomic spectroscopic data that already implied some form of quantization or discreteness in the frequencies of light emitted by atoms. However, Einstein thought otherwise and presented in 1905 his theory of photo electricity by proposing that light always remains as discrete indivisible quantized packets, which was later named as photon. Indivisible-photon model still dominates our current epistemology even though it has been repeatedly validated that the semi-classical model (light as waves and detectors as quantized) explains all the observed experiments [9,10].

4.3.1. Relativity: As if the photoelectric theory was not enough, Einstein presented the Special Relativity (SR) in the same year of 1905 to resolve the absence of a detectable cosmic medium so his photons can travel at the highest speed as a particle without the need of a supporting medium. IPM-E was about to become irrelevant in scientific thinking within about a decade. Its last *hurrah* was in 1913 when Bohr used IPM-E and gave us the *map* of electron orbits with quantized angular momentum around a proton to describe Hydrogen atom. Unfortunately, Bohr's model could not advance since it could not be generalized for more complex atoms. In the mean time, SR had been drawing serious attentions from all physicists as its formulation continued to validate all measured data. SR has revolutionized the very foundation of physics-thinking as our observed universe has become, as per SR, a space-time four dimensional universe.

The concept of 4D universe was further strengthened by Einstein with his General Relativity of 1916 where the gravitational force became space-time curvature. Neither of these theories of relativity allows very string IPM-E inquiry into them. IPM-E requires that the key parameters of a successful theory must be directly measurable using some interaction processes in nature. Unfortunately, the running time t is not a physical parameter of anything that we can directly measure. What we measure is the frequency of some entity that executes harmonic oscillation. We invert the measured frequency v and then define it as the period of the oscillation, $\delta t = 1/v$. Thus, we can only measure time as *intervals*; but even that is through the physical property of some other physically observable entity. Of course, we can measure space also only in terms of *intervals* of some physical scale we choose. The significance of this point is obvious from the fact that we know how to physically alter both the physical length of a reference scale and a reference frequency of oscillation. But we do not know how to physically alter, quantify and measure the physical 3D space, or 4D space-time. Should physical theories be considered final even when they are founded on a parameter that is not directly measurable? Should we then consider the concept of 4D space-time as the final reality of our cosmic system? The idea is not to discard theories of relativity, but to promote logic based debating platform that can keep us moving in the right direction regarding our map of the universe. Otherwise we might get lost in elegant theories without knowing how to get out of them, if need be.

Limiting particle velocity: Consider the hypothesis of limiting velocity for light by Einstein. Based on our C^{2}TF proposal, it is obvious that the velocity of light cannot exceed $c = \left|\varepsilon_0 \mu_0\right|^{-1/2}$, because it is the tension-restoration force of a medium that determines the wave velocity in it. However, our IPM-E thinking and the existence of particles as local resonances of C^{2}TF do not make it obvious that $\mathrm{v} \le c$ has to be the limiting velocity for particles. In SR it is derived from $m_{\mathrm{v}} = m_0[1 - \mathrm{v}^2 / c^2]^{-1/2}$, which implies that m_{v} will be infinity, hence limiting, when v approaches c. But, by Einstein's own famous relation on mass-energy equivalence, $m_0 = E_0 / c^2$, mass is only a behavioral quality, we call inertia of motion of a particles when a force field pushes or pulls it. In our C^{2}TF model, we have already posited that E_0 is the rest energy of a resonant particle oscillation. It can gather kinetic energy only when it is influenced by interaction between the mutual non-linear potential curvatures surrounding each other; of course, the gradients have to be compatible to influence each other. In this model we do not see the direct connection with the limiting velocity of light, c. However, ε_0 and μ_0 are two of the many intrinsic tension characteristics of C^{2}TF. So, the very existence of a resonant oscillation (particle) will modify local values of ε_0 and μ_0 in its immediate vicinity. But, we have already posited that such nonlinear changes actually correspond to various potential gradients (forces) into which they make other

particles *fall*. In particle accelerators, the particles are made to fall, not through a single big continuous potential gradient, but through innumerable repeated smaller gradients, which could be made even more numerous. So, the only physical cause for a limiting velocity v_{limit} will be that when the intrinsic inertia of motion experienced by the particle inside C^2TF makes it break down its resonant oscillation and become new particles, which will experience less inertial resistance by C^2TF. It then makes sense that we observe innumerable transient (very short lived) particles in very high energy accelerator collisions, which eventually decay into stable resonances. It is the stable resonances that make the material universe evolve *slowly* allowing biological evolutions and deserve more attention from us!

4.4. 1925 and forward

The formulation of Quantum Mechanics (QM) was presented in two different forms by Heisenberg (matrix) and Schrödinger (wave eq.) in1925. Schrodinger's attempts to preserve mapping natural processes through representing particles as "waves"(a la de Broglie) got only lip-service because his wave function was interpreted more as a mathematical probability amplitude, but not as something that can be directly measured. Surprisingly, Bohr became the strongest proponent of *theory+MDM-E* only; no need to visualize the micro universe. Interpretation of QM, known as the Copenhagen Interpretation, is basically Bohr's epistemology. Copenhagen Interpretation still prevails today because the original QM formulation provided us with enormous successes in predicting and experimentally validating the micro world of atoms and elementary particles. It has become fashionable to quote Feynman, another giant contributor to quantum physics, "Nobody understands Quantum mechanics!", to glamorize *theory+MDM-E* minus IPM-E is the best way to do physics, because it works. Mathematical model reigns supreme! We should *compute* and not waste our time to visualize and map the micro universe like we did in Classical Physics!

We believe that if we insist on applying IPM-E, we should be able to find out the physical processes behind our working theories and at the same time understand their limitation, which will then give us a better platform to iteratively improve/correct our existing theories. Or, find logical platform to propose new fundamental hypothesis. After all, our evolutionary journey requires us to keep on perfecting the map of the universe, so we do not get stuck in one blind alley.

4.4.1. From particle-paradigm to field-paradigm: We have mentioned earlier, that almost every single major successful theory of physics indicates that the cosmic space is not empty; it has rich properties. Surprisingly, most of our successful theories also are essentially field theories. Even QM and their extensions find *various concepts of fields* are unavoidable. Even though Einstein's successful relation $m = E / c^2 = E\varepsilon_0\mu_0$ implies that the origin of mass lies with the electromagnetic properties of the space, we are still looking for a massive Higg's Boson.

We can clearly appreciate the root of *particle-paradigm.* The manifest material universe does appear to be built out of impenetrable localized particles and their assemblies of various sizes, from atoms to galaxies. But, why are we so reluctant to accept the guidance we are getting from our successful mathematical logics, invented by our own collective human logics, which are clearly capturing many of the operational cosmic logics? Do we think that successful mathematical *fields* are merely helping tools and do not capture any physical realities of any physical interaction processes going on in the material universe? Are our theories meant only to model experimental data (MDM-E); but not the physical interaction processes that give rise to those data (IPM-E)? So, the author has made a serious attempt in proposing a *field-paradigm* that the manifest universe is built out of a Complex Cosmic Tension Field (C^2TF), which really is our cosmic space [29]. EM waves are propagating sinusoidal undulations of the C^2TF and the particles are 3D stable resonant harmonic but complex non-linear undulations of the same C^2TF. The various forces are secondary potential gradients imposed on the C^2TF around them by virtue of their undulations.

5. EVOLUTIONARY SUCCESS & OUR SUBJECTIVE THINKING PROPENSITY

Our homocentric brain is still dictated by 3B years' of cumulative success steps! To over-ride that trend and to become fully objective, we must first learn to identify how much of our current thinking is still driven by our evolutionary biology. Objective analysis and functional protocols of our neural network have only started; we are still far from understanding our neural system. Most humans still believe that our *consciousness* is super natural, which all other species are deprived of. We are still reluctant to accept that our minds, our mode of thinking, our epistemology, all are re-programmable software *Version3.5B+xx.yrs* embedded in a uniquely personal genome, guided by the biological *hard disc*, we call neural connectome! The dominant purpose of the connectome is to survive indefinitely through self-procreations. But we need to keep on inventing diverse technological tools for this purpose. Understanding deeper reality

of nature is only a derivative of our conscious mind for innovations, which requires conscious programming of the connectome with appropriate epistemology using the segment of our brain that is free to be visionary; is free to imagine and create new things beyond our immediate survival needs!

Attempts to stand outside of ourselves and observing ourselves interacting with the real world, using the same connectome, is a difficult but a must-do task! We must learn to critically evaluate the biological processes behind our perceptions and interpretations by *consciously framing and re-framing our questions* iteratively, again and again. Framing the questions dictate the answers that we can extract out of nature! So, we must learn to de-construct and re-construct our theories, instead of settling with a *set of final theories* like our religious counterparts have already done!

If we frame questions emotionally out of infallible reverence to some perceived god, while ignoring our slow but steady progress in understanding working rules of this universe, we create diverse religions. If we frame visionary but intellectual questions as to the meaning and purpose of the universe and our role in it, and try to find the answer without systematic experiments, we create philosophies. These are excellent tools for maintaining political order in complex human societies. But these endeavors do not necessarily assure our sustainable evolution. When we frame questions to understand and visualize the physical processes in natural phenomena, we succeed in emulating and/or modifying the processes to invent new tools as engineers. When we frame questions to find the universal cosmic rules behind diverse observable natural phenomena, we develop theories that can predict future behaviors in nature. We become scientists and in collaboration with the engineers, we can become master of the biosphere and assure our sustainable evolution. However, even scientists need to re-frame their questions as our understanding of the nature advances based on which parameters in our working theories represent primary physical parameter that we can measure directly; and which parameters represent physical variables indirectly due to the theoretical construction. Such questions are relevant to assure that we are modeling real physical parameters of nature, rather than some perceived parameter that brings harmony in a theory. For example, that time is not a physical parameter of any object, has been mentioned earlier. But our biological experience of life and death convinces us otherwise.

5.1. Recognizing our subjective interpretation and thinking driven by our evolutionary successes

Understanding the ultimate *reality* is very elusive & very difficult in contrast to our genetically programmed perception and interpretation about it! The evolution, growth and the strength of our inquiring and independent mind need to be consciously nurtured to assure objective interpretation of what we hear, smell, taste, touch and see. We grow up accepting the interpretations of the various sensorial inputs to our neural networks as *objective* information since they usually corroborate to a consistently reproducible, albeit only perceived *reality*. We keep on living with these perceived *realities* quite comfortably even after we grow up and learn that (i) molecules do not possess any objective properties like smells and tastes; (ii) vibrating air molecules, producing sounds, do not possess any intrinsic objective property we call melodies; (iii) light making images of flowers, fruits and leaves on our retina do not possess any intrinsic objective property we call colors. All these interpretations are learned-response made by our genomically entrained neural network for quick response to the external world for our evolutionary successes. Of course, the transformational signals received by the brain are essentially real, reproducible and are based on actual interactions and energy exchange between our sensorial molecules and the external agents. Our nose and tongue possess pre-designed molecular *grooves*, connected with nerve endings, to identify various smells and tastes of molecules that fit into them perfectly. The interpretation of melody is made by our brain based on the complex electrical signals it receives from the resonant hair-cells in our inner ears, which are stimulated by alternate compression and rarefaction of air (sound waves) reaching our ears. [It is the NIW-principle that allows us to enjoy all the distinctively different tones of a vast orchestra. The resonant hair cells can pick up the undisturbed frequencies of different musical instruments co-propagating through the same volume of air.] The interpretation of colors is also a vivid imagination of our brains. The objective property of light is their frequency of vibration. Our retina possesses mosaic of molecules sensitive to three bands of frequencies that humans have named red, green and blue. Each individual brain creates its own definition of diverse shades of colors based on the combination of strengths of signals coming from the red, green and blue retinal molecules. Fortunately, most of us, more or less, agree with our individual definitions of the shades of colors we observe; and hence only a few of us are declared *color blind*!

If we pay further careful attention to the deep and subtle link between our complex emotional patterns and thinking [30-32], and hence the interpretations we make, we can appreciate that maintaining a completely unbiased and perfectly objective and scientific view of the world is not a spontaneous faculty that is encouraged by our society. In fact, a person with a consistent objective scientific outlook about everything will appear as a rather unsocial species among her relatives and friends. Our survival will be threatened if our brain suddenly starts to interpret everything as an objective scientist. The whole world will literally appear *upside down* since the image on our retina is inverted!

The philosophical notion that observer determines the outcome of an observation is an issue that must be dissected rationally. If our sensorial system, not our cerebral interpretation of already registered data, is not directly involved in generating the measured transformation, then we have not *determined* or influenced the observed transformation. The rainbow in the sky is an excellent example to appreciate the point. The magnificent vibrant color of a rainbow in the sky is a pure figment of imagination (interpretation) by our evolved brain. Further, the objective existence of the rainbow is not in the water droplets in the cloud in the sky. Only an imaging device, like our eyes or a camera, with red-green-blue frequency sensitivity, can register a rainbow. But the dispersion (angular separation) of the red-green-blue frequencies of the Sun light is created by dispersive refraction through water droplets, which must have right size in the right kind of cloud and the Sun must be in the right position and angle with respect to the observer. This is the objective reality. However, without a color sensitive imaging device, rainbows do not exist! This is why no one ever succeeded in recovering the *pot of gold at the end of the rainbow*!

The universe is *real* and we are all *real* people! However, the *reality interpretations* we create out of our *perceptions* are uniquely personal (very much like color perceptions and color blindness). When we find *statistical agreement* with many others about such *personal realities*, we start assuming that they are the *ultimate realities.*

5.2. Have we invented all the ultimate mathematical logics to map the cosmic logics?

From our history of successes we already know that mathematics is the best logical tool to explore cosmic logics. The question is whether our current mathematical tool chest represents a complete set necessary to unravel all the cosmic logics. Still, we must ask: Are the human-logics-invented current mathematical logics the final ones for perpetual human evolution? Should we stay with the current mathematical logics and assume that we do not need to nurture our brains for any further evolutionary advancement?

Consider two simple cases from our biological world. An archer fish, with its tiny fish-brain, observes a cricket, a potentially juicy food on a leaf above water. It is swimming around to find a strategic location to shoot down the cricket. It aims at the cricket, which may also be crawling. Then it shoots a projectile of water and succeeds in making the cricket go off-balance and fall in water. Then it enjoys some fresh food. Or, consider a famous basket ball player to score a basket; the brain is huge compared to that of a finger-size archer fish. While jumping up with the ball, he is tackled and begins to fall down. During his falling motion he succeeds in throwing the ball with the right velocity at the correct angle and it falls through the basket-hoop. The question to the reader is this: Are both the tiny fish-brain and the huge human-

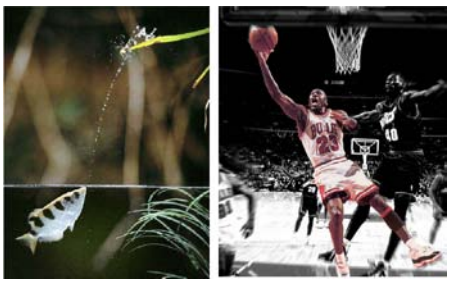

Figure 4. Do intelligent biological systems really solve Newton's laws of motion of parabolic curve under gravity or employ some other complex logics? An archer fish and a basket ball player make their living by being extremely successful in throwing their *projectiles* inspite of complex and rapidly time-varying initial conditions! [Photos copied from the web.]

brain assessing quantitatively all the necessary parameters, which are all varying with time as everything is dynamic, and then calculate the necessary initial velocity and angle at the very moment of shooting the projectile such that the projectile follow Newton's parabolic path and reach the desired target? Or, do their biological neural networks use some very different computational logic(s) for their successes? Their endeavors are reproducible and very accurate like Newton's projectile! Such examples in the biological worlds, from single-cell bacteria to genius artists and music composers to idiot savants, all do fascinatingly accurate quantitative assessments in their endeavors, which we still do not understand.

We have been achieving great successes since Descartes introduced the reductionist method of modeling natural phenomena and we have continued inventing diverse mathematical logics that have been fitting reductionism. The recent explosion of knowledge about the biological world has come about dominantly because of our rapid inventions of a wide variety of extremely powerful and accurate experimental tools to peer into the biological world. We have been

discovering a wide variety of rules of the very complex biological world, which can only be described as emergent rules (properties) of complex system. We have been unable to successfully apply or reductionism methods to explain these emergent phenomena. The best example, of course, is the emergence of consciousness. We know that all of our physical functions are ultimately based upon (emerge out of) interactions between various molecules in our body. Our QM can model some molecules, but it cannot model the emergence of consciousness. If the molecules become dysfunctional, the organ, or even the whole body dies. Should the epistemology of emergentism stimulate our theoreticians to engage in inventing a whole new direction of mathematical logics? May be, then eventually we will learn to logically and iteratively move between reductionist mathematics and emergentist mathematics and start unraveling the cosmic logics behind complex phenomena.

5.3. Road to consciously develop a consistently objective and analytical thinking by following an ultimate purpose

Based on our current knowledge, the external universe has been evolving in a quite orderly fashion for almost 14 billion years. We have arrived in the scene, on the Erath, barely 5 million years ago and the Earth did not exist beyond 4 billion years in the past. Our lack of fathoming the real processes undergoing in the micro universe may appear elusive, but because of lack of our complete knowledge about everything, we must not conclude that the real universe is non-causal, non-local and mystical! It is correct that our interpretations and perceptions of the universe vary from person to person. And the average model that we may agree upon, may vary quite dramatically from those perceived by other species on the Earth, or some other species that may exist on another planetary systems. However, that does not make the universe any less real. The key problem is that we are stuck in gathering knowledge about our universe only in incremental steps. We have already mentioned we are under perpetual information challenge (PIC) because everything in the universe is interconnected and, so far, our best methods of gathering information about anything through reproducible experimentations, never can yield complete information about the interactants we study. This is why none of our theories are final as they are based on incomplete information about the entities being modeled. However, the success stories behind our scientific history tell us that we are learning incrementally more and more about almost everything in this universe as our experimental techniques, along with our human logics and mathematical logics keep on enhancing and broadening. We just need to formulate a logical pattern out of this experience of our incremental advancement. We must learn how to formalize the iteration process of enhancing our scientific theory building technique.

What is the referent platform that will guide our iteration process towards a steady convergence on the cosmic logics that we are after? We believe that *platform* consists of two inseparable parallel efforts. First, we must approach understanding the universe as one inseparable evolving system that is logical and causal. This is somewhat like the grand vision of Einstein, but we must not try to fit everything into a single reductionist bottom-up theory. We must develop a systematic strategy to visualize the universe both from bottom-up (reductionism) and from top-down (emergentism). And then keep on attempting to integrate the two models seamlessly through indefinite iterations. The correctness and the maturity of this $R \rightleftarrows E$ model (Reductionism $\rightleftarrows$ Emergentism) have to be enhanced by implementing IPM-E. That is at every step, we must keep on trying to understand and visualize the interaction processes between the interactants under study. Intellectual humbleness and honesty requires us to recognize that we are like blind people, as in the ancient Indian allegorical story, trying to visualize the cosmic elephant using their personal sensors.

IPM-E has another profoundly important practical consequence. We know that our rapid emergence as the most dominant species on earth has been due to our capability to understand and emulate natural processes and re-organize those processes into new tools and technologies. To prolong our future sustainable evolution, we need to acceleration our technology innovation capabilities further. From the rate of progress in our understanding of the laws of the cosmic system, it is clear that we would need a very long time to completely and accurately visualize the Cosmic Elephant. In other words, we have a collective purpose for our scientific endeavors: We assure our sustainable evolution by employing IPM-E, which also keeps us in the right track to iteratively correct/improve upon our $R \rightleftarrows E$ model and, hopefully, we will eventually reach our nirvana and visualize and understand the Cosmic Elephant in vivid detail!

6. SUMMARY AND CONCLUSIONS

Based on our propensity for subjecting interpretation of the material universe due to our hard-wired genomic programming acquired through biological evolutionary successes, we need to develop a thinking strategy that can help us overcome this innate subjectivity. We all do thinking and theorizing, but without consciously identifying our individual methodology of thinking (epistemology), which vary from culture to culture and person to person. We have proposed the *Interaction Process Mapping Epistemology* (IPM-E) that provides us with a referent platform, both (i) for iteratively

refine/correct working theories as our measurement technologies and (ii) for enhancing our technology innovation capabilities through the emulation of interaction processes in nature. *Measurable Data Modeling Epistemology* (MDM-E) has been the prevailing mode of doing science for several centuries, empowered by outstanding series of successes in constructing theories. We believe that MDM-E must remain as the key first step of doing all sciences on which IPM-E must ride to facilitate aforementioned visualization of the interaction processes and iterative improvements of the working theories.

To validate the strength of IPM-E, we have used this method of thinking to analyze the steps behind the Measurement Problem and discovered one critical thinking issue and one neglected principle of nature. The first one is the *Perpetual Information Challenge* (PIC) signifying that we can never gather complete information about anything under study through any number of experiments. This gap of absence of information cannot be solved by elegant mathematical theorems. Iterative application of IPM-E on all working theories is the best strategy.

The neglected principle is the NIW-Principle (Non-Interaction of Waves) valid for all waves. For many light-matter interaction phenomena in classical and quantum optics, we have given very brief summary comments as to how these phenomena require critical revisit to extract better understanding and, of course, extract interaction process maps to promote technology innovations.

We would like to conclude by connecting human scientific endeavors with the desires of the average members of the human species. We like to live enjoyable and purposeful lives. This is clear from diverse human cultures evolving through hundreds of thousands of years. The free and creative component of the human brain, much larger in size compared to other species, is now being controlled and guided by human cultures, differently by different cultures, many a times within the same country. Thus, human cultures have taken over the role of the direction of human evolution. Unfortunately, we have not succeeded in developing a global vision for the purpose of our successful and collective evolution from within the domain of diverse cultures. Sustainability of the biospheric lives relies upon astounding diversity of specie, from single-cell bacteria to trillion-cell humans, living symbiotically and synergistically. The author believes that the PIC implies that we must also nurture diversity in our conceptual and theoretical ideas to assure the sustainability of the evolution of our scientific enterprise through symbiosis and synergy. But all the diversity of concepts must conform to the higher purpose of collective and sustainable biological evolution. This must be the reason why one set of members of the human species devote themselves for the purpose of understanding cosmic logics, while various other sets of members devote themselves to other diverse purposes, like more immediate physical well being and other complementary needs.

We believe that it is time for us to make a conscious cultural paradigm shift and redirect our evolution, from unconscious biological evolution to conscious & purposeful vision-directed evolution. It is time to recognize that the SAFE-ty of our sustained evolution depends upon recognizing the biospheric and socio-economic interdependence and concomitant collective evolution by implementing Self Actualization for Everybody (SAFE) as an essential tool to bring biospheric harmony [32]. We already recognize that our scientific enterprise is inseparable from our politico-economic enterprise. It also is time to recognize that we must overcome our *Messiah-Complex*, which served us well for the last several thousand years!

The modern scientific enterprise being a surviving profession for all scientists, it is time for our knowledge gate-keepers to inspire the next generation of our graduate students by making some declarations openly, sincerely and persuasively: (i) That the basic structure of the edifice of science has not yet been finalized. (ii) That the foundational logical stones (hypotheses) of our successful theories are not perfectly integrating with the universal substrate of cosmic logics. This is true inspite of the staggering successes of these theories in helping us peer deep into both the complexities of the macro and micro universes [1-8]. (ii) That they have the bright future of re-building physics from the bottom up starting from the days of Galileo. (iii) That they have the responsibility to learn to respectfully *climb on the shoulders of all the giant thinkers* and emulate their legacy of critical evaluation of the preceding theories even when those appeared to be working. Because bowing down at their feet out of our personal blinding reverence will only constrain our vision and hence endanger further evolution of our innate power of critical thinking; rather than engendering discovery of new science and technologies, and hence our sustainable evolution!

7. REFERENCES

[1] F. Wilczek, [The lightness of being: mass, ether, and the unification of forces], Basic Books (2010).
[2] L. Smolin, [Trouble with Physics], Houghton Mifflin (2006).
[3] R. Laughlin, [A Different Universe: Reinventing Physics from the Bottom Down], Basic Book (2006).
[4] R. Penrose, [Road to Reality], Alfred Knopf (2005).

[5] M. Gleiser, [A tear at the edge of creation], Free Press (2010).
[6] P. Davies and N. H. Gregersen, [Information and the nature of reality], Cambridge U. Press (2010).
[7] N. C. Panda, [Maya in Physics], Motilal Banarsidass Publishers (1999).
[8] T. Silverman, [Philosophical Solutions: In Physics, Mathematics and the Science of Sentience], International Institute for Advanced Studies (2010).
[9] E. T. Jaynes, "Is QED Necessary?" p. 21 in *Proceedings of the Second Rochester Conference on Coherence and Quantum Optics*, L. Mandel and E. Wolf (eds.), Plenum, New York, 1966. See also: Jaynes, E. T., and F. W. Cummings, "Comparison of Quantum and Semiclassical Radiation Theory with Application to the Beam Maser"; http://bayes.wustl.edu/etj/node1.html#quantum.beats; Proc. IEEE. **51,** 89 (1063).
[10] W. E. Lamb and M. O. Scully, "The Photoelectric Effect without Photons", pp363-369, in *Polarization, matter and radiation*; Jubilee volume in honor of Alfred Kastler, Presses Universitaires de France, Paris (1969). See also W. E. Lamb, "Anti-photon"; Appl. Phys. **B60**, p77-84 (1995); can be found in W. E. Lamb, *Interpretation of Quantum Mechanics*, Rinton Press (2001).
[11] C. Roychoudhuri, "Inevitable incompleteness of all theories: an epistemology to continuously refine human logics towards cosmic logics"; Ch.6 in *The Nature of Light: What is a Photon?* by C. Roychoudhuri, A. F. Kracklauer & Kathy Creath; CRC/Taylor & Francis (2008).
[12] A. D. Aczel, God's Equation, Four Walls Eight Windows (1999)
[13] M. Livio, *Is God a Mathematician?* Simon and Schuster (2009).
[14] C. Roychoudhuri, "Can photo sensors help us understand the intrinsic differences between quantum and classical statistical behavior?", pp.167-177, in "Foundations of probability and physics-5"; AIP Conf. Proc.**1101** (2009).
[15] Yoh Tanimoto, "Noninteraction of waves in two-dimensional conformal field theory"; arXiv:1107.2662v1 (2011).
[16] P. J. Boyd, "The noninteraction of waves with the zonally averaged flow on a spherical earth and the interrelationships on eddy fluxes of energy, heat, momentum"; J. Atmos. Sci. 33, 2285-2291 (1976).
[17] C. Roychoudhuri, "Principle of non-interaction of waves"; doi:10.1117/1.3467504; J. Nanophoton., Vol. **4**, 043512 (2010). See also DongIk Lee and C. Roychoudhuri, "Measuring properties of superposed light beams carrying different frequencies"; http://www.opticsexpress.org/abstract.cfm?URI=OPEX-11-8-944 ; Optics Express **11**(8), 944-51, (2003).
[18] C. Roychoudhuri, "Why we need to continue the 'What is a Photon?' conference? To re-vitalize classical and quantum optics"; keynote presentation; SPIE Conf. Proc. Vol. **7421**-28 (2009).
[19] C. Roychoudhuri, "Re-interpreting *coherence* in light of Non-Interaction of Waves, or the NIW-Principle"; in this volume; SPIE Conf. Proc. Vol.**8121**-44 (2011).
[20] C. Roychoudhuri, "Propagating Fourier frequencies vs. carrier frequency of a pulse through spectrometers and other media", SPIE Conf. Proc. Vol. **5531**, pp.450-461 (2004).
[21] C. Roychoudhuri and A. Michael Barootkoob, "Generalized quantitative approach to two-beam fringe visibility (coherence) with different polarizations and frequencies"; SPIE Conf. Proc. Vol.**7063**-4 (2008).
[22] C. Roychoudhuri, "Various Ambiguities in Generating and Reconstructing Laser Pulse Parameters"; see section 3; Ch.7 in *Laser Pulse Phenomena and Applications*; Ed. F. J. Duarte; InTech (2010).
[23] C. Roychoudhuri, N. Tirfessa, C. Kelley & R. Crudo; "If EM fields do not operate on each other, why do we need many modes and large gain bandwidth to generate short pulses?" SPIE Conf. Proc.Vol.**6468**-53 (2007).
[24] A. Muthukrishnan & C. Roychoudhuri, "Indivisibility of the Photon"; Proc. SPIE Vol. **7421**-4 (2009).
[25] N. Tirfessa and C. Roychoudhuri, "Analysis of spectrometric data and detection processes corroborate photons as diffractively evolving wave packets"; in this volume; SPIE Conf. Proc.Vol.**8121**-33 (2011).
[26] C. Roychoudhuri, R. Machorro and M. Cervantes, "Some interference experiments and quantum concepts-II", Boletin Inst. Tonatzintla, Vol.2, June (1976).
[27] J. S. Bell, *Speakable and unspeakable in quantum mechanics*, Cambridge U. Press (1997).
[28] C. Roychoudhuri, "Comments on the panel discussions: Is indivisible single photon really essential for quantum communications, computing and encryption?" SPIE Conf. Proc. Vol. **7421** (2009).
[29] C. Roychoudhuri, "The constancy of "c" everywhere requires the cosmic space to be a stationary and complex tension field"; SPIE Conf. Proc.Vol.**8121**-23 (2011).
[30] K. Richardson; *The Evolution of Intelligent Systems: How Molecules became Minds*; Palgrave Macmillan (2010).
[31] Candace B. Pert; *Molecules of Emotion: The Science Behind Mind-Body Medicine*; Touchstone (1999).
[32] C. Roychoudhuri, "The consilient epistemology: structuring evolution of logical thinking"; *Proc. 1st Interdisciplinary CHESS Interactions Conf.*, chap. 16, Imperial College Press, London (2009).