FQXI-Essay Contest : Is Reality Digital Or Analog?

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Abstract :- Reconciling Digital nature of Reality with its Analog nature is deeply related to the problem of " *Quantum-Gravity* ". If the digital and analog nature of Reality are successfully explained on the basis of a ' common-concept',then the problem of Quantum-Gravity is solved.How this is done is the theme of this article. Digital & Analog Nature of Reality are intrisically related to the structure of Space and Time.

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The Advaitha (Non-Dualism) Of Digital & Analog Nature Of Reality :

Introduction:-It is well known that the physical Reality exhibits both properties,digital and analog.It is digital (discrete or discontinuous)at the micro (or quantum) level and analog (continuous) at the macro (classical) level. Digitality (discreteness) of the quantum world is explained by Quantum-Mechanics (QM). The Analog (or continuous) nature of the classical world is explained by classical physics or General-Relativity (GR). Digital nature of the quantum world is visualized as a result of ' *gaps* ' or ' *discontinuitie*s ' in Space and Time. Analog nature of the classical world is explained on the basis of *continuity* of Space and Time.

Now to explain both forms of Reality on the basis of a common theory leads to the formulation of the theory of Quantum-Gravity (QG) in which both QM and GR are merged and unified. If both forms of Reality are left alone,then we have to accept the *'Duality'* of the Reality. But the nature of the human mind is such that it never rests until it finds some sort of relationship between both,leading to *Non-Dualism* (or *Advaitha* as it is called in Indian philosophy). So the formulation of the theory of Quantum-Gravity ultimately leads to the Advaitha of physics,the dream of the great Einstein.

While discussing the theory of QG,it is essential to discuss the role played by the structure of Space and Time.

The ideas underlying QG are elucidated non-mathematically and it is shown how a mathematical theory of QG can be formulated on the basis of these ideas.

To explain how both forms of Reality (i.e.,Digital & Analog) follow from a basic 'common-concept' ,the concept of "*Acceleration*" (or *'Gravity'*) is treated as the basic 'common-concept' and given utmost importance. It is the role played by 'acceleration' which is central to developing the theory of QG. Because *'acceleration'* plays *'dual-role'* in the quantum and the classical physics. Acceleration is *quantized* in the quantum world and hence represents *quantum of energy* .It is this new concept of *acceleration* in the quantum world which gives new interpretation to QM in addition to the already existing ones.

Ideas used in this article to develop theory of QG,do not take in to consideration ideas from String-Theory,Loop QG, etc. The theory of QG formulated can be tested even at the moleculer and

atomic range down to Planck's length of 10^{-33} cm, convincing any one of the veracity of the theory.

In the macro (classical) world QG effects do exit in Black-Holes. The Black-Hole physics is identified with that of the micro (quantum) world with the help of two laws of QG enunciated here. The path described in QG field is Logarithmic (Equiangular) spiral path by both quantum particles and test-masses of classical size.

Space & Time :- According to the theories of Relativity,Special Relativity (SR) and General Relativity (GR),both Space and Time are relative; Space in itself and Time in itself have no meaning. Space is meaningful only with respect to distance measured between two objects or bodies. Similarly Time is meaningful only with respect to some event happening in time-interval or time-gap measured with the help of a clock. Thus Space and Time form four dimensional Space-Time manifold in which events happen. So, Space and Time are emerging dynamical entities. Where as according to QM, Space and Time are treated as back-ground entities and events are observed as happening in them. So both Space and Time, in QM, are static.

According to GR, Space and Time have structures. So in the gravitational field (described by GR) ,the path described by test-masses is *geodesic* because Space-Time is curved describing geodesic. Thus the structure of Space-Time is determined by the type (or kind) of force acting in it or physical interaction taking place in it. Since there are four fundamental physical forces (Strong, Weak, Electro-Magnetic and Gravitational), Space-Time structures are likely to vary accordingly. But the first three interactions belong to micro (quantum) world and they are explained by QM. The Strong and Weak interactions operate over short distances, so there is no need to study the structure of Space-Time in them; where as Electro-Magnetic (EM) interaction has long range effect and hence Space-Time structure in EM field can be studied.

Dual-Role of Acceleration (or Gravity) in Classical & Quantum Physics:

The conept of *Acceleration* (or *Gravity*) is very important in realizing the theory of QG.The words *acceleration* and *gravity* are synonymously used since the formulation of GR. In classical physics, acceleration is defined as "the rate of change of velocity". So that in uniform accelerated frames, like gravitation, the velocity of a test-mass of classical size changes and consequently its kinetic-energy also changes. This definition of acceleration has been accepted as such in quantum physics. But this is untenable according to the concept of acceleration we have formulated in the quantum world. That is," **Acceleration** (or **Gravity**) is *quantized* and *quantized acceleration* (or *quantized gravity*) is equivalent to *quantum of energy*". If 'E' is the quantized energy and 'a' is the acceleration, then E = ka=kg. Where 'k' is the *quantizing constant* of acceleration or gravity. The value of 'k' is, $k = 3.15 \times 10^{-17}$ gm.cm (in CGS units). The dimension of 'k' is mass x length. If 'k' is expressed in electron-Volt (eV), $k = 2 \times 10^{-5}$ eV/cm/sec^2 . The above concept of acceleration is enunciated as the second law of QG. (Go through my article "New Conceptual foundations for Quantum-Gravity & Quantum-Mechanics", in web site "http://www.sreenath.webs.com" and click on Abstract.) According to this law,there can be change in the 'energy' of a quantum particle *if and only if* there is change in its 'acceleration' and *not* otherwise. So *change* in the *acceleration-state* of a particle is accompanied by corresponding *change*

in its *energy-state* and vice-versa.

Now it is time to know how 'acceleration' exhibits dual-role on the basis of which we can reconcile digital & analog nature of Reality. It is said above that the structure of Space-Time (or Space & Time) depends on the type of physical interaction or force acting in it. Now if the acceleration is uniform as in the case of GR, describing gravitation, the structure of Space-Time is continuous although curved. Test-masses of classical size move *continuously* along the *geodesic* , which is responsible for the 'analog' behaviour of Reality. Where as quantum particles (like ions,molecules,atoms and sub-atomic particles like electron,proton,etc.) also move continuously although they *'float'* in the uniform accelerated field. This is because quantum particles find uniform accelerated (or gravity) field as *uniform* energy field, in which their kinetic-energy remains uniform in contrast to classical test-masses and obey the relation E = ka= 1/2 mv^2 in non-relativistic case and ka = $p^2/2m$ in relativistic case; where 'm' is the mass of the particle and 'v' is its velocity, and 'p' is the momentum possessed by the particle. Now if the acceleration (or gravity) *varies*,let us say *exponentially* as in the case of EM field (*bremsstrahlung*) as well as in the QG field, test-masses of classical size still describe continuous path although in QG field they describe *logarithmic* (or *equiangular*) *spiral path* on a plane or *conical spiral path* in three dimensions as they are subjected to 'Torsion'. (Test-masses of classical size are *unaffected* by the EM field.) But in the above varying accelerated field, quantum particles although move along the logarithmic or conical spiral path, they find *quantum gaps* in Space-Time whenever there is *change in acceleration*. It is the appearence of such quantum-gaps in Space-Time which is responsible for the 'digital' behaviour of quantum particles. In other words, if particles change their acceleration, Spatial and Temporal *gaps* appear and it is acceleration when it *changes* has the *capacity* to produce such gaps in Space and Time thus leading to their discrete or quantized behaviour. In case of *unitary* change in acceleration, as in atomic energy transitions, spacial-gaps at atomic scale appear *singly*. The length of these spacial-gaps is very small (microscopic). The length varies from about 10^{-13} cm to 2.7 x 10^{-2} cm.Where 10^{-13} cm is the minimum length of the gap or *quantum- jump* which will be made by the particle when it undergoes minimum quantum energy transition and 2.7 x 10^{-2} cm is the maximum length of the quantum- jump which will be made by the particle when it undergoes maximum quantum energy transition. Maximum and minimum values of the gaps or lengths are *independent* of the mass of the quantum particles. They remain same irrespective of the mass of the particle which undergoes quantum energy transition and quantum energy transitions vary but only in between these two values of the gap or length. This is how space is quantized in the EM field. Now we can also see why classical test-masses are unaffected by these spatial-gaps all along their motion, for the simple reason that their radius exceeds the maximum value of the spatial-gap i.e. 2.7 x 10^{-2} cm. Even if their radius is smaller than this value, it is impossible to make them undergo quantum energy transitions as the *force* required to produce such effects exceeds by many orders of magnitude the force that is attained in lab currently , because energy to attain would of the order of 10^{16} GeV and higher.

For further details, one can go to my above web-site and see my views on QM.

From the above consideration of the concept of acceleration,it is clear that if the acceleration remains uniform as in classical physics or GR, Space and Time would be continuous and the Reality appears Analog. Where as, if the acceleration varies, Spatial and Temporal gaps appear or discontinuities appear

and the Reality appears Digital or discrete. So 'acceleration' is the *basic unifying concept* which says not only how Reality appears as both digital and analog but also at the same time leads to the unification of quantum forces with the classical force of gravitation ,thereby paving the way for merging QM with GR. It is difficult and almost impossible for anyone associated with the classical definition of acceleration as "rate of change of velocity" to acquaint with or even to accept the new concept of acceleration as *quantum of energy* in quantum physics, because this definition is in direct constrast with the classical definition of acceleration. This is so for the following reason: according to the classical definition of acceleration, the kinetic-energy (KE) and hence the velocity of all test-masses of classical size and micro particles of quantum size,go on increasing in the uniform accelerated field as long as they are subjected to acceleration. But if we accept the new definition of acceleration as quantum of energy in the micro world, we cannot accept the above classical definition for quantum particles (although it is valid for test-masses of classical size) because quantum particles see the uniform accelerated field as uniform energy field and hence there would be no increase in their KE and consequently in velocity as they would remain uniform.So the velocity of quantum particles remains uniform (although it depends on the mass of the particle).

Now we can see the difficulty of accepting the new definition of acceleration in the micro world, if we accept the old definition of acceleration in classical physics. But in overcoming this difficulty or inertia, for accepting new concepts and theories (in this case, new definition of acceleration) lies the solution for unification of not only digital and analog nature of Reality but also of all the four physical interactions (or forces). For any one who has gone through the history of science (especially physics) it is evident that such difficulties arose often since the time of Greeks and then Gelilio and Newton down to Einstein and founders of QM. If we are to solve the problem of QG, it is time that we take such bold and drastic step and look for bright future.

The proof for the second law of QG is given while proposing the theory of QG. So the new concept of acceleration as valid in quantum physics (or micro world) cannot be dismissed

but must be accepted as a fact of Nature. Many of the facts of QM like interference,diffraction,entanglement,etc. have no classical analogues. Similarly,many of the concepts of QM like energy momentum,spin,etc are in direct contrast with the corresponding concepts in the classical physiccs. To this list,we now include "acceleration".

The theory of Quantum-Gravity:

The successful theory of QG must account for all facts of QM and GR by merging (or unifying) The two at all microscopic (quantum) and macroscopic (classical) scales and predict new facts. Here microscopic scale means 'Interaction-range' (Ir) like atomic range, molecular range,nuclear range, electro- weak range,etc. down to planck's length of 10^{-33} cm. Ir varies from 10^{-5} cm to 10^{-33} cm. Classical scale means the radius of 'Black-Holes' (BH) ranging from a certain minimum BH radius of 10^{5} cm upto about $4X10^{17}$ cm. The relationship between quantum physics and classical physics can be established if we take classical objects as Black-Holes *only*. The relationship between BH radius and interaction range (Ir) is

given by the relation $\mathbf{r/R=2\pi G\beta/c^2}$ where r= Interaction range, R=Radius of BH, G=Newton's gravitational constant, c=Velocity of light and β=Bm/r. Bm is the binding- mass of the quantum particle like

e-, p+, w+-, etc. and value of Bm depends on the Ir. But in the above equation it is the binding mass of w+ - particle. β is constant for a particular particle and its dimensions are mass/length (gm/cm). The value of 'β' depends on the rest mass of the particle. For w+- , $\beta = 1.5 \times 10^{-8}$ gm/cm. For p+, $\beta = 1.6 \times 10^{-10}$ gm/cm and for e^-, $\beta = 10^{-13}$ gm/cm.

The value of $r/R = 2\pi G\beta/c^2 = 6.66 \times 10^{-36}$. Where β corresponds to w+- particle and hence $\beta = 1.5 \times 10^{-8}$ gm/cm. This is so because the quantum of energy possessed by w+- particle due to QG force at any Ir is equal to that possessed by BH at the corresponding radius R, according to the above equation. The energy possessed by BH at various radii (R) is given in the **Black-Hole chart** (BH chart) and the corresponding energy possessed by quantum particles is given in **Interaction Table** (IT).

The Laws Of Quantum Gravity

The First Law:

The force of quantum gravity is directly proportional to the product of the two masses and inversely proportional to the square of the distance between them:

i.e. $F_Q = \check{G}\,(Mm/2R^2)$

Where F_Q = Force of quantum gravity operating from the center of mass 'M' to its event-horizon (or surface) where the particle of mass 'm' is present.

M =Mass of the body which has attained its gravitational radius 'R' i.e. 'R' is the radius of the Black-hole (BH), Quasar etc.

m =Mass of the particle (micro) which has manifested itself at the surface of the black-hole of mass 'M'. Due to the gravitational interaction free energy is available at the surface of the Black Hole and 'm' is the mass corresponding to that free energy according to the relation $E = mC^2$.

$\check{G}$ = Constant of Quantum Gravity and $\check{G} = 1.5 \times 10^7$ $cm^3/gm.\ Sec^2$ in CGS units.

The mark 'x' represents the multiplication sign. Thus the value of $\check{G}$ is reciprocal to the value of 'G' the Newtonian Gravitational constant, and having the same dimensions of 'G'.

$\therefore \check{G}G = 1 (Cm^3/gm.\ Sec^2)^2$ and $\check{G}/2G \approx 10^{14}$.

The *second law* is already given.But it is closely related to Planck's law.

Since the energy corresponding to gravity (or acceleration) is quantized, the relation E = kg (or E = ka) may be readily identified with the Planck's relation E = ħν (where ħ = h/2π). Therefore, kg = ka = ħ ν. i.e. $\hbar/k = a/\nu = \check{C}$. Where, Č is another fundamental constant like 'C' the velocity of light and Č also represents velocity. The most important thing is that the value of Č is reciprocal to the value of 'C'. i.e., Č = |1/C|. i.e. CČ = 1 cm^2/sec^2 and Č/C ≈ 10^{-21}, a dimension less number. The value of Č = ħ/k = $1.05x10^{-27}/3.15x10^{-17} = 3.33x10^{-11}$ cm/sec (in cgs units). ∴ ħ = k Č. Hence, 'ħ' and 'k' are intimately related.

As, a = Č ν, the *change* in acceleration 'a' is intimately related to the frequency of the radiation 'ν' emitted corresponding to that. Since ν = C/λ, $g = a = (C\check{C}/\lambda)$ cm/sec^2

Proof of the second law of Quantum Gravity i.e. E = ka

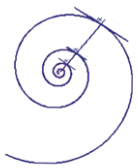
The second law of Quantum Gravity can be proved experimentally in the following way. In the electro static field, the energy 'E' possessed by the electron is given by the equation $E = eU/300$ where e = charge of the electron = $4.8 * 10^{-10}$esu, U = voltage applied in volts and '300' is the conversion factor. So, e/300 = $1.6 * 10^{-12}$ erg = 1ev, therefore E = U ev. If U = 1 volt, E = 1ev; if U = 10^3 volts, E = 10^3ev, now we can equate this equation $E = U\ ev$, with the second law of Quantum Gravity, i.e. E = ka in the form $E = 2\pi ka$ (This is because 'k' is related to ħ, since E is related to 2πħ(i.e. h) often, we got to take 2πk instead of 'k' in such cases). We get 2πka =U ev, i.e. U = $1.25*10^{-4}$a as 'k' is taken in terms of ev i.e., k = $2*10^{-5}$ev/cm/sec^2. But we know that a λ_{min} = CČ = 1 cm^2/sec^2. Substituting in the equation U = $1.25 * 10^{-4}$a, we get U = $1.25 * 10^{-4}$ CČ/λ_{min} i.e. U λ_{min} = $1.25* 10^{-4}$ CČ = $1.25 * 10^{-4}$ volts.cm.

i.e. U λ_{min} = $1.25 * 10^{-4}$ volts.cm.

This is the experimentally established expression for the electron in bremsstrahlung. In the book [1] this equation is given in the form $\lambda_{min}=12390/U$, where λ_{min} is expressed in angstrom. Thus the expression (7) not only confirms the validity of the second law of QG but also at the same time confirms the value of 'k'

= $2*10^{-5}$ ev/cm/sec^2, the quantizing constant of gravity or acceleration. Hence, the equation a λ = ĆČ = 1 cm^2/sec^2 is taken in the form $a\ \lambda_{min} = C\check{C} = 1$, as λ_{min} represents the maximum initial energy 'E' possessed by the electron in bremsstrahlung according to the equation E = hC/ λ_{min}.

Black Hole Dynamics Or Quantum Gravity Field.



While discussing the QG force, it is said that it exists inside BH. The field associated with the QG Force is the QG field. So QG field is limited to objects, which have attained their gravitational radius. Thus the QG field exists inside Black Hole.Since QG field is an exponentially varying accelerated field (EVAF), in which both the gravitational field and the EM field vary exponentially, both gravitational field and the EM Field are intertwined in it and together form the QG field. The equations describing how gravitational field and the EM field are combined in the QG field are similar to the equations describing how electric field and magnetic field are combined to produce EM field in the Maxwell's equations, although there are some fundamental differences between both. The equations describing the QG field are:

div Ģ =$4\pi\ \rho_m$

curl EM. = [(1/-Č) * (dĢ/dt)] + $4\pi\sigma/\check{C}$

div EM = $4\pi\rho_e$

curl Ģ= [(1/Č)(dEM/dt)] + $4\pi j/\check{C}$

Ģ = Gravitational Field strength

ρ_m = Mass density

EM = Electro Magnetic Field Strength

σ = density vector of mass jet.

ρ_e = Charge density

j = Density vector of Electric current.

Ĉ is the velocity encountered in the QG field. It is the minimum change in the velocity or minimum velocity attainable by particles: Č= ħ/k = velocity of the QG field=$3.333*10^{-11}$ cm/sec. In other words, velocity smaller than Č is impossible. If 'C' is upper limit, 'Č' is the lower limit.

The first equation is an inverse square law and also says, "How the gravitational field is related to the distribution of mass". The third equation is also an inverse square law and says, "How EM field is related to the distribution of electric charges". The second equation says "how the rate of change of the gravitational field" at any moment is determined by what are the values of the EM field and the mass-jet are, at that moment. Similarly the 4^{th} equation says "how the rate of change of EM field" at any moment is determined by what are the values of the gravitational field and the electric current are at that moment.

It is the second law of QG, which plays the central role in combining varying gravitational force (GF) with other types of forces such as EM, EW, and GUTs etc. Because it is the varying acceleration (or gravity) which represents the strength of the GF (or G force) on the one hand and also strength of the quanta of energies of EM, weak, strong, GUTs etc. fields (or forces) on the other hand. Thus it is the second law of QG, which has made it possible to unify GF with the other types of forces.

Conclusion: If we develop the theory of QG on the lines envisaged in this article, we can see how powerful the force of QG is and how it powers the Black-Holes thus making them centres of energy productions in the universe and at the same time explaining the mystery behind exotic energy emitting sources in the cosmos. Besides these, it can also explain the problem of Dark-matter and Dark-energy along with apparent expansion of the universe. At last, we see how digital and analog nature of Reality are blended by the new definition of acceleration along with its old one, leading to the formulation of the theory of QG.

References:

[1] Savelyev I V 1981 *Physics-A General Course* vol 3(Moscow: MIR publishers) p36

[2]G. Lambiase, Gen. Rel. Grav. 34 (2002) 1437

[3]B. d'Espagnat, "The quantum theory and reality," *Scientific American* 241(5), 158-181 (November 1979)

[4]J D Jackson *Classical Electrodynamics* (Wiley, New York, 1962).

[5]Eric W. Weisstein, "Golden Ratio" From *MathWorld*--A Wolfram Web Resource

[6]http://www.amazon.com/Gravitation-Cosmology-Principles-Applications-Relativity/dp/0471925675/ref=cm_lmf_tit_2

[7]CONNECTIONS IN CLASSICAL AND QUANTUM FIELD THEORY

by L Mangiarotti (University of Camerino, Italy) & G Sardanashvily (Moscow State University, Russia

[8]ARROW OF TIME AND REALITY: IN SEARCH OF A CONCILIATION

by Anne Magnon (Universite Blaise-Pascal, France)

End Note: Black-Hole Chart is given.

Table 1. *Black Hole Chart (BH Chart).*

The units are expressed in CGSE system and the Energy in Electron volt (ev).

Range or Radius of BH in macro world 'R' in cms.	Corresponding mass (M) of the BH $M=(C^2/2G)$ R gms $=6.75*10^{27}R$	Quantum of energy (E_Q) possessed due to QG force; $E_Q = \check{G}kC^2/4GR$ ev $= 10^{30}/R$ ev	Free energy/ self –energy in ev Quantum of energy (E_N) possessed due to gravitational force; $E_N= kC^2/2R=10^{16}/R$ev
10^5 cm	$6.75*10^{32}$ gm	10^{25} ev (10^{16}Gev)	10^{11}ev (10^2Gev)
10^6	$6.75*10^{33}$	10^{24}	10^{10}
10^7	$6.75*10^{34}$	10^{23}	10^9
10^8	$6.75*10^{35}$	10^{22}	10^8
10^{10} cm	$6.75*10^{37}$ gm	10^{20} ev	10^6 ev.
10^{11}	$6.75*10^{38}$	10^{19}	10^5
10^{13}	$6.75*10^{40}$	10^{17}	10^3
10^{15}	$6.75*10^{42}$	10^{15}	10^1
$3.8*10^{17}$cm	$2.55*10^{45}$ gm	$2.7*10^{12}$ ev	$2.7*10^{-2}$ev
This is the center of the BH chart. The intensity of the interactions increases as we move upwards in the Black Hole Chart.			
10^{19} cm	$6.75*10^{46}$ gm	10^{11} ev	10^{-3} ev
10^{21}	$6.75*10^{48}$	10^9	10^{-5}
10^{23}	$6.75*10^{50}$	10^7	10^{-7}
10^{25}	$6.75*10^{52}$	10^5	10^{-9}
10^{27}	$6.75*10^{54}$	10^3	10^{-11}
10^{28}	$6.75*10^{55}$	10^2	10^{-12}

10^{29}	$6.75*10^{56}$	10^{1}	10^{-13}
$1.5*10^{30}$	10^{58}	$\approx$ 1 ev	10^{-14} ev