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# Global Journal of Science Frontier Research: A

# Physics and Space Science

Outline of Real Physics

Progress in Physics and Cosmology

Highlights

Quantum Set Theory Proposal

Crystallization of Magnetic Moments

Discovering Thoughts, Inventing Future

VOLUME 20 ISSUE 3 VERSION 1.0

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Physics & Space Science

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By F. F. Mende

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*Keywords: magnetic field, magnetic moment, ferromagnetic material, ferrite, magnetic bubble.*

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FORCEDMACROSCOPICCRYSTALLIZATIONOFMAGNETICMOMENTSINTHEFERRITERINGS

*Strictly as per the compliance and regulations of:*

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F. F. Mende

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*Keywords:* *magnetic field, magnetic moment, ferromagnetic material, ferrite, magnetic bubble.*

## I. Introduction

Soft-iron materials these are the materials, which possess the properties the ferromagnetic material or the ferrimagnet, moreover of them the coercive force by the induction comprises not more than 4 kA/m. Such materials also possess the high by magnetic permeability and by low losses on hysteresis. In connection with the smallness of coercive force such materials cannot be magnetized and lose magnetization after the removal from them of magnetic field.

Soft-iron materials are used as the cores the transformers, electromagnets, in the meters and in other cases, where it is necessary with the smallest expenditure of energy to reach the greatest the induction. For decreasing the losses on the eddy currents in the transformers soft-iron materials with that increased are used they are commonly used, by resistivity in the form magnetic circuits, the assembled from separate isolated from each other thin sheets. Sheets are insulated by varnish from each other. This performance of core is called charged.

The soft-iron materials include ferrites, which possess high specific resistance, and they can work at the high frequencies.

However, from the above-indicated rule there are exception. It occurs that the rings, made from soft-iron materials, they can be magnetized, preserving in itself the magnetic induction, with which magnetic lines of force compose the annular circles, inserted in the material of ring. In this case depending on the prehistory of magnetization the direction of magnetic lines of force can be directed both to one and to other side.

The idea of the memory unit in the form of ferrite core matrix for the first time arose in 1945 to the year u John Prespera Ekerta, its report widely circulated among the American computer specialists. In 1949 to the year Van An and In Vaydun - the young colleagues Harvard University Chinese origin- they invented the shift register on the magnetic cores (van named it "the device, which controls the transfer of pulses"-pulse transfer controlling device) and the principle "record - readout- restoration", which made it possible to use cores, whose process of readout destroys information. In October 1949 the year of vans it gave patent application, and was obtained it in 1955 the year 1. To the middle of the 50's of past century the magnetic-core storage already received wide acceptance. Van gave to the law court to IBM, and IBM it was necessary to redeem patent in Vana after $500 000.

Meanwhile, Jay Forrester in Massachusetts Institute of Technology it worked at the computer system Whirlwind ("Vortex"). In 1949 the year, just as in Vana, in Forrester arose the idea about the magnetic-core storage. According to the assertions of Forrester himself, it arrived at this solution independent of of vana. In March 1950 the year Forrester with his command developed the ferrite memory, which works according to the principle of the agreement of currents; the proposed by them diagram with four sensing wires-X, Y, prohibition - became conventional. In May 1951 the year Forrester gave patent application, and was obtained it in 1956 the year 2.

## II. Properties of Ferrite Cores and their use as the Memory Elements

The physical properties of ferrite cores are critically important for the functioning of memory; therefore it is very important to understand them. The diagram of the functioning of memory element on the ferrite core is depicted in Fig. 1.

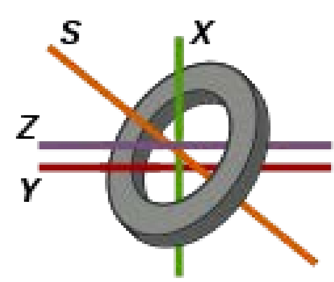


*Fig. 1:* Diagram of the functioning of memory element on the ferrite core

*Author:* *e-mail: fedormende@gmail.com*

The conductors, passing through the core, have the following designation: X, *Y* — the wire of excitation, *S* — readout, *Z* — prohibition.

If heavy current is passed along the wire through the core, then core will be magnetized in accordance with the direction of flow (on to the right-hand rule). Current in one direction will write down into the core "unit", current will in the opposite direction cause opposite magnetization and will write down into the core "zero".

The very important parameter of core is its giserezis: current must exceed the specific threshold in order to influence the magnetization of core. Low current will show no effect, but the current of higher than the specific threshold will lead to the passage into the magnetized state in accordance with the direction of flow.

The property of hysteresis makes the selection of concrete core in the memory system possible. "Half" current is sent along the appropriate wire of excitation X, and "half" current — on the appropriate wire of the excitation Y. Thus, only this only core among thousands of rest will obtain the current, sufficient for changing its state.

Last important property consists in the fact that when the core changes the direction of magnetization, it induces current in the sensing wire, passing through this core. If the direction of magnetization does not change, then there is no current there. This induced current is used for the readout of the state of the bit of memory. As consequence, with the readout of information from the core information is erased and must be rewritten. In Fig. 2 is depicted memory matrix on the magnetic cores.

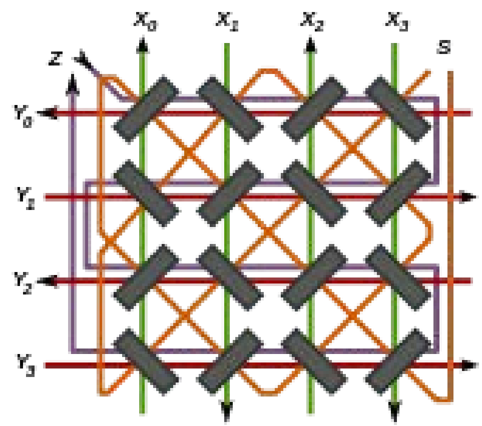


*Fig. 2:* Memory matrix on the magnetic cores

Memory elements on the magnetic cores received wide acceptance in the 60- tenth years of past century. The matrices of ferrite memory and their use in the composition of computers are depicted in Fig. 3-5.

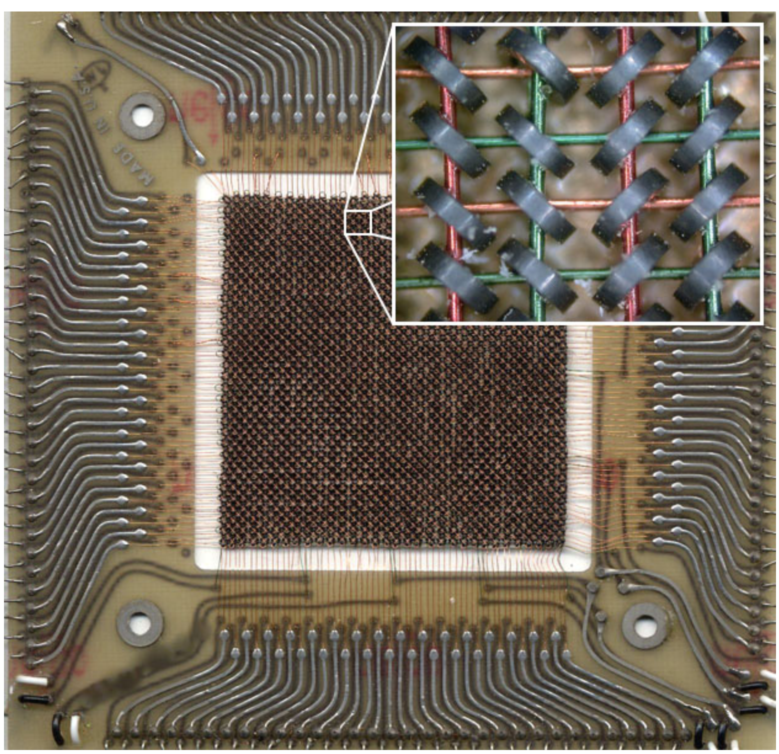

*Fig. 3:* Matrix of the ferrite memory of the super-computer CDC 6600 (1964). Size 10,8×10,8cm, the capacity 4096 the bit

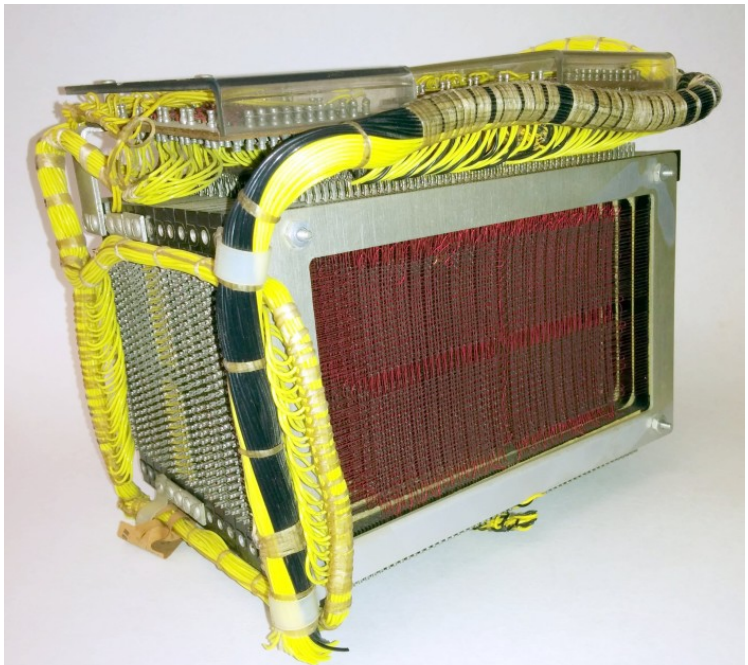

*Fig. 4:* Module of ferrite memory on 4000 symbols in meynfreyme IBM 1401

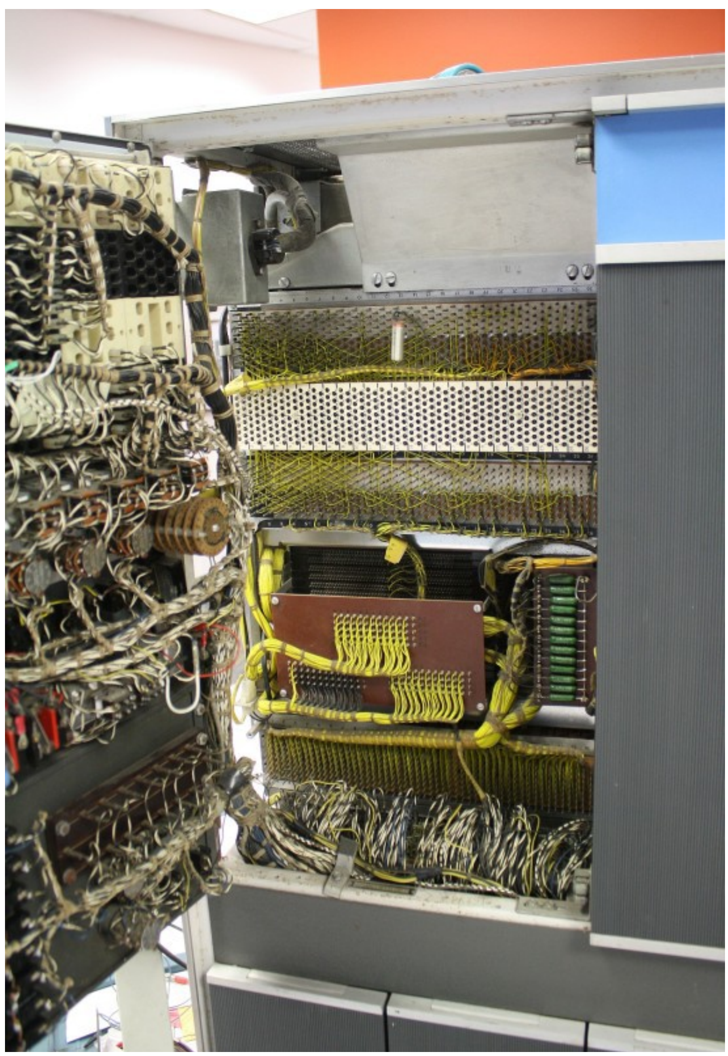

*Fig. 5:* Module of magnetic-core storage (in the center) on meynfreyme 1401

Meynfreym IBM 1401 was developed in 1959 the year, and it became to the middle of the 60th by the most popular computer in the world, considerably anticipating competitors. Special demand it enjoyed in the average and large business, in view of its cheapness. The key factor of success 1401 was its magnetic-core storage (ferrite memory) on 4000 the symbols, where the data were stored on the tiny ferrite rings.

It should be noted that, until now, it is not clear in conclusion, why the ferrite cores, made from soft-iron material, can be magnetized in the determinate direction and the physical mechanism of this process, until now, is not opened.

## III. Self Induction and Energy of the Magnetic Field

Self-induction it is an important special case of the electromagnetic induction, when the changing magnetic flux, which causes the electromotive force (EMF) of induction, is created by current in the outline itself. If current in the outline for some reasons in question changes, then changes the magnetic field of this current, and, therefore, also its own magnetic flux, which penetrates outline. In the outline appears EMF of self-induction, which accordingly to Lentz's rule it prevents a change of the current in the outline.

Its own the magnetic flux $\Phi$, the penetrating outline or coil with the current, is proportional to current strength $I$:

$$\Phi = LI .$$

Constant of proportionality $L$ in this formula it is called by the coefficient of the self-induction or by the inductance coil. As an example let us calculate the inductance of the long solenoid, which has, $N$ turns, sectional area $S$ and the length $l$. The magnetic field of solenoid is determined by the formula

$$B = \mu_0 nI ,$$

where $I$ – current in the solenoid, $n = N/e$ – the number of turns per unit of the length of solenoid.

Magnetic flux, which penetrates everything $N$ the turns of solenoid, it is equal

$$\Phi = BSN = \mu_0 n^2 SlI .$$

Consequently, the inductance of solenoid is equal

$$L = \mu_0 n^2 Sl = \mu_0 n^2 V ,$$

where $V = Sl$ – the volume of the solenoid, in which is concentrated the magnetic field. The obtained result does not consider edge effects; therefore it is approximately valid only for the sufficiently long solenoids. If solenoid is filled with substance s by magnetic permeability $\mu$, that with the assigned current $I$ the induction of magnetic field grows on the module $\mu$; therefore the inductance of coil with the core also increases $\mu$:

$$L_\mu = \mu L = \mu_0 \mu n^2 V .$$

EMF of self-induction, appearing in the coil with the constant value of inductance, accordingly Faraday's law it is equal

$$EMF_{ind} = EMF_L = -\frac{\Delta\Phi}{\Delta t} = -L\frac{\Delta I}{\Delta t} .$$

Magnetic field possesses energy. Similarly, as in the charged capacitor there is it stored up electrical energy, in the coil, over turns of which the current flows, there is it stored up magnetic energy. If we switch on electric lamp in parallel to coil with the large inductance in the electrical direct-current circuit, then with breaking of key is observed the short-term flash of lamp (Fig. 6). Current in circuit appears under the action EMF of self-induction. The source of the energy, which separates in this case in the electrical chain, the magnetic field of coil is.

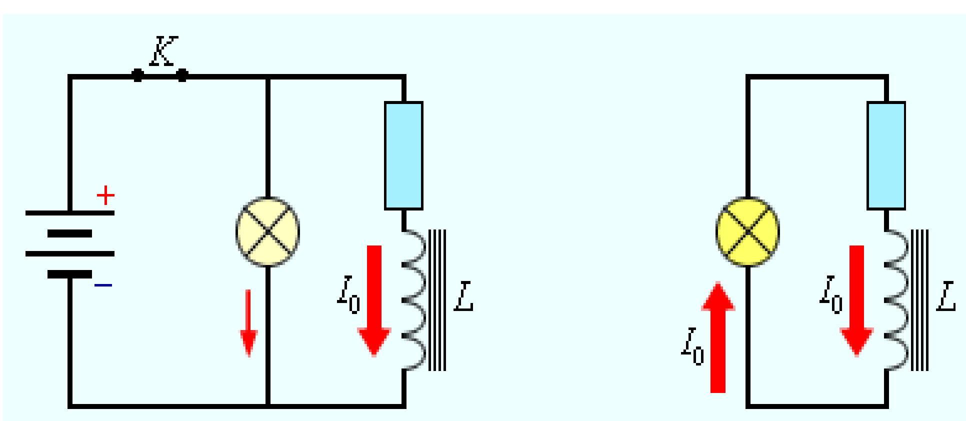


*Fig. 6:* With closing of key k the lamp vividly flares up

It follows from the law of conservation of energy that entire energy, stored up in the coil, will be isolated in the form Joule heat. If we designate through $R$ the impedance of chain, then in the time $\Delta t$ a quantity of the heat will be isolated $\Delta Q = I^2 R \Delta t$.
Current in circuit is equal

$$I = \frac{EMF_L}{R} = -\frac{L}{R}\frac{\Delta I}{\Delta t}.$$

Expression for $\Delta Q$ it is possible to write down in the form

$$\Delta Q = -LI\Delta I = -\Phi(I)\Delta I .$$

In this expression $\Delta I < 0$, and current in circuit gradually diminishes from the initial value $I_0$ to zero. A total quantity of heat, which was isolated in the chain, can be obtained, after performing the operation of integration in the limits from $I_0$ to 0. This it gives

$$Q = \frac{LI_0^2}{2}.$$

Thus, the energy $W_m$ the magnetic field of coil with the inductance $L$, created by the current $I$, it is equal

$$W_M = \frac{\Phi I}{2} = \frac{LI^2}{2} = \frac{\Phi^2}{2L}.$$

Let us apply the obtained expression for the energy of coil to the long solenoid with the magnetic core. Using the formulas for the coefficient of the self-induction given above $L_\mu$ solenoid and for the magnetic field $B$, created by the current $I$, it is possible to obtain:

$$W_M = \frac{\mu_0 \mu n^2 I^2}{2} V = \frac{B^2}{2\mu_0 \mu} V ,$$

where $V$ – the volume of solenoid. This expression shows that magnetic energy is localized not in the turns of the coil, over which the current flows, but it is distributed throughout entire volume, in which is created the magnetic field. Physical quantity

$$W_0 = \frac{B^2}{2\mu_0 \mu}$$

equal to energy of magnetic field per unit of volume, is called with the bulk density of the magnetic energy.

## IV. The Mechanical Analog of the Self-Induction

In the previous division it was shown that the presence of ferromagnetic core in the coil essentially increases its inductance. But physics of this process is nowhere described.

It was considered Until now that energy is determined by those magnetic fields, which are connected with the inductance. Let us describe the mechanism, which explains this phenomenon (Fig. 7).

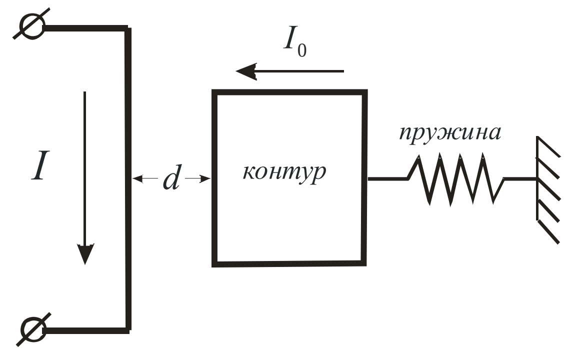


*Fig. 7:* Outline with the frozen current near the conductor, along which flows the current

Let us assume that we have the superconductive outline, in which is frozen the current $I_0$ (which is equivalent to the magnetic moment of atom in the ferromagnetic material), located at a distance $d$ from the conductor, along which flows the current $I$. Outline with the frozen current is fixed with the aid of the spring to the rigid base. If we carry the current through conductor, then outline with the frozen current will begin to it to be attracted, extending spring and thus, stocking in the spring energy. Moreover, the greater the current in the outline will be, the stronger it will be attracted to the wire, and the greater the energy will be accumulated in the spring. Therefore with one and the same values of current in the conductor, the energy, spent for the tension of spring, will be different and there will be it to zavisettakzhe, also, from the current in the short-circuited outline. The system examined is equivalent to inductance with the only difference that energy in this inductance will be equivalent accumulated not in the magnetic field, but in the spring. Moreover inductance in this case will depend also on the distance between the outline and the conductor, and from the current, which flows along the conductor also of the current, frozen in the outline. The characteristic property of the system examined is the fact that the approximation of outline with the frozen current to the wire, along which flows the current, will lead to the excitation it the currents, opposite to initial current. Thus, the resulting current will prove to be less than that current, which would take place in the absence of outline with the frozen current. This behavior of summed current testifies about loading of wire, along which flows the current. If we rapidly turn off current in the outline, then outline with the frozen flow, returning to the previous state, will direct in the conductor EMF. This process is equivalent to self-induction.

It is possible to present another form of such an interaction (Fig. 8). For this it is necessary outline with the frozen current to place on the axis, which passes, through its center, and to the axis to fasten the helical spring, which ensures the steady state of outline in the situation, when its conductors are exist equidistantlyed from the conductors of outer ducts (Fig. Then with the flow of the current through conductor outline with the frozen current will be turned in that or other side, turning helical spring. In this case in the spring the energy will be accumulated, and the direction of the twisting of spring will depend on direction of flow in the conductor.

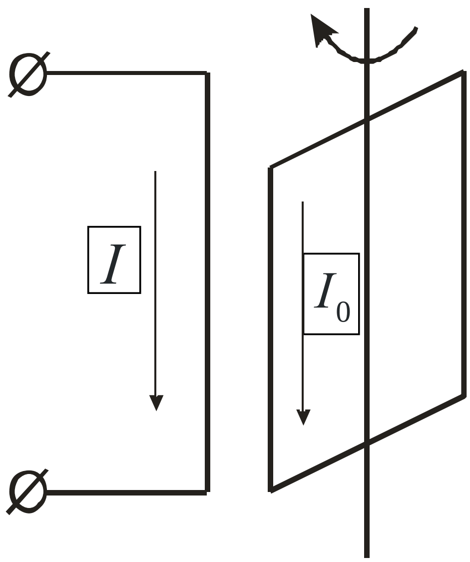


*Fig. 8:* Outline with the frozen current near the conductor, along which flows the current

Until to the ferromagnetic material is superimposed strange external magnetic field, its atoms or the molecules, which represent the microscopic of outline by the szamorozhennym current, they be in the disordered state. This state appears for them it is equilibrium.

Let us take ferrite and will wind winding around it. If we into the winding introduce current, then rod will begin to be magnetized. But external magnetic field as soon as is superimposed on the ferromagnetic material, in it the orientation of magnetic moments along the field begins to occur, on what the energy is expended, since the magnetic moments, located in parallel, are repulsed. But if current in the winding rapidly was turned off, magnetic moments will begin to pass into the initial disordered state and in the winding it will be induced by EMF.

## V. Forced Macroscopic Crystallization of Magnetic Moments in the Ferrite Rings

As was noted in the division 4, the carried out examination of the processes of self-induction it is approximate, since with this examination were not taken into account the magnetic fields of the scatterings, which be present around the magnetized model (Fig. 9). These fields also possess additional energy and makes a contribution to the general energy of the magnetic field of the magnetized model. Any system is approached the minimization of its free energy and if we roll up the magnetized model into the ring and to magnetize it, then stray fields will be absent. In this case this configuration will correspond to the minimum of free energy. But if we in the magnetized annular model make the clearance, located across the ring, then stray fields there are formed. But since in this case at the opposite ends they are formed the pole of different signs, such of pole will be attracted, attempting to make free energy of the split ring of minimum, attempting to roll up it into the ring.

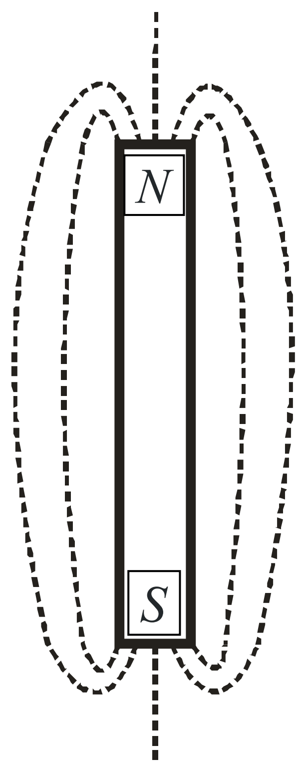


*Fig. 9:* Stray fields of the magnetized model

With this process in the magnetized ferrite ring the magnetic moments will be located in the strictly defined order, and their vector will be directed to one side, as shown in Fig. 10.

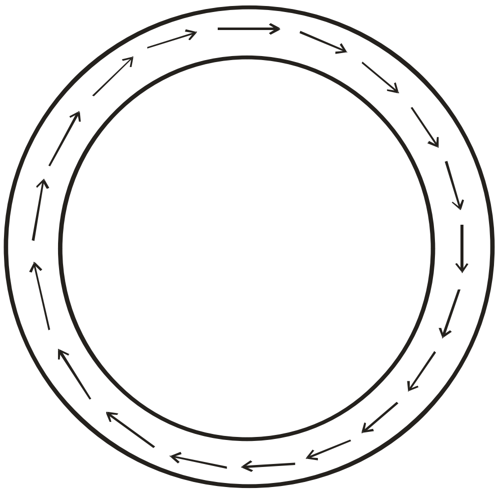

*Fig. 10:* Structure of magnetic moments in the magnetized ferrite ring

In this structure will be absent the stray fields, and structure itself will be steady, since the origin of the previous vector of magnetic moment is attracted the toward the end following vector. This case is very similar to the linear crystallization of atoms in the rod, bent into the ring, with the only difference that atom sites occupy magnetic moments.

If ring was reversed magnetism, then the vector of magnetic moments they change their direction, but their structure will as before remain stable after the removal of magnetizing field.

But if we ring divide into two parts and to spread them, then approaching the minimum of free energy, with which the stray fields must be absent, the parts indicated will be demagnetized.

It is known that in the magnetic crystals also there are microscopic domains, in which the magnetic moments are spontaneously oriented to one side. Domains exist in ferromagnetic, antiferromagnetic, ferroelectric the crystals and other substances, which possess the spontaneous by the long-range order.

In the ferrite ring the magnetic moments also are located in the determined order; however, this occurs not spontaneously, as it takes place in the magnetic bubbles. The magnetization of ferrite ring bears the goal-directed forced nature, and this process can be named by the forced macroscopic crystallization of magnetic moments.

## VI. Conclusion

Ferrite is soft-iron material and therefore it cannot be magnetized. However, the rings, made from ferrite, can be magnetized in the assigned direction. This special feature of the magnetization of such rings did not have, until now, of physical substantiation. In the article are examined the processes of the magnetization of the models of different configuration, including annular. It is shown that the magnetization of ferrite rings can be considered as the forced crystallization of magnetic moments.

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# Outline of Real Physics

By Zhong-Cheng Liang
*Nanjing University of Posts and Telecommunications*

*Abstract-* Real physics is an axiomatic theoretical system based on the model of elastic particles. Unlike point-like and wave-like particles, elastic particles are objects with both mass and volume, which can spin and deform. Electrons, protons, and atoms are elastic particles. Elastic particles have three motion modes of translation, rotation, and vibration. The system of elastic particles follows simple and universal laws of motion. This paper briefly reviews the core concepts, basic principles, main contents, and major achievements of real physics. It shows that the classical physical laws (laws of motion, gravitation, electromagnetism, and thermodynamics) are all conclusions drawn from the statistics of elastic particles, which reveals the irreversibility of natural processes.

*Keywords: particle, interaction, the unified field, the essence of quantum, laws of physics.*

*GJSFR-A Classification: FOR Code: 249999*

OUTLINEOFREALPHYSICS

# Outline of Real Physics

Zhong-Cheng Liang (梁忠诚)

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*Keywords: particle, interaction, the unified field, the essence of quantum, laws of physics.*

— God does not play dice. God made dice, and man plays dice.

## I. General Introduction

Real physics is a new theoretical system [1-9] different from classical physics and modern physics. The meaning of real physics includes actual physics, realistic physics, and real number physics. This paper briefly reviews the core concepts, basic principles, main contents, and major achievements of real physics.

*a) Core concepts*

Matter, particle, space, time, and interaction are the core concepts of physics. The difference in core concepts is the basis for the classification of different theoretical systems. Table 1 summarizes the core concepts of the three physics systems, of which the conceptions of real physics are put forward as physical axioms.

*Table 1:* The core concepts of three physics systems

| Core concept | Classical physics | Modern physics | Real physics |
|---|---|---|---|
| Matter | Discrete particle | Continuous field | Discrete particle |
| Particle | Point-like geometry, mass conservation, zero volume | Wave-like exciting field, mass non-conservation, infinite volume | Body-like elastic object, mass conservation, finite volume |
| Space | Uniform, empty, 3-dimensional space | Non-uniform, energy suffused, 4-dimensional spacetime | Uniform, particle filled, 3-dimensional space |
| Time | Uniform, unidirectional | Non-uniform, non-unidirectional | Uniform, unidirectional |
| Interaction | Gravitational force, electromagnetic force | Gravitational force, electromagnetic force, weak force, strong force | Mass attraction, motion repulsion |

*b) Physical axioms*

(1) Matter. Discrete particle is the only form of matter. Real physics proves that the field is composed of elastic particles, thus denying the modern idea that matter is a continuous field.

(2) Particle. The cornerstone of real physics is the model of elastic particles. Elastic particles are objects with both mass and volume, which can spin and deform. The mass of elastic particles is conserved, but the volume and shape are variable. Elastic particles have three independent motion modes of translation, rotation, and vibration. The particle model of classical physics is a point-like geometry (point-mass and point-charge), the particle model of modern physics is a wave-like field (wave-particle duality), and the particle model of real physics is a body-like (three-dimensional) elastic object. The elastic particle model has made fundamental amendments to classical physics and modern physics.

(3) Space. Real-space is three-dimensional, uniform, and full of particles. The three-dimensionality gives up the assumption of four-dimensional spacetime in modern physics and indicates that space is independent of time.

*Author: College of Electronic and Optical Engineering, Nanjing University of Posts and Telecommunications, Nanjing, 210023, China.*
*e-mail: zcliang@njupt.edu.cn*

The uniformity shows that the real-space is isotropic and translation invariant. The real-space axiom holds that the physical space is full of particles, and the vacuum of classical physics does not exist.

(4) Time. Real-time is uniform and unidirectional. Uniformity indicates that time is incompressible, and unidirectionality means that time is irreversible. The four-dimensional spacetime of relativity theory permits the compression of time. The mathematical spacetime of quantum theory allows the reversal of time. The principle of real physics requires that the physical process is irreversible, and the causality is unbreakable.

(5) Interaction. The interaction of elastic particles includes mass attraction and motion repulsion, which can unify the four fundamental interactions of gravitational force, electromagnetic force, weak force, and strong force.

*c) Main contents*

The contents of real physics include the particle field theory, the motion state theory, and the thermodynamics theory. Real physics essentially is a statistical theory of elastic particles. The basis of the particle field theory is the statistics of mass and momentum, the basis of the motion state theory is the statistics of motion energy, and the basis of the thermodynamics is the statistics of particle number. Table 2 lists the statistical methods and the main mathematical tools used in the three theories.

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*Table 2:* Main contents, statistical methods, mathematical tools, and references

| Content | Statistical method | Mathematical tool | Reference |
|---|---|---|---|
| Particle field theory | Mass and momentum statistics | Statistics, vector calculus, differential equations | 1, 2, 6, 9 |
| Motion state theory | Motion energy statistics | Statistics, algebra, analytic geometry | 3, 5-9 |
| Thermodynamic theory | Particle number (ensemble) statistics | Statistics, calculus, differential equations | 4, 6-9 |

*d) Theoretical features*

Real physics inherits the tradition of simplicity and intuition of classical physics and integrates the principles of the relativity and quantum theories of modern physics. The theoretical hardcore is the elastic particle model, and the initial method is the particle statistics. Real physics is presented in the form of an axiomatic system with mathematical rigor and logical consistency. The simplicity of principles and the universality of conclusions are the remarkable characteristics of real physics.

*e) Major achievements*

(1) On the basis of the physical axioms, real physics strictly deduces the classical laws of motion, gravitation, electromagnetism, and thermodynamics. It modified the laws of physics, rebuilt the foundation of physics, and unified the theories of physics.

(2) It solved many fundamental problems in physics. For example, the essence of quantum, the nature of dark matter, and the unity of interactions.

(3) It solves many physical application problems. Such as the equation of motion, the equation of state, the phase transition, and the radiation mechanism.

*f) Important conclusions*

(1) There are only two types of primary particles in nature: protons and electrons. They are elastic particles. Other elementary particles in modern physics are the composite particles of protons and electrons.

(2) There are two kinds of interactions between elastic particles: mass attraction and motion repulsion. They can unify the four fundamental interactions in modern physics. The charge is a defective concept and is no longer necessary in real physics.

(3) Mass and energy are two different physical quantities. Mass is the intrinsic attribute of an object, and energy is the motion attribute of the object. The mass of an elastic particle is conserved, and the mass and energy are not interchangeable.

(4) The vacuum does not exist, but “dark matter” does exist. Dark matter is the ubiquitous electrons. Gaseous electrons are the background of the cosmos, and gathered protons are isolated islands in the universe.

(5) Gravitational waves and electromagnetic waves are the same things in nature. They are the vibration of the electron gas. They have the same propagation speed.

(6) Elastic particles transfer interactions. Electron gas is the medium that transmits gravitational and electromagnetic forces. The speed of action is finite, and there is no spooky action at a distance.

(7) The physical space is isotropic and flat. The anisotropic curved space of general relativity is an unreal mathematical imagination. The isotropic space does not need the metric of tensor form.
(8) The essence of quantum is the scale of a physical quantity. The scale is the metric and identifier of the physical quantity. Physical space is isotropic, and the metric of the physical quantity must be a scalar.
(9) There is no black hole in the cosmos. The black hole is a false thing produced by the theory of curved space. The interaction of motion repulsion excludes the possibility of star collapse. The motion of galaxies does not need the gravitational support of black holes.
(10) The motion laws of matter are the statistical conclusions of the random motion of elastic particles. The statistical nature of motion laws explains the irreversibility of natural processes.
(11) The motion laws of matter are unified. No matter classical or quantum world, low-speed or high-speed movement, low-energy or high-energy particles, all follow the same mathematical formulation.

*g) On relativity theory*

Einstein's motivation in establishing the relativity theory was to solve the problem of relative motion. Classical mechanics uses trajectory to describe the movement (position, velocity, acceleration) of particles. The calculation of trajectory needs the help of the coordinate frame. Describing relative motion leads to the concepts of inertial, non-inertial, and absolute reference frames. Real physics abandons the trajectory method due to the complexity of the motion of elastic particles. Real physics adopts the center-of-mass reference frame of elastic particles. In the center-of-mass frame, elastic particles have three independent motion modes of translation, rotation, and vibration. Also, real physics uses the quantities of spacing and displacement to exclude the influence of the fixed reference frame.

To extend the classical laws of physics (laws of motion, electromagnetism, and gravitation) to any reference frame (inertial frame and non-inertial frame), Einstein established his special relativity and general relativity. Relativity principle requires that the motion equations are invariant under the coordinate transformation (or covariant under the metric transformation), namely, the physical laws are independent of the reference frames. Therefore, the soul of relativity is the unity of physics. Although the relativity theory broke the confinement of the reference frame, the price was to enter a complicated four-dimensional mathematical spacetime. Real physics uses the center-of-mass reference frame in three-dimensional space to eliminate the influence of relative motion. Furthermore, it introduces a new mathematical dimension (scale dimension) to establish the unity principle of real physics (objectivity principle).

*h) On quantum theory*

The essence of quantum involves the digitization of physical quantity. Physical quantity must be digitized (quantized) to calculate and measure. Classical physics uses coordinates to digitized the particle motion, and quantum theory uses the energy quantum $(h\nu)$ to digitized the continuous field. Elastic particles are discrete. Based on the number of particles $(N)$, the statistical average of physical quantity provides an objective standard for measurement. This standard is called scale. The scale is the metric and identifier of a physical quantity, and its essence is quantum. For example, the energy scales of the three motion modes are translation quantum $(K_s = K/N = kT)$, rotation quantum $(L_s = L/N = lz)$, and vibration quantum $(H_s = H/N = h\nu)$.

The basic principle to unify the quantum field is the invariance of the Lagrangian gauge transformation. Up to now, the unified field theory, including gravitational and electromagnetic interactions, has not been successful. The main reason is that the particle model and the charge concept are incorrect. The unity principle of real physics is the principle of objectivity. The objectivity principle requires the invariance of scale transformation of the mathematical formulas; that is, the physical equations apply to any scale range of the physical quantity.

*i) Objectivity principle*

The objectivity principle that combines the basic ideas of relativity and quantum theories is the fundamental principle of real physics. The thought of the objectivity principle is that the law of motion of matter is objective and does not depend on the observer's subjectivity. The physical equations must exclude all human subjective factors.

The physical process is objective, but a physical observation (measurement) is subjective. Physical observation involves the establishment of measuring standards and the selection of reference frames, both of which are subjective factors. The principle of objectivity requires that the physical equations are scale irrelevant and origin irrelevant.

Real physics realizes the objectivity principle by expressing the physical quantitiy in the form of real-quantity. The real-quantity $(\boldsymbol{x})$ is the product of the scale factor $(x_s)$ and the digit factor $(\widetilde{\boldsymbol{x}})$; that is, $\boldsymbol{x} = x_s \cdot \widetilde{\boldsymbol{x}}$. The scale irrelevance means that the physical quantities and equations are scale transformation invariant. Real physics demonstrates that the form of real-quantity is the most convenient scheme of digitization (quantization), and the objectivity principle is the most practical principle of unification.

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## II. Models of Theory

The first task of real physics is to establish the theoretical models for physical axioms and basic principles [1-6,9]. To transform the physical thought into a mathematical form is the necessary step to the success of a new theory.

### a) Space

The real-space is uniform, three-dimensional, and full of particles. In real-space, the physical quantities are defined in the domain of the real number, the imaginary number and infinity ($\infty$) have no physical meaning. The uniformity of real-space includes the isotropy and translational invariance. The isotropy of real-space requires that the metric (measurement unit) of physical quantity must be a scalar, namely, the physical quantity $\boldsymbol{x}$ can be expressed in the form of real-quantity as follows

$$\boldsymbol{x} = x_s \cdot \tilde{\boldsymbol{x}}; \quad 0 < x_s < \infty. \tag{1}$$

The factor $x_s$ is a scalar and is called scale. The scale is the metric and identifier of a physical quantity and essentially is the quantum. The factor $\tilde{\boldsymbol{x}}$ is the amount of the physical quantity and is called a digit. The digit $\tilde{\boldsymbol{x}}$ is a vector or a scalar, depending on the physical quantity.

A position vector $(\boldsymbol{r})$ expresses the position of real-space

$$\boldsymbol{r} = r_s \cdot \tilde{\boldsymbol{r}} = \overrightarrow{OP} = (x, y, z). \tag{2}$$

Where the position scale $r_s$ is also called space scale (space quantum). $\boldsymbol{r}$ and $\tilde{\boldsymbol{r}}$ are three-dimensional vectors, indicating that space is three-dimensional. The origin of the position vector $(O)$, is a spatial reference point. The three-dimensionality of real-space also means that space is independent of time. Space and time are two different physical quantities.

The volume scale (volume quantum) of real-space is $V_s = r_s^3$. The volume quantum is a cube of side length $r_s$, which is also called space cell. The real-space filled with particles means that every space cells contain particles. Therefore, the particle density in real-space is not zero, $n(\boldsymbol{r}) \neq 0$. Real physics holds that there is only proton and electron in nature. Apart from protons, the particles that fill the cosmos can only be electrons. The ubiquitous electrons are so-called dark matter.

### b) Time

Real physics defines the real-time as

$$t = t_s \cdot \tilde{t}\,; \quad \tilde{t} = 0,1,2,\cdots,k,k+1,\cdots \tag{3}$$

The time scale $t_s$ is called time quantum. The digit of time, $\tilde{t}$, is a sequence of natural numbers, indicating that time is uniform and unidirectional. The definition includes the incompressibility of time and the irreversibility of physical processes. It is a direct expression of causality.

In formula (3), $\tilde{t} = 0$ is starting time, $\tilde{t} = k$ is any time, and $\tilde{t} = k + 1$ is next time. The starting time is determined by a synchronizing protocol [1,2,6]. It stipulates to send a signal $t_0$ from the origin $O$ with a communication speed $c$. The observer at spatial point $P(\boldsymbol{r})$ set the time to $t = t_0 + r/c$ when he receives the signal. After synchronization, we mark the spatial point by $P(\boldsymbol{r}, t)$, where $\boldsymbol{r}$ and $t$ are mutually independent parameters. The signal speed $c$ used for synchronization has special significance in real physics. Signal speed is a system constant, not a universal constant. Both light speed and sound speed can be employed as signal speed.

### c) Particle

Real particles are three-dimensional (body-like) elastic objects. Elastic particles have both mass and volume and can spin and deform. Electrons, protons, and atoms are elastic particles. Electrons and protons are the only two primary particles. The mass density of an elastic particle is finite, as it has both mass and volume. The mass of an elastic particle is conserved, but its volume, density, and shape can be changed.

The spatial states of an elastic particle include position, profile, and posture. We describe the position by the position vector of the center of mass $\boldsymbol{r}_c = (x_c, y_c, z_c)$, the profile by the eigenvalues of the inertia matrix $\boldsymbol{I}_c = (I_1, I_2, I_3)$, and the posture by the directions of the eigenvector $\boldsymbol{\theta}_c = (\theta_1, \theta_2, \theta_3)$. The elastic particle has three independent motion modes of translation, rotation, and vibration, which correspond to the time variations of position, posture, and profile. Translation leads to temperature, rotation leads to magnetism, and vibration leads to radiation. The elastic vibration of particles is the cause of wave-particle duality. The motion of elastic particles covers the translation mode of point-like particles in classical physics and the vibration mode of wave-like particles in modern physics.

*d) Matter*

Matter in nature is made up of discrete elastic particles. Strict mathematical analysis shows that continuous field is not an independent form of matter, but a statistically related object composed of a large number of discrete particles [1,2,6,9].

Let the velocity scale be the speed of synchronizing signal ($u_s = c$), then the space quantum is $r_s = ct_s$. By calculating the mass and momentum in space cell ($V_s = r_s^3$), we can construct the mass potential (scalar potential) and momentum potential (vector potential) of the particle field. The mass and momentum potentials have definite physical meanings. They are the spatial correlation functions of mass density and momentum density. Starting from the mass and momentum potentials, we derived a set of differential equations by using vector calculus. The spatial first derivative of the potential field is the action field. The spatial second derivative of the potential field includes the gravitational potential equation, and the formulas similar to electromagnetic field equations. The scale transformation shows that both gravitational field and electromagnetic field originate from mass potential and momentum potential. Gravitational field, electromagnetic field, and fluid field are all unified in elastic particle field.

*e) Interaction*

The interaction between elastic particles includes mass attraction and motion repulsion. Mass attraction represents the aggregation tendency of particles, and motion repulsion indicates that there are gaps between particles. The mathematical condition of motion repulsion is that the spacing of different particles is larger than zero, namely, $r_{ij} = \sqrt{\boldsymbol{r}_{ij} \cdot \boldsymbol{r}_{ij}} > 0$. The direct inference of motion repulsion is that the mass density of any object is finite, namely, $\rho = M/V < \infty$.

In the theory of particle field, the mass potential represents mass attraction, and the momentum potential represents motion repulsion. The calculation shows that the forms of interaction include gradient force, curl force, and divergence force, which correspond to the translation force, rotation force, and vibration force, respectively. Gravitational and electrostatic forces belong to gradient force, magnetic force belongs to curl force, and alternating electromagnetic force belongs to divergence force. Weak force and strong force are the combined effects of gradient force, curl force, and divergence force.

*f) Objectivity principle*

The principle of objectivity states that the laws of motion are objective and do not depend on the subjective consciousness of the observer. The physical process is objective, but a physical observation (measurement) is subjective. The physical observation needs to choose the measurement unit and the reference system, both of which contain human factors. The principle of objectivity requires that physical formulas have scale irrelevance and origin irrelevance.

In the form of real-quantity (formula 1), the physical quantity is objective and absolute, the scale is a subjective factor and the digit is a relative factor. The mathematical expression of scale irrelevance is the equivalence between the physical relation and the digital relation, namely

$$z = R(x, y) = z_s \cdot \tilde{z}; \quad \tilde{z} = R(\tilde{x}, \tilde{y}). \tag{4}$$

Formula (4) determines the operation rules of physical quantity [1,2,6].

The origin irrelevance requires that the physical formulas have nothing to do with the selection of reference points of time and space. Therefore, we define the physical quantity at any time ($\tilde{t} = k$). The position vector of particles $(\boldsymbol{r}_i = \overrightarrow{OP_i})$ can only appear in the form of spacing $\boldsymbol{r}_{ij} = \overrightarrow{OP_j} - \overrightarrow{OP_i} = \overrightarrow{P_iP_j}$ and displacement $\Delta\boldsymbol{r}_i(k) = \overrightarrow{OP_i(k+1)} - \overrightarrow{OP_i(k)} = \overrightarrow{P_i(k)P_i(k+1)}$ to eliminate the influence of spatial reference point.

The scale irrelevance indicates that the physical laws apply to any scale range of the physical quantity. No matter of the classical or quantum world, high-speed or low-speed motion, low-energy or high-energy particles, all follow the same and indistinguishable equations of motion (no approximation). The origin irrelevance indicates that the physical laws apply to any time and any place, independent of the choice of the reference frame. The objectivity principle is the universal and unifying principle of physics.

*g) Operation rules*

The scale irrelevance specifies the following operation rules of the physical quantity, in which the difference quotient does not involve taking the limit, thus eliminating the logic contradiction implied in the operation of the differential quotient. [1,6]

(1) Addition and subtraction.

$$z = x \pm y = x_s \cdot (\tilde{x} \pm \tilde{y}) = z_s \cdot \tilde{z}; \;\; z_s = x_s = y_s, \tilde{z} = \tilde{x} \pm \tilde{y}.$$

(2) Multiplication.

$$z = x\cdot y = (x_s\cdot y_s)\cdot(\tilde{x}\cdot\tilde{y}) = z_s\cdot\tilde{z};\quad z_s = x_s\cdot y_s\,, \tilde{z} = \tilde{x}\cdot\tilde{y}.$$

(3) Division.

$$z = \frac{y}{x} = \frac{y_s}{x_s}\cdot\frac{\tilde{y}}{\tilde{x}} = z_s\cdot\tilde{z};\quad z_s = \frac{y_s}{x_s},\quad \tilde{z} = \frac{\tilde{y}}{\tilde{x}}.$$

(4) Difference.

$$\Delta x_k = x_{k+1} - x_k = x_s\cdot(\tilde{x}_{k+1} - \tilde{x}_k) = x_s\cdot\Delta\tilde{x}_k\,;\quad \Delta\tilde{x}_k = \tilde{x}_{k+1} - \tilde{x}_k\,.$$

(5) Integral.

$$z(n) = \sum_{k=1}^{n}[y(x_k)\cdot\Delta x_k]_{\Delta x_k = x_s} = (y_s\cdot x_s)\cdot\sum_{k=1}^{n}\tilde{y}(x_k) = z_s\cdot\tilde{z};$$

$$z_s = y_s\cdot x_s,\qquad \tilde{z}(n) = \sum_{k=1}^{n}\tilde{y}(x_k).$$

(6) Difference quotient.

$$\frac{dy}{dx} = \left(\frac{\Delta y}{\Delta x}\right)_{\Delta\tilde{x}=1} = \frac{y_s}{x_s}\cdot\left(\frac{\Delta\tilde{y}}{\Delta\tilde{x}}\right)_{\Delta\tilde{x}=1} = \frac{y_s}{x_s}\cdot\Delta\tilde{y}.$$

(7) Differential quotient.

$$\frac{\tilde{d}y}{\tilde{d}x} = \left(\frac{\Delta y}{\Delta x}\right)_{\Delta\tilde{x}\to 0} = \frac{y_s}{x_s}\cdot\left(\frac{\Delta\tilde{y}}{\Delta\tilde{x}}\right)_{\Delta\tilde{x}\to 0} = \frac{y_s}{x_s}\cdot\frac{d\tilde{y}}{d\tilde{x}}.$$

(8) Others. The operations of exponent, logarithm, and trigonometric functions demand $x_s = 1$. In other words, these functions only operate on digits.

$$\mathrm{e}^{x} = \mathrm{e}^{x_s\cdot\tilde{x}} = (\mathrm{e}^{x_s})^{\tilde{x}} = \mathrm{e}^{\tilde{x}}.$$

$$\ln x = \ln(x_s\cdot\tilde{x}) = \ln x_s + \ln\tilde{x} = \ln\tilde{x}.$$

$$\sin x = \sin(x_s\cdot\tilde{x}) = \sin\tilde{x}.$$

*h) Quantum relations*

The scale is the identifier and metric of physical quantities, and scale is the quantum. Scales are the identification for distinguishing physical quantities, and the same scale represents the same kind of physical quantities. Scales are the measurement standards, *i.e.*, metric or units. We emphasize that scale is the metric of the physical quantity, not the metric of space. The scale is a scalar because the real-space is flat and isotropic, not curved and anisotropic.

The real-space is three-dimensional, and there are only three independent scales in the physical system. The scale system of relativity theory consists of $E_s, t_s, u_s = c$ ($E_s$ energy scale, $t_s$ time scale, $u_s$ velocity scale, $c$ communicating speed), which includes the following scale relations

$$r_s = ct_s,\quad \omega_s = 1/t_s\,,\quad M_s = E_s/c^2,$$

$$I_s = E_s t_s^2,\quad p_s = E_s/c\,,\quad s_s = E_s t_s. \tag{5}$$

Among them, $r_s$ is the space scale, $\omega_s$ the frequency scale, $M_s$ the mass scale, $I_s$ the rotary inertia scale, $p_s$ the momentum scale, and $s_s$ the angular momentum scale. In this scale system, the velocity scale (speed quamtum) is a constant, and the others are variables. $r_s\omega_s = c$ is the uncertainty relation between the space scale and the frequency scale. $E_s = M_s c^2$ is the famous Einstein energy.

The scale system of quantum theory consists of $u_s = c$, $s_s = h$, $\omega_s = v$ ($h$ Planck constant), which includes the following relations

$$t_s = 1/v\,,\qquad r_s = c/v\,,\qquad E_s = hv,$$

$$M_s = hv/c^2\,,\quad I_s = h/v\,,\quad p_s = hv/c. \tag{6}$$

The scale system of quantum theory has two constants $(c, h)$, and the only variable scale is frequency $(v)$. The quantum uncertainty relations include $r_s p_s = E_s t_s = h$. The space scale $r_s = c/v$ is the wavelength, and $r_s = h/(M_s c)$ is the Compton wavelength. $E_s = hv$ is the famous Planck energy.

Elastic particles have three independent motion modes. The scales of translation, rotation, and vibration energies $\{K, L, H\}$ are respectively

$$K_s = K/N = kT,\ L_s = L/N = lz,\ H_s = H/N = hv. \tag{7}$$

Where $N$ is the number of particles. $T$ is the thermodynamic temperature, $z$ is the magnetic induction strength, $v$ is the vibration frequency. $k, l, h$ are Boltzmann constant, Bohr magneton constant, and Planck constant, respectively. In fact, Einstein energy is the translation quantum, which is suitable for the translation of high-speed particles. Planck energy is the vibration quantum, which is suitable for the vibration of microscopic particles.

## III. Theory of Particle Field

The premise of particle field theory is the axiom of real-space. The real-space assumes that space is full of particles, and the cosmos is full of electrons. The ubiquitous electrons are so-called dark matter. Statistics on the mass and momentum of particles constitute the mass potential and momentum potential. The potentials contain all the interactions of particles. The classical laws of motion, gravitation, and electromagnetism are all inferences of the particle field theory [1,2,6,9].

### a) *Essence of field*

Modern physics believes that the field is the basic form of matter. The field is the energy dispersed in continuous space, and particles are the excited states of field. Strict mathematical analysis shows that the field is not the basic form of matter, but the statistical effect of a large number of discrete particles. The field of real physics describes the motion of elastic particles in a continuous form, called elastic particle field. Based on the statistics of particle mass and momentum, the particle field theory derives a complete set of field equations under the constraint of mass conservation, thus revealing the particle nature of the field and disclosing the motion laws of field.

### b) *Space quantization*

Real-space is continuous. It is necessary to quantize (discretize) space with volume quantum to describe the field. The particle field theory uses the wave speed $c$ as the velocity scale ($u_s = c$). Therefore, the space quantum is $r_s = ct_s$, and the volume quantum is $V_s = r_s^3$. The volume quantum is also called space cells.

Consider any object that has a finite volume $V$, a free boundary $S$, and contains the number of particles $N$. The volume is divided by the $V_s$ into $\tilde{V}$ cells. Thus $V = V_s \cdot \tilde{V}$. The space cells are marked by $\mathrm{C}(\boldsymbol{r}_q, \tilde{t})$, where $\boldsymbol{r}_q$ is the position vector of the *q*-cell. Figure 1 is a sketch map showing the space quantization, which is a two-dimensional field containing nine cells and 30 particles. Gaps are reserved between particles to reflect the repulsion of motion.

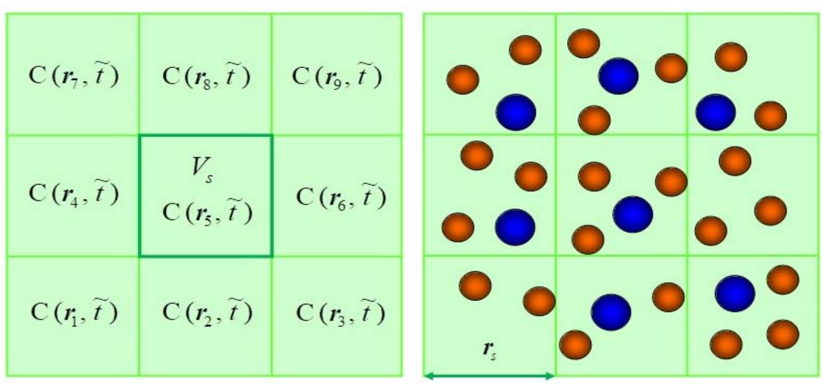


*Figure 1:* Sketch map showing the space quantization

### c) *Equations of field*

(1) Density field. By calculating the mass and momentum of the particles in cells, we obtain the sum of particle mass, $M_q(\boldsymbol{r}_q, \tilde{t})$, and the sum of particle momentum, $\boldsymbol{p}_q(\boldsymbol{r}_q, \tilde{t})$. The mass density and momentum density are $\rho_q(\boldsymbol{r}_q, \tilde{t}) = M_q/V_s$ and $\boldsymbol{j}_q(\boldsymbol{r}_q, \tilde{t}) = \boldsymbol{p}_q/V_s$, respectively. $\rho_q(\boldsymbol{r}_q, \tilde{t})$ and $\boldsymbol{j}_q(\boldsymbol{r}_q, \tilde{t})$ are called density field.

(2) Potential field. We construct the mass potential $\Phi_q$ and momentum potential $\boldsymbol{A}_q$ by using the mass and momentum of the cells

$$\Phi_q(\boldsymbol{r}_q, \tilde{t}) = \frac{-1}{\varphi} \sum_{k=1,k\neq q}^{N_q=\tilde{V}} \frac{M'_k}{|\boldsymbol{r}_q - \boldsymbol{r}'_k|} = \frac{-1}{\varphi} \sum_{k=1,k\neq q}^{N_q=\tilde{V}} \frac{M'_k}{r_{kq}}, \tag{8a}$$

$$A_q(\boldsymbol{r}_q,\tilde{t}) = \alpha \sum_{k=1,k\neq q}^{N_q=\tilde{V}} \frac{\boldsymbol{p}'_k}{|\boldsymbol{r}_q - \boldsymbol{r}'_k|} = \alpha \sum_{k=1,k\neq q}^{N_q=\tilde{V}} \frac{\boldsymbol{p}'_k}{r_{kq}}. \tag{8b}$$

$\varphi$ and $\alpha$ are respectively called medium constant and dynamic constant. When $\tilde{V} \ll N$, the summation is converted into integral form. The continuous density field and potential field are

$$\rho = \rho(\boldsymbol{r},t), \qquad \boldsymbol{j} = \boldsymbol{j}(\boldsymbol{r},t). \tag{9}$$

$$\Phi(\boldsymbol{r},t) = \frac{-1}{\varphi}\iiint_V \frac{\rho(\boldsymbol{r}',t)}{|\boldsymbol{r}-\boldsymbol{r}'|}d\boldsymbol{r}' = \frac{-1}{4\pi\varphi_s}\iiint_V \frac{\rho(\boldsymbol{r}',t)}{r}d\boldsymbol{r}';\ \Phi_s = c^2. \tag{10a}$$

$$\boldsymbol{A}(\boldsymbol{r},t) = \alpha\iiint_V \frac{\boldsymbol{j}(\boldsymbol{r}',t)}{|\boldsymbol{r}-\boldsymbol{r}'|}d\boldsymbol{r}' = \frac{\alpha_s}{4\pi}\iiint_V \frac{\boldsymbol{j}(\boldsymbol{r}',t)}{r}d\boldsymbol{r}';\ A_s = c. \tag{10b}$$

Where the mass potential $\Phi$ is a scalar potential, and the momentum potential $\boldsymbol{A}$ is a vector potential. They are the spatial correlation functions of the mass density $\rho$ and momentum density $\boldsymbol{j}$, respectively. These correlations include all the connections between the cells and are inversely proportional to the distance between the cells. By using vector calculus, we can derive the laws of interaction from the potential field.

Mathematically, the opposite signs of the mass potential and momentum potential are specified to indicate the opposite effects of attraction and repulsion. But that's not exactly the case, because the mass potential and momentum potential are not independent. They are related to each other through the medium constant $\varphi$ and the dynamic constant $\alpha$. The relationship between $\varphi$ and $\alpha$ is

$$\alpha\varphi = \alpha_s\varphi_s = c^{-2}. \tag{11}$$

(3) Mass conservation. Conservation of mass is the demand for physical axiom. Its mathematical form in particle field theory is [1]

$$\frac{D\rho}{Dt} \equiv \frac{\partial\rho}{\partial t} + \nabla\cdot(\rho\boldsymbol{u}) = \frac{\partial\rho}{\partial t} + \nabla\cdot\boldsymbol{j} = 0, \tag{12}$$

where $\boldsymbol{u} = \boldsymbol{j}/\rho$ is the velocity field, and $D\rho/Dt$ is called the motion derivative of the mass density. The influence of the boundary is the cause of the second term in the motion derivative.

(4) Boundary condition. The boundary condition of the particle field is

$$B(S) = \frac{\alpha_s}{4\pi}\oiint_S \frac{\boldsymbol{j}(\boldsymbol{x}',t)\cdot d\boldsymbol{S}'}{r} = 0. \tag{13}$$

The condition is valid at the place far from the boundary.

(5) Action field. The action field is the spatial first derivative of the potential field. The action field includes gradient field $\boldsymbol{G}$, curl field $\boldsymbol{C}$, and divergence field $D$.

$$\boldsymbol{G}(\boldsymbol{r},t) \equiv -\nabla\Phi = \frac{-1}{4\pi\varphi_s}\iiint_V \frac{\rho(\boldsymbol{r}',t)\,\boldsymbol{r}}{r^3}d\boldsymbol{r}';\ G_s = \frac{\Phi_s}{r_s} = \frac{r_s}{t_s^2}. \tag{14}$$

$$\boldsymbol{C}(\boldsymbol{r},t) \equiv \nabla\times\boldsymbol{A} = \frac{\alpha_s}{4\pi}\iiint_V \frac{\boldsymbol{j}(\boldsymbol{r}',t)\times\boldsymbol{r}}{r^3}d\boldsymbol{r}';\ C_s = \frac{A_s}{r_s} = \frac{1}{t_s}. \tag{15}$$

$$D(\boldsymbol{r},t) \equiv \nabla\cdot\boldsymbol{A} = \frac{1}{u_s^2}\frac{\partial\Phi}{\partial t};\ D_s = \frac{A_s}{r_s} = \frac{1}{t_s}. \tag{16}$$

The curl and divergence fields are frequency fields, which respectively represent the rotation and vibration frequencies. The gradient field is an acceleration field. Negative acceleration represents attraction, and positive acceleration represents repulsion. Since the gradient of the mass potential can be positive or negative, the gradient force includes both attraction and repulsion.

(6) Field equations. The field equations contain the spatial second and third derivatives of the potential field. The eq.17 in Table 3 is the Poisson equation of mass potential, which is also the equation of Newtonian potential. The first four equations (eqs.17-20) are similar to Maxwell equations. There are two pairs of Poisson equations: the Poisson equation of potential field (eqs.17,22) and the Poisson equation of action field (eqs.23,24). Eq.23 shows that the gradient of mass density is the source of the gradient field. Eq.24 shows that the curl of momentum density is the source of the curl field. Eq.21 shows that the temporal variation of the gradient field results in the spatial variation of the divergence field. The particle field equations are derived from the density field, and the density field is no other than the solution of the field equations.

*Table 3:* The basic equations of the elastic particle field

| Name | Field equation | Scale | |
|---|---|---|---|
| Divergence of gradient field | $\nabla\cdot\boldsymbol{G}=-\nabla^2\Phi=-\rho/\varphi_s$ | $G_s r_s^{-1}=t_s^{-2}$ | (17) |
| Curl of gradient field | $\nabla\times\boldsymbol{G}=-\nabla\times\nabla\Phi\equiv 0$ | $G_s r_s^{-1}=t_s^{-2}$ | (18) |
| Divergence of curl field | $\nabla\cdot\boldsymbol{C}=\nabla\cdot(\nabla\times\boldsymbol{A})\equiv 0$ | $C_s r_s^{-1}=r_s^{-1}t_s^{-1}$ | (19) |
| Curl of curl field | $\nabla\times\boldsymbol{C}=\alpha_s\,\boldsymbol{j}-\frac{1}{u_s^2}\frac{\partial\boldsymbol{G}}{\partial t}$ | $C_s r_s^{-1}=r_s^{-1}t_s^{-1}$ | (20) |
| Gradient of divergence field | $\nabla D=\nabla(\nabla\cdot\boldsymbol{A})=-\frac{1}{u_s^2}\frac{\partial\boldsymbol{G}}{\partial t}$ | $D_s r_s^{-1}=r_s^{-1}t_s^{-1}$ | (21) |
| Poisson equation of momentum potential | $\nabla^2\boldsymbol{A}=-\alpha_s\,\boldsymbol{j}$ | $A_s r_s^{-2}=r_s^{-1}t_s^{-1}$ | (22) |
| Poisson equation of gradient field | $\nabla^2\boldsymbol{G}=-\nabla\rho/\varphi_s$ | $G_s r_s^{-2}=r_s^{-1}t_s^{-2}$ | (23) |
| Poisson equation of curl field | $\nabla^2\boldsymbol{C}=-\alpha_s\,\nabla\times\boldsymbol{j}$ | $C_s r_s^{-2}=r_s^{-2}t_s^{-1}$ | (24) |

(7) Elastic particle waves. The equation of the divergence field (eqs.16,21) is the wave equation with a general solution

$$\Phi(\xi)=-W(\xi),\ \boldsymbol{A}(\xi)=(\boldsymbol{\kappa}/\omega)W(\xi),\ \ \xi=\boldsymbol{\kappa}\cdot\boldsymbol{x}-\omega t. \tag{25}$$

$W(\xi)$ is an analytic function in the positive real domain.

*d) Equation of motion*

(1) Motion theorem. We define the force density as the motion derivative of the momentum density [1].

$$\boldsymbol{f}\equiv\frac{D\boldsymbol{j}}{Dt}=\frac{\partial\boldsymbol{j}}{\partial t}+\nabla\cdot(\boldsymbol{j}\boldsymbol{u})=\rho\left[\frac{\partial\boldsymbol{u}}{\partial t}+(\boldsymbol{u}\cdot\nabla)\boldsymbol{u}\right];\quad f_s=\frac{j_s}{t_s}=\frac{\rho_s r_s}{t_s^2}. \tag{26}$$

This equation is called the motion theorem. We can write it in the form of Newton's second law

$$\boldsymbol{f}=\rho\boldsymbol{a},\quad \boldsymbol{a}=\frac{\partial\boldsymbol{u}}{\partial t}+(\boldsymbol{u}\cdot\nabla)\boldsymbol{u};\quad a_s=\frac{f_s}{\rho_s}=\frac{r_s}{t_s^2}. \tag{27}$$

Where $\boldsymbol{a}$ is acceleration, $\partial\boldsymbol{u}/\partial t$ is linear acceleration, and $(\boldsymbol{u}\cdot\nabla)\boldsymbol{u}$ is curve acceleration.

(2) Force field. The coupling of the density field and action field produces the force field, which includes gradient force $\boldsymbol{f}_G$, curl force $\boldsymbol{f}_C$, and divergence force $\boldsymbol{f}_D$.

$$\boldsymbol{f}_G=\rho\boldsymbol{G}=-\rho\nabla\Phi;\qquad f_s=\rho_s G_s=\rho_s r_s/t_s^2. \tag{28a}$$

$$\boldsymbol{f}_C=\boldsymbol{j}\times\boldsymbol{C}=\rho\boldsymbol{u}\times\boldsymbol{C};\ \ f_s=\rho_s u_s C_s=\rho_s r_s/t_s^2. \tag{28b}$$

$$\boldsymbol{f}_D=D\boldsymbol{j}=\rho D\boldsymbol{u};\qquad f_s=\rho_s D_s u_s=\rho_s r_s/t_s^2. \tag{28c}$$

The gradient force appears as gravitational force and electrostatic force, the curl force appears as Coriolis force and Lorentz force, and the divergence force appears as motion resistance. The curl force is perpendicular to the curl field and the motion direction. The divergence force is proportional to the speed, and the resistance coefficient is $\rho D$.

(3) Motion equation. The condition of the force balance $\boldsymbol{f} = \boldsymbol{f}_G + \boldsymbol{f}_C + \boldsymbol{f}_D$ gives the motion equation of objects as follows

$$\boldsymbol{f} = \rho\left[\frac{\partial \boldsymbol{u}}{\partial t} + (\boldsymbol{u}\cdot\nabla)\boldsymbol{u}\right] = \rho(\boldsymbol{G} + \boldsymbol{u}\times\boldsymbol{C} + D\boldsymbol{u}). \tag{29}$$

The motion equation has the position of the Navier-Stokes equation in fluid dynamics. The force densities at the right side of the equation have definite sources and meanings. The solution of the equation must exist.

*e) Unification of fields*

(1) Particle field and fluid field. The particle field is a Euler description of fluid motion. The equations of the elastic particle field are unified fluid field equations. For general fluids, sound speed is used as the speed quantum when dealing with dynamics problems, and light speed is used as the speed quantum when dealing with optical phenomena.

(2) Particle field and gravitational field. The mass potential (eq.10a) of particle field is the same as Newton's gravitational potential. Taking gravitational constant as $\gamma = 6.6742867\times10^{-11}\mathrm{Nm^2kg^{-2}}$, and speed quantum as $c = 2.9979246\times10^{8}\mathrm{ms^{-1}}$, we can determine the medium constant $\varphi$ and the dynamic constant $\alpha$.

$$\varphi = \gamma^{-1} = 1.4982874\times10^{10}\ \mathrm{N^{-1}m^{-2}kg^2}, \tag{30a}$$

$$\alpha = \varphi^{-1}c^{-2} = \gamma c^{-2} = 7.4261454\times10^{-28}\ \mathrm{Ns^2kg^{-2}}. \tag{30b}$$

(3) Particle field and electromagnetic field. The electromagnetic field is a pure electron field. As shown in Table 4, we obtain the relationship between the electromagnetic field and particle field by introducing the mass-to-charge ratio $\beta$ and the scale conversion factor $\theta$.

$$\beta = M_e/Q_e = -5.6856296\times10^{-12}\mathrm{kg\ C^{-1}};\quad \beta_s = M_s/Q_s. \tag{31a}$$

$$\theta = \epsilon/\varphi = 4\pi\epsilon_s\gamma = 7.4261454\times10^{-21}\mathrm{C^2kg^{-2}};\quad \theta_s = Q_s^2/M_s^2. \tag{31b}$$

*Table 4:* The transformation between the electromagnetic field and elastic particle field

| Electromagnetic field | Transformation relation | Transformation coefficient |
|---|---|---|
| Vacuum permittivity | $\epsilon_s = \theta\varphi_s$ | $\theta = 7.4261454\times10^{-21}\mathrm{C^2kg^{-2}}$ |
| Vacuum permeability | $\mu_s = \theta^{-1}\alpha_s$ | $\theta^{-1} = 1.3465936\times10^{20}\mathrm{C^{-2}kg^2}$ |
| Charge density | $\rho_e = \beta\theta\rho$ | $\beta\theta = -4.2222312\times10^{-32}\mathrm{Ckg^{-1}}$ |
| Current density | $\boldsymbol{j}_e = \beta\theta\boldsymbol{j}$ | $\beta\theta = -4.2222312\times10^{-32}\mathrm{Ckg^{-1}}$ |
| Electric potential | $\Phi_e = \beta\Phi$ | $\beta = -5.6856296\times10^{-12}\mathrm{kgC^{-1}}$ |
| Magnetic potential | $\boldsymbol{A}_e = \beta\boldsymbol{A}$ | $\beta = -5.6856296\times10^{-12}\mathrm{kgC^{-1}}$ |
| Electric field | $\boldsymbol{E}_e = \beta\boldsymbol{G}$ | $\beta = -5.6856296\times10^{-12}\mathrm{kgC^{-1}}$ |
| Magnetic induction | $\boldsymbol{B}_e = \beta\boldsymbol{C}$ | $\beta = -5.6856296\times10^{-12}\mathrm{kgC^{-1}}$ |

The main difference between the transformed particle field equations (17)-(20) and Maxwell's equations is that the curl of the electric field is not zero. Maxwell's equations are incomplete, as shown by the particle field equations (Table 3). In addition to Maxwell's equations, there is a separate wave equation (divergence field equation). The theory of the elastic particle field should replace the theory of electromagnetic field.

*f) Important conclusions*

(1) The cosmos is full of electrons. Electrons are so-called dark matter. The electronic background of the cosmos is the basis of the application of particle field theory to cosmology.

(2) The potential field contains all the interactions between particles in the field. The potential field is the spatial correlation functions of the mass density and momentum density. The correlation between each pair of space cells is directly proportional to the mass and momentum, and inversely proportional to their distance.

(3) Gravitational field, electromagnetic field, and fluid field are all unified in the elastic particle field. The particle field equations show that the source of the gradient field is the gradient of mass density, and the source of the curl field is the curl of momentum density. The temporal variation of the gradient field results in the spatial variation of the divergence field. The divergence field equation is the wave equation, which has a general solution in the real number domain.

(4) The electromagnetic field is a pure electron field (electron gas). Electron is the medium of transmitting waves and interactions. The propagation speed of the electromagnetic field is the wave speed in the electron gas, namely, the speed of light.

(5) Maxwell's equations are incomplete. They are only part of the particle field equations. Although Maxwell's equations are self-consistent, they only retain the property of waves and lose the interaction of particles.
(6) The concept of electric charge is defective. The charge model stipulates that protons carry positive charges, and electrons carry negative charges. The stipulation can explain the attraction of protons and electrons, but it excludes the motion repulsion between them.
(7) Newton's law of gravitation needs amendment. Both the gravitational field and electrostatic field belong to the gradient field. The gradient field is the spatial derivative of mass potential, which can be positive or negative. The gradient force may be either attraction or repulsion, namely, there is repulsive gravitation.
(8) Newton's second law needs supplement. Acceleration includes linear acceleration and curve acceleration. The curve acceleration causes the bending motion of the object.
(9) The equation of motion in the form of Newton's second law is similar to the Navier-Stokes equation. The force density at the right end of the equation has clear physical significance. The solution of the equation must exist.
(10) The basis of the particle field equations is the statistics of the mass and momentum of elastic particles. The classical laws of motion, gravitation, and electromagnetism are all inferences of particle field theory. The statistical nature of the field is the source of the irreversibility of natural processes.

## IV. Theory of Motion State

The motion state theory comprehensively copes with the translation, rotation, and vibration of elastic particles. The motion energy of the particle system constitutes an energy space. The state variation in the energy space reflects the state variation of matter [3-9].

### *a) Object structure*

An object is a system of elastic particles. The spatial structure of an object is the nesting of particles at different levels. For example, nuclei and electrons form atoms, atoms form molecules, and molecules form supra-molecule, and so on. We put forward a general model to describe the nested structure [3-8]

Top-particle ⊇ meso-particles ⊇ base-particles ⊇ sub-particles.

The top-particle is the object to be studied, while the base-particle is the elastic particle with a conservative number. The meso-particles may be inelastic with a non-conservative numbers. The elasticity of base-particles comes from the motion of sub-particles. For example, the atomic elasticity mainly comes from the electronic motion outside the nucleus. An upper-level particle comprises all particles in lower levels. The more particle levels of an object contain, the more complex the structure of the object.

### *b) Object state*

(1) Space state. The space state of an object includes position, profile, and posture. We express the position by the position vector of the center-of-mass in a fixed coordinate frame, $\boldsymbol{r}_c = (x_c, y_c, z_c)$, the profile by the eigenvalues of the inertia matrix, $\boldsymbol{I}_c = (I_1, I_2, I_3)$, and the posture by the directions of the eigenvectors of the inertia matrix, $\boldsymbol{\theta}_c = (\theta_1, \theta_2, \theta_3)$.
(2) Motion state. The changes of position, posture, and profile are respectively called translation, rotation, and vibration. The translation is the shift of the center-of-mass in space, the rotation is the spin of the object around the center-of-mass, and the vibration is the extension and contraction of the object relative to the center-of-mass. Translation, rotation, and vibration are three independent modes of motion, each of which has three degrees of freedom. An elastic particle has 3×3=9 degrees of freedom, and an object composed of *N* base-particles has 9*N* degrees of freedom.
(3) Energy state. The motion energy of the particle system, $\{H, L, K\}$, represents the energy state of an object. If the vibration, rotation, and translation energies of the base-particle are $H_{i\alpha}, L_{i\alpha}, K_{i\alpha}$ $(\alpha = 1,2,3)$, then the total energies of vibration, rotation, and translation are respectively

$$H = \sum_{i=1}^{N} \sum_{\alpha=1}^{3} H_{i\alpha}\,; \;\; H_{i\alpha} = \frac{V_i \chi_{i\alpha}^2}{2Y_{i\alpha}}.$$

$$L = \sum_{i=1}^{N} \sum_{\alpha=1}^{3} L_{i\alpha}\,; \;\; L_{i\alpha} = \frac{s_{i\alpha}^2}{2I_{i\alpha}}. \qquad (32)$$

$$K = \sum_{i=1}^{N} \sum_{\alpha=1}^{3} K_{i\alpha}\,; \;\; K_{i\alpha} = \frac{p_{i\alpha}^2}{2M_i}.$$

Among them, $Y_{i\alpha}$ is the principal elastic modulus, $I_{i\alpha}$ is the principal rotary inertia, and $M_i$ is the mass of the particle. $\chi_{i\alpha}$ is the principal stress component, $s_{i\alpha}$ is the angular momentum component, and $p_{i\alpha}$ is the translation momentum component. $H, L, K$ are respectively the sum of 3*N* independent square terms, so $H > 0,\ L > 0,\ K > 0$, namely, the motion energy of the object is always positive.

c) *Energy space*

(1) Definition of energy space. The energy space of object is a set of ordered array $\{\mathbb{E}^h, \mathbb{E}^l, \mathbb{E}^k\}$ composed of $\{H, L, K\}$

$$\mathbb{E}^h = \langle H^h, L^h, K^h \rangle,\ \ \mathbb{E}^l = \langle L^l, K^l, H^l \rangle,\ \ \mathbb{E}^k = \langle K^k, H^k, L^k \rangle. \tag{33}$$

Where $x = h, l, k$ is the zone index. $\mathbb{E}^h, \mathbb{E}^l, \mathbb{E}^k$ are respectively called a gas zone, solid zone, and liquid zone.

We can express the energy space intuitively by a Cartesian coordinate space composed of $(H, L, K)$. Due to the positivity of motion energy, we confine the energy space to the first octant $(+,+,+)$ of the Cartesian space. The energy vectors $(\boldsymbol{E}^x)$ of the three zones in the energy space are

$$\begin{aligned} \boldsymbol{E}^h &= (H^h, L^h, K^h) = H^h\,\mathbf{i} + L^h\,\mathbf{j} + K^h\,\mathbf{k} = E^h\,\mathbf{e}_0, \\ \boldsymbol{E}^l &= (H^l, L^l, K^l) = H^l\,\mathbf{i} + L^l\,\mathbf{j} + K^l\,\mathbf{k} = E^l\,\mathbf{e}_0, \\ \boldsymbol{E}^k &= (H^k, L^k, K^k) = H^k\,\mathbf{i} + L^k\,\mathbf{j} + K^k\,\mathbf{k} = E^k\,\mathbf{e}_0. \end{aligned} \tag{34}$$

Where $\mathbf{e}_0$ is the unit vector in the direction of the energy vector. The energy vector has the length

$$E^x = \sqrt{(H^x)^2 + (L^x)^2 + (K^x)^2}\,. \tag{35}$$

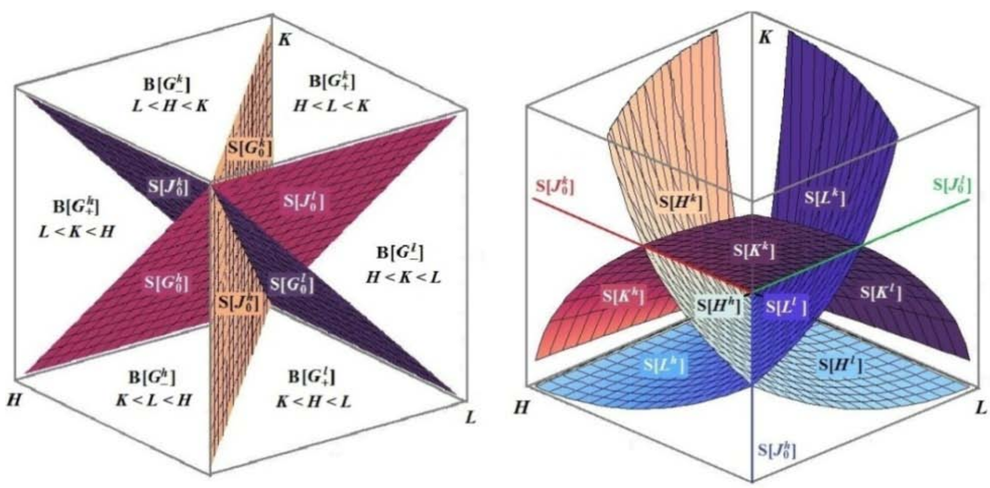


*Figure 2:* (a) Structure of energy space. (b) Equilibrium surfaces in energy space

(2) Structure of energy space. Three planes $\{H = K, K = L, L = H\}$ divide the energy space into six phases: $\{\mathrm{B}[G_\pm^h], \mathrm{B}[G_\pm^l], \mathrm{B}[G_\pm^k]\}$. $\mathrm{B}[H] = \mathrm{B}[G_+^h] + \mathrm{B}[G_-^h]$ is the gas zone, $\mathrm{B}[L] = \mathrm{B}[G_+^l] + \mathrm{B}[G_-^l]$ is the solid zone, and $\mathrm{B}[K] = \mathrm{B}[G_+^k] + \mathrm{B}[G_-^k]$ is the liquid zone. There are six interfaces between the six phases. Among them, the J-type interface $\{\mathrm{S}[J_0^h], \mathrm{S}[J_0^l], \mathrm{S}[J_0^k]\}$ is the interface of zero potential energy, the G-type interface $\{\mathrm{S}[G_0^h], \mathrm{S}[G_0^l], \mathrm{S}[G_0^k]\}$ is the interface of zero chemical energy. Figure 2(a) shows the structure of the energy space.

(3) Equations of equilibrium state. We define the entire energy equals the length of the energy vector, *i.e.*,

$$\begin{aligned} E^h &\equiv L^h + K^h = \sqrt{(H^h)^2 + (L^h)^2 + (K^h)^2}, \\ E^l &\equiv K^l + H^l = \sqrt{(H^l)^2 + (L^l)^2 + (K^l)^2}, \\ E^k &\equiv H^k + L^k = \sqrt{(H^k)^2 + (L^k)^2 + (K^k)^2}. \end{aligned} \tag{36}$$

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These relations give the equations of equilibrium state as

$$(H^h)^2 = 2L^hK^h, \quad (L^l)^2 = 2K^lH^l, \quad (K^k)^2 = 2H^kL^l. \tag{37}$$

(4) Surfaces of equilibrium state. There are three parabolic surfaces in the energy space that represent the equilibrium state of the object. They are the vibration surface $\mathrm{S}[H]$, the rotation surface $\mathrm{S}[L]$, and the translation surface $\mathrm{S}[K]$. Their corresponding equilibrium equations are

$$H = \sqrt{2LK}, \quad L = \sqrt{2KH}, \quad K = \sqrt{2HL}. \tag{38}$$

$\mathrm{S}[H]$, $\mathrm{S}[L]$, and $\mathrm{S}[K]$ represent vibration (radiative) equilibrium, rotation (magnetic) equilibrium, and translation (thermal) equilibrium, respectively. Each surface extends to four phases and three zones, as shown in Figure 2(b).

Table 5 is a matrix describing the structure of the equilibrium surfaces. The diagonal elements $\{\mathrm{S}[H^h], \mathrm{S}[L^l], \mathrm{S}[K^k]\}$ are stable areas, and the rest are excited areas.

*Table 5:* Structure of equilibrium surface

| | $\mathbf{B}[\boldsymbol{H}]$ | $\mathbf{B}[\boldsymbol{L}]$ | $\mathbf{B}[\boldsymbol{K}]$ |
|---|---|---|---|
| $\mathrm{S}[H]$ | $\mathrm{S}[H^h]$ | $\mathrm{S}[H^l]$ | $\mathrm{S}[H^k]$ |
| $\mathrm{S}[L]$ | $\mathrm{S}[L^h]$ | $\mathrm{S}[L^l]$ | $\mathrm{S}[L^k]$ |
| $\mathrm{S}[K]$ | $\mathrm{S}[K^h]$ | $\mathrm{S}[K^l]$ | $\mathrm{S}[K^k]$ |

(5) Definition of energy parameter. Table 6 lists the parameters on the equilibrium surfaces. Among them, $\{X, Y, Z\}$ is motion energy, and $\{E, Q, J, G\}$ is auxiliary energy. $\{a, b\}$ is called the order parameter, which satisfies the relation $ab = 1/2$.

*Table 6:* The definition of the parameters on the equilibrium surfaces

| Equilibrium surface | Definition | $\mathbf{S}[\boldsymbol{H}]$ | $\mathbf{S}[\boldsymbol{L}]$ | $\mathbf{S}[\boldsymbol{K}]$ |
|---|---|---|---|---|
| Equilibrium equation | $X = \sqrt{2YZ}$ | $H = \sqrt{2LK}$ | $L = \sqrt{2KH}$ | $K = \sqrt{2HL}$ |
| Major energy | $X$ | $H$ | $L$ | $K$ |
| Ahead energy | $Y$ | $L$ | $K$ | $H$ |
| Back energy | $Z$ | $K$ | $H$ | $L$ |
| Ahead parameter | $a = Y/X$ | $L/H$ | $K/L$ | $H/K$ |
| Back parameter | $b = Z/X$ | $K/H$ | $H/L$ | $L/K$ |
| Entire energy | $E = Y + Z$ | $L + K$ | $K + H$ | $H + L$ |
| Thermal energy | $Q = Z + X$ | $K + H$ | $H + L$ | $L + K$ |
| Potential energy | $J = Y - X$ | $L - H$ | $K - L$ | $H - K$ |
| Chemical energy | $G = Z - Y$ | $K - L$ | $H - K$ | $L - H$ |
| Energy quantum | $X_s$ | $H_s = hv$ | $L_s = lz$ | $K_s = kT$ |

*d) Quantum state*

(1) Energy quantum. The energy quanta of the *N*-particle system are the average energies of three-modes of motion

$$H_s = H/N = hv, \; L_s = L/N = lz, \; K_s = K/N = kT. \tag{39}$$

In the SI system, $v$ is the vibration intensity (frequency) with unit hertz (Hz), $z$ is the rotation intensity (magnetic induction strength) with unit tesla (T), and $T$ is the translation intensity (thermodynamic temperature) with unit kelvin (K). Taking the energy unit as joule (J), then, $h = 6.6260693 \times 10^{-34}\ \mathrm{J \cdot Hz^{-1}}$ is Planck constant, $l = 9.2740095 \times 10^{-24}\ \mathrm{J \cdot T^{-1}}$ is Bohr magneton constant, and $k = 1.3806506 \times 10^{-23}\ \mathrm{J \cdot K^{-1}}$ is Boltzmann constant.

(2) Quantum state theorem. A quantum state is a state in which the digits of energy on the equilibrium surface take integers $\{\tilde{X}, \tilde{Y}, \tilde{Z}\}$. The quantum state $\{\tilde{X}, \tilde{Y}, \tilde{Z}\}$ is a set of positive integer solutions of the algebraic equations $\{X^2 = 2YZ, Y^2 = 2ZX, \; Z^2 = 2XY\}$.

(3) Quantum state plot: With *Z* as abscissa and *Y* as ordinate, we can plot the quantum state of the curved surface $\mathrm{S}[X]$ with the *Y*-*Z* plane, as shown in Figure 3.

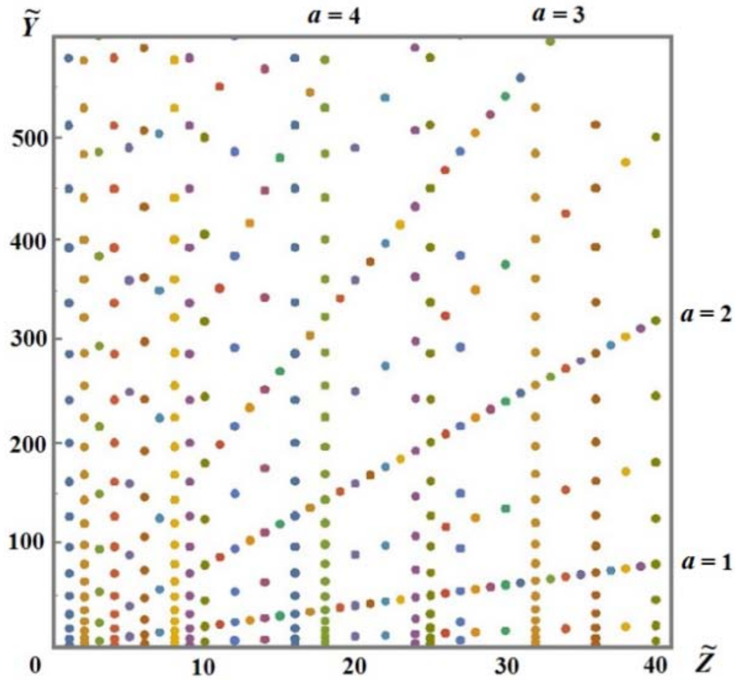


*Figure 3:* The plane plot of the quantum state of equilibrium surface $S[X]$

e) *Application examples*

(1) Equations of state. The entire energy of an object can be decomposed according to the motion mode, volume, and particle number, as shown in Table 7. The equations of state (including gas, solid, and liquid) are obtained by equating various decomposition formulas [3,4,6].

*Table 7:* The decompositions of entire energy and the equations of state

| Zone (index $\boldsymbol{x}$) | Gas (index $\boldsymbol{h}$) | Solid (index $\boldsymbol{l}$) | Liquid (index $\boldsymbol{k}$) |
|---|---|---|---|
| Energy quantum | $H_s = hv$ | $L_s = lz$ | $K_s = kT$ |
| Mode decomposition | $E^h = \mu_h^h H^h$ | $E^l = \mu_l^l L^l$ | $E^k = \mu_k^k K^k$ |
| Volume decomposition | $E^h = q^h V^h$ | $E^l = q^l V^l$ | $E^k = q^k V^k$ |
| Particle decomposition | $E^h = \mu_h^h N H_s$ | $E^l = \mu_l^l N L_s$ | $E^k = \mu_k^k N K_s$ |
| Equation of state | $q^h V^h = \mu_h^h N H_s$ | $q^l V^l = \mu_l^l N L_s$ | $q^k V^k = \mu_k^k N K_s$ |

(2) Phase transition. Two types of phase interfaces correspond to two different types of phase transition: G-type interface corresponds to the continuous phase transition, J-type interface corresponds to the discontinuous phase transition. Table 8 shows the phase transition parameters in the J-type interface. The order parameter on the interface has 1/2 jump, and the leap of potential energy represents the latent energy of phase transition [4,6].

*Table 8:* The discontinuity at the zone interfaces (J-type phase transition)

| Zone interface | Gas-Solid $\mathbf{S}[\boldsymbol{J}_0^h]$ | Solid-liquid $\mathbf{S}[\boldsymbol{J}_0^l]$ | Liquid-Gas $\mathbf{S}[\boldsymbol{J}_0^k]$ |
|---|---|---|---|
| Equilibrium condition | $H^h = L^h = 2K^h$ | $L^l = K^l = 2H^l$ | $K^k = H^k = 2L^k$ |
| | $H^l = L^l = 2K^l$ | $L^k = K^k = 2H^k$ | $K^h = H^h = 2L^h$ |
| Order parameter | $\Delta a^{hl} = -1/2$ | $\Delta a^{lk} = -1/2$ | $\Delta a^{kh} = -1/2$ |
| | $\Delta b^{hl} = 1/2$ | $\Delta b^{lk} = 1/2$ | $\Delta b^{kh} = 1/2$ |
| Entire energy | $\Delta E^{hl} = 3(K^l - K^h)$ | $\Delta E^{lk} = 3(H^k - H^l)$ | $\Delta E^{kh} = 3(L^h - L^k)$ |
| Chemical energy | $\Delta G^{hl} = K^l + K^h$ | $\Delta G^{lk} = H^k + H^l$ | $\Delta G^{kh} = L^h + L^k$ |
| Thermal energy | $\Delta Q^{hl} = 4K^l - 3K^h$ | $\Delta Q^{lk} = 4H^k - 3H^l$ | $\Delta Q^{kh} = 4L^h - 3L^k$ |
| Potential energy | $\Delta J^{hl} = -K^l$ | $\Delta J^{lk} = -H^k$ | $\Delta J^{kh} = -L^h$ |

(3) Hydrogen spectrum [5]. Table 9 is the quantum state of $\tilde{L} = 1 \sim 10$ on the thermal equilibrium surface $S[K]$. In the table, $S[K^h]$ represents the excited state of vibration. $L[J_0^k]$ is the intersection of $S[K]$ and $S[H]$, representing a stable state. The first column, $\tilde{L} = 1$, is the ground state.

*Table 9:* Quantum state of $\tilde{L} = 1 \sim 10$ with ground state $\tilde{L} = 1$ on the $S[K]$ surface

| State | $L[J_0^k]$ | $S[K^h]$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\tilde{K}$ | 2 | 8 | 18 | 32 | 50 | 72 | 98 | 128 | 162 | 200 | … |
| $\tilde{H}$ | 2 | 16 | 54 | 128 | 250 | 432 | 686 | 1024 | 1458 | 2000 | … |
| $\tilde{L}$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | … |
| $a$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | … |

According to the equilibrium state equation and the above table, we obtain the Balmer formula of the emission spectrum for the ground state $(\tilde{L} = 1)$.

$$\bar{v}_{a'a} = \frac{H(a)}{2h}\left(\frac{1}{a^2} - \frac{1}{a'^2}\right), \quad (a = 1,2,3,\cdots;\ a' = a+1, a+2, a+3, \cdots). \tag{40}$$

$\bar{v}_{a'1}, \bar{v}_{a'2}, \bar{v}_{a'3}$ are the spectral frequencies of the Lyman series, the Palmer series, and the Paschen series of hydrogen atoms, respectively. The ahead order parameter is the principal quantum number in Bohr's atomic theory.

*f) Important conclusions*

(1) Elastic particles have three independent motion modes of translation, rotation, and vibration. They are the origins of heat, magnetism, and radiation of objects, respectively. The wave-particle duality comes from the elastic vibration of the microscopic particles.

(2) The motion energies of the three modes $\{H, L, K\}$ express the state of an object. Energy space is a complete description of the motion state of particles inside an object. We can use it to explain the mechanism of state variation (such as the equations of state, phase transition, and light emission).

(3) There are three equilibrium surfaces in the energy space, which represent the thermal (translation) equilibrium, magnetic (rotation) equilibrium, and radiative (vibration) equilibrium.

(4) Energy quantum $\{H_s = hv,\ L_s = lz,\ K_s = kT\}$ is the statistical average of motion energy $\{H, L, K\}$. Quantum states are thermodynamic equilibrium states in which the digits of energy take integers $\{\tilde{H}, \tilde{L}, \tilde{K}\}$.

(5) The order parameter is the ratio of motion energy. The order parameter includes ahead parameter and back parameter. The ahead parameter $(a)$ represents the ordered degree of the system, and the back parameter $(b)$ represents the disordered degree of the system. It has $ab = 1/2$ for an equilibrium system.

(6) The essence of pressure is the density of motion energy. There are three modes of motion energy, and so, three modes of pressure. The pressure is a vector of energy space, not a vector of physical space.

(7) Mass and energy are two different physical quantities. Mass is the intrinsic quantity of an object, and energy is the motion quantity of the object. Without motion, there is no energy. Mass and energy are not interchangeable.

(8) Relativity theory applies to high-speed translating particles, and quantum theory applies to microscopic vibrating particles. Real physics comprehensively considers the translation, rotation, and vibration of elastic particles, and applies to any object.

## V. Theory of Thermodynamics

The thermodynamics of real physics is a theory of the ensemble statistics based on the conservation of particle number. The basic goal is to derive thermodynamic relations and equations through the particle statistics and reveal the essence of classical thermodynamic laws [3,4,6,9].

*a) Statistical principle*

(1) Cluster ensemble. The object volume $V$ is divided into $\tilde{V}$ cells by the volume quantum $V_s = r_s^3$. The set of particles in a space cell is called a cluster, and the cluster with *n* particles is called an *n*-cluster. Imagine to take the "snapshot" of the particle configuration by the time interval $t_s$. Within the finite time $t = t_s \cdot \tau;\ \tau = 1,2,\cdots,k,\cdots N_\tau$, the set of all snapshots is called a cluster ensemble. Figure 4 is a sketch map of a cluster ensemble with ten particles at $\tau = 1,2,3,4$.

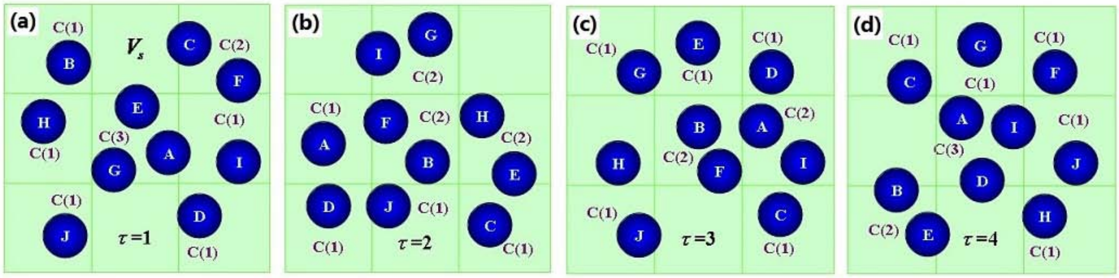


*Figure 4:* Sketch map for the statistical principle of cluster ensemble

(2) Cluster statistics. An $N \times N_\tau$ matrix describes the cluster of the ensemble, and the matrix element $C_{n\tau}$ represents the number of $n$-clusters in the $\tau$-snapshot. The number of $n$-clusters $(C_n)$ and the total number of clusters $(C)$ are

$$C_n = \frac{1}{N_\tau} \sum_{\tau=1}^{N_\tau} C_{n\tau}, \tag{41}$$

$$C = \sum_{n=1}^{N} C_n = \frac{1}{N_\tau} \sum_{n=1}^{N} \sum_{\tau=1}^{N_\tau} C_{n\tau} = \tilde{V} \leq N. \tag{42}$$

The cluster ensemble satisfies the condition of the particle number conservation

$$\sum_{n=1}^{N} (n \cdot C_n) = N. \tag{43}$$

The occurrence probability of $n$-cluster satisfies the condition of normalization

$$\rho_n \equiv \frac{C_n}{C}, \quad \sum_{n=1}^{N} \rho_n \equiv \sum \rho_n = 1. \tag{44}$$

(3) Cluster energy. The energies of $n$-clusters, $\eta_n, \lambda_n, \kappa_n, \varepsilon_n, \theta_n, \varphi_n, \gamma_n$, are respectively the vibration energy, rotation energy, translation energy, entire energy, thermal energy, potential energy, and chemical energy. Thus, we can obtain the total energies through cluster statistics.

$$\begin{aligned}
H &= \sum C_n \eta_n = C \sum \rho_n \eta_n = C\eta, \quad \eta = \sum \rho_n \eta_n. \\
L &= \sum C_n \lambda_n = C \sum \rho_n \lambda_n = C\lambda, \quad \lambda = \sum \rho_n \lambda_n. \\
K &= \sum C_n \kappa_n = C \sum \rho_n \kappa_n = C\kappa, \quad \kappa = \sum \rho_n \kappa_n. \\
E &= \sum C_n \varepsilon_n = C \sum \rho_n \varepsilon_n = C\varepsilon, \quad \varepsilon = \sum \rho_n \varepsilon_n. \\
Q &= \sum C_n \theta_n = C \sum \rho_n \theta_n = C\theta, \quad \theta = \sum \rho_n \theta_n. \\
J &= \sum C_n \varphi_n = C \sum \rho_n \varphi_n = C\varphi, \quad \varphi = \sum \rho_n \varphi_n. \\
G &= \sum C_n \gamma_n = C \sum \rho_n \gamma_n = C\gamma, \quad \gamma = \sum \rho_n \gamma_n.
\end{aligned} \tag{45}$$

Where $\eta, \lambda, \kappa, \varepsilon, \theta, \varphi, \gamma$ are the average energies of the cluster.

(4) Partition function. The partition functions of gas, solid, and liquid are respectively

$$\begin{aligned}
Z_L^h &= \int_{\Gamma^h} \exp(-\tilde{L}^h)\, d\Gamma^h, \\
Z_K^l &= \int_{\Gamma^l} \exp(-\tilde{K}^l)\, d\Gamma^l, \\
Z_H^k &= \int_{\Gamma^k} \exp(-\tilde{H}^k)\, d\Gamma^k.
\end{aligned} \tag{46}$$

Where $\Gamma^x(x = h, l, k)$ is the space of statistical zone. $\exp(-\tilde{L}^h)$, $\exp(-\tilde{K}^l)$, and $\exp(-\tilde{H}^k)$ are the probability density of the ahead energy. The partition function gives the digit of ahead energy as

$$\tilde{L}^h = \ln Z_L^h, \quad \tilde{K}^l = \ln Z_K^l, \quad \tilde{H}^k = \ln Z_H^k. \tag{47}$$

*b) Statistical Functions*

Table 10 lists the statistical functions of the particle system given by strict calculation [4]. Where $Y_s$ is the elastic modulus scale, $I_s$ is the rotary inertia scale, and $M_s$ is the mass scale. The results show that the motion energy of the cluster is proportional to the logarithm of its volume. The order parameters of gas, solid, and liquid are the statistical functions of elastic modulus, rotary inertia, and mass of clusters, respectively.

*Table 10:* Statistical functions of the particle system

| | Gas | Solid | Liquid |
|---|---|---|---|
| Energy quantum | $H_s = H/N = Y_s V_s = hv$ | $L_s = L/N = I_s \omega_s^2 = lz$ | $K_s = K/N = M_s u_s^2 = kT$ |
| Partition function | $Z_L^h = \prod_{n=1}^{N} (\tilde{V}_{n\varphi}^h / \tilde{V}_{n\eta}^h)^{C_n^h}$ | $Z_K^l = \prod_{n=1}^{N} (\tilde{V}_{n\varphi}^l / \tilde{V}_{n\lambda}^l)^{C_n^l}$ | $Z_H^k = \prod_{n=1}^{N} (\tilde{V}_{n\varphi}^k / \tilde{V}_{n\kappa}^k)^{C_n^k}$ |
| Vibration energy | $\tilde{H}^h = -\sum (C_n^h \cdot \ln \tilde{V}_{n\eta}^h)$ | $\tilde{H}^l = -\sum (C_n^l \cdot \ln \tilde{V}_{n\eta}^l)$ | $\tilde{H}^k = -\sum (C_n^k \cdot \ln \tilde{V}_{n\eta}^k)$ |
| Rotation energy | $\tilde{L}^h = -\sum (C_n^h \cdot \ln \tilde{V}_{n\lambda}^h)$ | $\tilde{L}^l = -\sum (C_n^l \cdot \ln \tilde{V}_{n\lambda}^l)$ | $\tilde{L}^k = -\sum (C_n^k \cdot \ln \tilde{V}_{n\lambda}^k)$ |
| Translation energy | $\tilde{K}^h = -\sum (C_n^h \cdot \ln \tilde{V}_{n\kappa}^h)$ | $\tilde{K}^l = -\sum (C_n^l \cdot \ln \tilde{V}_{n\kappa}^l)$ | $\tilde{K}^k = -\sum (C_n^k \cdot \ln \tilde{V}_{n\kappa}^k)$ |
| Order parameter | $a^h = \frac{3}{4} \cdot \ln(2\pi \tilde{Y}_c)$ | $a^l = \frac{3}{4} \cdot \ln(2\pi \tilde{I}_c)$ | $a^k = \frac{3}{4} \cdot \ln(2\pi \tilde{M}_c)$ |
| cluster correlation | $\ln \tilde{Y}_c = \sum (\rho_n^h \cdot \ln \tilde{Y}_n)$ | $\ln \tilde{I}_c = \sum (\rho_n^l \cdot \ln \tilde{I}_n)$ | $\ln \tilde{M}_c = \sum (\rho_n^k \cdot \ln \tilde{M}_n)$ |

*c) Thermodynamic functions*

(1) Motion energy. Because the three energy zones have even permutation symmetry for $\langle H, L, K \rangle$, we take the liquid zone $\mathbb{E}^k = \langle K^k, H^k, L^k \rangle$ as an example to give the calculation results.

For liquid, the major energy is translation energy $K$, the ahead energy is vibration energy $H$, the back energy is rotation energy $L$, and the energy quantum is $K_s = kT$. The ahead and back parameters are $a = H/K$ and $b = L/K$, respectively.

According to the relationship $C = bN$, we can decompose the motion energy by the number of particles $N$ and the number of clusters $C$ as

$$\begin{aligned} K &= NK_s = C\kappa, & \kappa &= b^{-1}K_s. \\ H &= aNK_s = C\eta, & \eta &= ab^{-1}K_s. \\ L &= bNK_s = C\lambda, & \lambda &= K_s. \end{aligned} \tag{48}$$

(2) Auxiliary energy. We can express the auxiliary energy by the particle number and the cluster number as

$$\begin{aligned} E &= N(a+b)K_s = C\varepsilon, & \varepsilon &= (ab^{-1}+1)K_s. \\ Q &= N(b+1)K_s = C\theta, & \theta &= (1+b^{-1})K_s. \\ J &= N(a-1)K_s = C\varphi, & \varphi &= (a-1)b^{-1}K_s. \\ G &= N(b-a)K_s = C\gamma, & \gamma &= (1-ab^{-1})K_s. \end{aligned} \tag{49}$$

(3) Internal energy and enthalpy energy. We introduce two other auxiliary functions: internal energy $U$ and enthalpy energy $Y$.

$$U \equiv Q - H = K + L - H, \quad Y \equiv Q + G = K + 2L - H. \tag{50}$$

We express the internal energy and enthalpy energy by the particle number and cluster number as follows

$$U = N(1 + b - a)K_s = Cv, \quad v = (1 + b - a)b^{-1}K_s. \tag{51}$$

$$Y = N(1 + 2b - a)K_s = C\psi, \quad \psi = (1 + 2b - a)b^{-1}K_s. \tag{52}$$

(4) Thermal entropy and chemical entropy. We define the thermal entropy $S$ and the chemical entropy $Z$ as

$$S \equiv Q/T = (b + 1)Nk, \quad Z \equiv G/T = (b - a)Nk. \tag{53}$$

The thermal entropy $\sigma$ and chemical entropy $\zeta$ of the cluster is

$$\sigma = \frac{S}{C} = \frac{\theta}{T}, \quad \zeta = \frac{Z}{C} = \frac{\gamma}{T}. \tag{54}$$

According to Boltzmann entropy formula $S = k \cdot \ln \Omega$, we find the thermodynamic probability $\Omega$.

$$\Omega = \exp(S/k) = \exp[(b + 1)N]. \tag{55}$$

*d) Thermodynamic equations*

Table 11 lists the energy relations and basic equations of thermodynamics [4,9]. The energy function corresponds to the characteristic function of classical thermodynamics. The basic equations are derived from the differential of cluster energy [4]. They contain the basic laws of classical thermodynamics (the first law and the second law).

*Table 11:* The Energy relations and equations of the liquid

| Energy | Relation | Equation |
|---|---|---|
| Vibration energy | $H = J + K = L - G = Q - U$ | $dH = SdT + q_l dV - \gamma dC$ |
| Rotation energy | $L = H + G = Q - K, \quad L = q_l V$ | $dL = SdT + q_l dV + Cd\gamma$ |
| Translation energy | $K = H - J = Q - L = U - G$ | $dK = TdS - q_l dV - Cd\gamma$ |
| Thermal energy | $Q = L + K = H + U, \quad Q = ST$ | $dQ = TdS + Vdq_l - Cd\gamma$ |
| Chemical energy | $G = L - H = U - K, \quad G = C\gamma$ | $dG = -SdT + Vdq_l + \gamma dC$ |
| Internal energy | $U = Q - H = K + L - H$ | $dU = TdS - q_l dV + \gamma dC$ |
| Enthalpy energy | $Y = Q + G = K + 2L - H$ | $dY = TdS + Vdq_l + \gamma dC$ |
| Zero | $0 = Q - Q = L - L = G - G$ | $0 = SdT - Vdq_l + Cd\gamma$ |

*e) Important conclusions*

(1) Thermodynamics of real physics is a theory based on the statistics of the cluster ensemble. In a cluster ensemble, the number of particles is conserved, but the number of clusters is variable. The statistics of the cluster ensemble are a complete and accurate statistical method.

(2) The elastic particle system has three kinds of balance states. They are the thermal (translation) equilibrium, magnetic (rotation) equilibrium, and radiative (vibration) equilibrium. The zeroth law of thermodynamics claims the situation of thermal equilibrium (heat balance).

(3) The positivity of motion energy $\{H > 0, L > 0, K > 0\}$ demands the positivity of equilibrium parameter $\{v > 0, z > 0, T > 0\}$. The third law of thermodynamics claims the situation $T > 0$ (Absolute zero kelvin is unreachable).

(4) The thermal energy $(Q)$ is a state function. The internal energy $(U = Q - H)$ is the difference between the thermal energy $(Q)$ and the vibration energy $(H)$. $dU = dQ - dH$ is a form of the first law of thermodynamics. Where the heat is the difference of the thermal energy $(dQ)$, and the work done by the system comes from the reduction of the vibration energy $(-dH)$.

(5) The entropy of a thermodynamic system includes thermal entropy and chemical entropy. Thermal entropy is always positive, and chemical entropy can be positive or negative. The formula $S \equiv Q/T = (b + 1)Nk$ shows

that the thermal entropy is proportional to the number of particles and the back parameter, which reflects the disorder degree of the system.

(6) The motion energy and auxiliary energy contain all characteristic functions of the classical thermodynamics, and have definite meanings. For example, Helmholtz free energy is the negative vibration energy $(-H)$, and grand potential is the negative rotation energy $(-L)$.

(7) The equation $SdT - Vdq_l + Cd\gamma = 0$ is equivalent to the Gibbs relation of classical thermodynamics.

(8) The motion energy of clusters is proportional to the volume logarithm, which reveals the relationship between the motion and volume of objects. The larger the size of an atom is, the larger the energy it contains. The energy released by splitting a heavy atom is the motion energy of particles inside the nucleus, not the loss of mass.

*Conclusive remark*

Salute, classical physics; goodbye, modern physics; welcome, real physics！

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# Platonic Quantum Set Theory Proposal and Fractal-Cantorian Heterotic Kaluza-Klein Spacetime

By Mohamed S. El Naschie
*University of Alexandria*

*Abstract-* The four basic building blocks of the cosmos hypothesized by the Athenian philosopher Plato and his corresponding theory are replaced by the backbone golden mean based scaling pertinent to each of the four kinds of blocks. In the course of doing this we stretch and generalize Plato's philosophical ideas to ultimately find out that it is essentially the deep philosophical origin of the golden mean number system of E-infinity Cantorian spacetime theory of high energy physics and quantum cosmology. Subsequently we use this new platonic form of E-infinity quantum set theory to uncover a remarkably rich Kaluza-Klein fractal version of Gross et al's ingenious Heterotic superstring theory.

*Keywords: platonic building blocks of nature, e-infinity theory, heterotic superstrings, fractal heterotic kaluza-klein spacetime, the golden mean number system of cantorian spacetime.*

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PLATONICQUANTUMSETTHEORYPROPOSALANDFRACTALCANTORIANHETEROTICKALUZAKLEINSPACETIME

# Platonic Quantum Set Theory Proposal and Fractal-Cantorian Heterotic Kaluza-Klein Spacetime*

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*Abstract-* The four basic building blocks of the cosmos hypothesized by the Athenian philosopher Plato and his corresponding theory are replaced by the backbone golden mean based scaling pertinent to each of the four kinds of blocks. In the course of doing this we stretch and generalize Plato's philosophical ideas to ultimately find out that it is essentially the deep philosophical origin of the golden mean number system of E-infinity Cantorian spacetime theory of high energy physics and quantum cosmology. Subsequently we use this new platonic form of E-infinity quantum set theory to uncover a remarkably rich Kaluza-Klein fractal version of Gross et al's ingenious Heterotic superstring theory.

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## I. Introduction

The present author first encountered the ideas of Plato speculations on what the universe as we know it is made of ultimately not through the study of philosophy in general nor the writings of Plato in particular, but rather from the powerful recollections of Werner Heisenberg and Karl Friedrich Wizecker [1] and attending various informal talks, general lectures, philosophical seminars and subsequent reading, discussion and correspondence [1-6]. The effect on the writer who at the time, was nothing more than a diligent student of structural engineering at the Technical High School of Hannover, Germany where he later on obtained a so called Vordiplom in Civil Engineering and two years later his Diplom in 1969 (see Ref. [7]) was far more than profound, in fact mind blowing. The young man of that time was both elated and bewildered to observe Nobel Laureates in Physics and world famous scientists who were suspected to be capable of designing an atom bomb [8-11] not only engage in ideal philosophical discourses but considering philosophy to be in a sense the quasi foundation of their ground breaking work on high energy particle physics [12]. The author was exceedingly impressed but never the less not totally convinced and thought that the reference to philosophy as a precursor to the standard model and the Work at institutions such as CERN [13] is a consequence of the learnedness of those eminent scientists and an interesting look back in history to motivate the general non-specialized reader to endure what is otherwise a highly difficult mathematical and technical subject [2], [12-13]. All the same, as time has gone by and the author graduated from Hannover with a Dipl. Ing [7] and then got his Ph.D. from University College, London in Applied Mechanics [14] and finally as a young professor decided to change career altogether and moved to physics first in Cambridge, UK and then to many other universities world wide, it was time after time the early ideas on Plato's thesis that kept him captive and then via nonlinear dynamics, chaos, fractals and M. Feigenbaum's golden mean renormalization group [15-17] that gave him the feeling of a golden mean connection between Plato's philosophy, high energy physics and his relatively new discovery of the golden mean number system [18-25] which was then linked to the associated transfinite Turing golden mean computer as well as von Neumann's cellular automaton [26-28].

There are a great number of publications that emanated from pondering these subjects [29-87] from that period. In addition to that and with the passing of time, we gained an increased intuition that the golden mean number system holds the secret for solving the mystery implicit in Plato's speculation as well as supports the results of sophisticated experiments of various laboratories and powerful accelerators all around the world [84-85]. That is how our work on unification of all fundamental forces [2],[19],[34],[39] andthe empty set nature of the Aether, Casimir-dark energy reactors proposal, fuelless space travel and the like came about and can be viewed and understood with the benefit of hindsight [52],[57],[64].

Having said all that we must admit that for some strange or not fully understood reason from our side, it is only now that we just realized the utter depth and almost super advanced power of the ideas of Plato which when we probed further and more intense, turned out to lead to an even simpler theory than we could ever have guessed or imagined and this theory in turn lead to

*Author: Distinguished Professor, Dept. of Physics, Faculty of Science, University of Alexandria, Alexandria, Egypt. e-mail: chaossf@aol.com*

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a refinement of E-infinity Cantorian spacetime theory which we propose here to call the platonic quantum set theory [4-6]. It is the ultimate theory of unification which goes beyond unification of all fundamental interactions [43],[46],[60] and represents a first serious step to unify science and art [23],[27],[69],[85-86] all apart of giving a rational scientific explanation for artificial intelligence and even artificial life [18[,[28],[69],[81],[86].

In the first part of the present work we give an outline of this platonic quantum set theory proposal starting rom the main postulates of E-infinity Cantorian spacetime theory. In the second part we apply by way of illustration, the new proposal to D. Gross et al's ingenious Heterotic superstring theory [44-45],[67] to first converting it to a transfinite Heterotic string [44-45] and subsequently to a Heterotic fractal Kaluza-Klein spacetime theory [12],[40] which we use to determine accurately and with a minimal amount of computation, the density of the ordinary and the dark components of the energy of the cosmos [19],[21],[40],[47].

## II. Plato's Quantum Set Theory Proposal

*a) Review of previous concepts, the pre-quantum particle and the pre-quantum wave of E-infinity Cantorian spacetime theory*

Clearly the best way to present our new proposal is to start where we left off in our transfinite set theory founded quantum mechanics, i.e. E-infinity theory Cantorian spacetime [2],[12],[20-21]. This is obvious from the simple self evident fact mentioned in the introduction that the present proposal is sharpening and simplifying E-infinity theory in the light of our new and deep understanding of the wealth, width and breadth of Plato's ideas that lay dormant in our subconscious from our very own early student days more than half a century ago. Let us summarize what we discovered and used extensively in the past and then we will reconnect and expand it in the light of our present new deeper understanding [20,21].

(a) A pre-quantum particle is modelled in E-infinity Cantorian-fractal spacetime theory by a zero set which has two dimensions, namely first a zero for being a point-like entity as a topological dimension and a second dimension which is a Hausdorff dimension $\phi=\left(\sqrt{5}-1\right)/2=0.618033$ for being not a simple point but really a pre-point belonging to a pre-geometry called Cantorian geometry or more accurately, it is a Mauldin-Williams one dimensional random Cantor set with $\phi$ as a Hausdorff dimension and a zero length, i.e. it is a thin Cantor set of a measure zero [20-21]. Needless to say that at this level of description all pre-quantum particles are the same. However as we move towards the experimentally observable standard model only the photon of all other quantum particles retain this $\phi$ value as explained in detail elsewhere in many previous publications.

(b) A pre-quantum wave is modelled in E-infinity using the empty set [20-21] of set theory and following the classical definition of empty set it was fixed again by two dimensions. The first is a topological dimension equal minus one as reasoned by the deductive Menger-Urysohn dimensional theory while the second is a Hausdorff dimension equal to $\phi^2$. In other words, $\phi^2$ is the intersection of two zero sets $(\phi)\otimes(\phi)=\phi^2$ exactly as what comes out of the dimensional function of Penrose fractal tiling universe deduced by Alain Connes, the creator of noncommutative geometry [20-30].

(c) From the preceding exposition it then turns out that there are higher dimensions implied by the above, namely $\phi^3$ for spacetime fluctuation as well as Casimir topological pressure, $\phi^4$ for the topological Unruh temperature and so on. However nothing has so much impact on mathematical physics in general and E-infinity in particular as the discovery of Hardy's quantum probability of entanglement which is found theoretically and experimentally to be exactly $\phi^5$ as discussed in many relatively recent papers by the author and his associates and colleagues, notably Prof. Ji-Huan He, Prof. L. Marek-Crnjac and Prof. A. Helal [4-6],[15-21],[23]. Finally for the moment we must mention $\phi^6$ which is the famous Barbero-Immirzi parameter which brings two fundamental theories together at least as far as black hole entropy is concerned [20-21]. That ends our quintessential minimal review of things that are retained in our new proposal and we may now direct our attention to the refinement we need to introduce to bring E-infinity to the level of the platonic E-infinity.

*b) Deeper into the platonic quantum set theory proposal*

From section 2.1 and following E-infinity golden mean quantum set theory, we have $\phi$ zero set from pre-quantum particles and $\phi^2$ empty set pre-quantum wave. Consequently following the same thinking pattern of combinatoric basic to the platonic methodology we see that $\phi$ and $\phi^2$ may be joined either inter-sectionally or via a simple intersection to give [20]

$$\phi\otimes\phi^2=\phi^3 \tag{1}$$

i.e. a quantum fluctuation equivalent to a Casimir topological pressure or a simple union

$$\phi+\phi^2=1 \tag{2}$$

which may be interpreted as a pre-classical particle. The vital point is that in the first case the inversion of $\phi^3$ leads us to [12],[20]

$$1/\left(\phi\otimes\phi^2\right)=4+\phi^3 \quad (3)$$

which is a fractal dimension of a scale invariant Einstein four-dimensional space [20-30]. On the other hand, in the case of $\phi+\phi^2=1$, the inversion remains a neutral one dimension. Let us insist pedantically on looking inside this one dimension in terms of the zero set pre-quantum particles. This leads to the elementary expansion [12]

$$\begin{aligned}1/\phi &= 1+\phi \\ &= 2\phi+\phi^2\end{aligned} \quad (4)$$

Similarly in terms of $\phi^2$ we find that

$$\begin{aligned}1/\phi^2 &= 2+\phi \\ &= 2\phi+2\phi^2+\phi \\ &= 3\phi+2\phi^2\end{aligned} \quad (5)$$

Consequently we have then the following elementary duality

$$\left(1+\phi\right)\left(\phi\right)=1 \quad (6)$$

and

$$\left(2+\phi\right)\left(\phi^2\right)=1 \quad (7)$$

which is a useful tautology that could be applied to $4+\phi^3$ of Einstein's scale invariant fractal spacetime to find the indistinguishability condition at the root of the two slit experiment with quantum particles, namely [21],[31],[50]

$$\left(1+\phi\right)+\left(2+\phi\right)=4+\phi^3 \quad (8)$$

and

$$\left(1+\phi\right)x\left(2+\phi\right)=4+\phi^3 \quad (9)$$

In other words in physical terms there is no difference between union and intersection in $4+\phi^3$ space and obtaining a which way information based on probability theory is fundamentally not possible and such a space is said to fundamentally and irreducibly nonlocal as discussed in numerous previous publications in the past twenty years or so [29-39]. The novel point however is the similarity to the platonic arguments applied many centuries ago using pure reason. For instance Plato's 8-sided platonic figure which represents air may be created by combining two five platonic figures which are each four sided. Thus in essence there is no fundamental difference between air and fire except the intrinsic topology of the geometric shape which is orchestrated to obey a single scaling law governed by number theoretical necessities dictated by the golden mean number system translating numeric to geometry as well as topology and visa versa. This is exactly what we conclude from the discussion of section 1.2 as well as this section because we can now get rid of any fundamental distinction between particles and fields or spacetime and quantum waves [20-21]. At the pre-geometry, pre-particle and pre-wave all the imagined fundamental problems evaporate and we are left with very simple golden mean combination [72-82]. The conventional theories by contrast are plagued with paradoxes and anomalies and require a huge super computer and the not yet invented quantum computer to tackle the highly complex time consuming computation if at all practically possible to calculate in the first place. The best one could do now is to apply our proposal to a concrete problem and that is our next task, which will be to develop a Heterotic Kaluza-Klein theory for determining the ordinary, and dark energy density sectors of the cosmos [19-28].

## III. Fractal Heterotic Kaluza-Klein Spacetime from the Fractal Heterotic Superstring Theory

### a) *Thefractal Heterotic superstring*

In numerous previous publications D. Gross et al's ingenious combination of the bosonic (old) string theory with D = 26 and superstring theory D = 10 resulting in the Heterotic superstring with 16 extra bosons was extended to a transfinite fractal version with the help of golden mean scaling and the 'tHooft's renormalon quasi particle $k=\phi^3\left(1-\phi^3\right)$[59-69]. That was how the new Heterotic superstring was used to accurately calculate the ordinary cosmic energy density as well as the density of the pure dark energy as well as the density of dark matter energy. Skipping the various details of the relatively exceedingly simple computation, we arrive at the following equations [74-76]:

(a) First we generate the main Heterotic spacetime [44-45],[67] from the inverse electromagnetic fine structure constant $\bar{\alpha}_2=137+k_o$ as follows

$$\frac{1}{2}\left(\frac{\bar{\alpha}_o}{2}\right)(\phi)^n \quad \begin{array}{ll} \underrightarrow{n=1} & 42+2k \\ \underrightarrow{2} & 26+k \\ \underrightarrow{3} & 16+k \\ \underrightarrow{4} & 10 \\ \underrightarrow{5} & 6+k \\ \underrightarrow{6} & 4-k \end{array} \tag{10}$$

Note that while $4+2k$ is the inverse non-super symmetric quantum gravity coupling, $6+k$ is the compactified dimensions of superstring theory and $4-k$ is 'tHooft-Weltman-Wilson fractal spacetime, the $(26+k)-10=16+k$ are the extra gross bosons and k is the 'tHooft renormalon where $k=\phi^3\left(1-\phi^3\right)$ which is related to Hardy's quantum entanglement probability $\phi^5$ by the simple relation $k=2\phi^5$ [74-76].

(b) As shown in many previous publications we can find the maximal energy density of the universe from $E=kmc^2$ of Umov-Lorentz-Poincare and Einstein by noting that $k_{max}$ is equal one and in this case $k=\frac{(26-4)}{(26-4)}=\frac{22}{22}$ so that the 22 are divided into three parts, namely 1+5+16=22 leading to [75-76]

$$E=\left(\frac{1+5+16}{22}\right)kmc^2 \tag{11}$$

where the ordinary density is

$$E(O)=\left(\frac{1}{22}\right)kmc^2 \tag{12}$$

while the dark matter energy and the pure dark energy density of the cosmos are [74-76]

$$E(DM)=\left(\frac{5}{22}\right)mc^2 \tag{13}$$

and

$$E(PD)=\left(\frac{16}{22}\right)mc^2 \tag{14}$$

respectively.

(b) Clearly these are the approximate values which may be made more accurate by including the 'tHooft renormalon, i.e. transfinite correction k so that one finds [74-76]

$$E(O)=\left(\frac{1}{22+k}\right)mc^2 \tag{15}$$

$$E(DM)=\left(\frac{5}{22+k}\right)mc^2 \tag{16}$$

and

$$E(PD)=\left(\frac{16+k}{22+k}\right)mc^2 \tag{17}$$

Again except for the exact result for E(O), the two other values given by equations (16) and (17) are not exact but only very good approximations because the ordinary energy density is decoupled from the dark energy sector but within the dark energy section, dark matter energy density and pure dark energy density are weakly coupled and the coupling constant $\Lambda$ was determined in previous publications [75-76] and enters into the corresponding density with a minus and plus sign cancelling out in the final analysis so that at the end one finds

$$E=\left[\frac{1}{22+k}+\frac{5-\Lambda}{22+k}+\frac{16+k+\Lambda}{22+k}\right]\left(mc^2\right) \tag{18}$$

(c) Now we proceed further by inserting the exact value of the coupling namely $\Lambda=0.080325$ in equation (18) and find all the exact values for the corresponding cosmic energy density of the dark sector as explained in previous publications. However ignoring the minor effect of the $\Lambda$ coupling one finds the rather satisfactory accurate approximation for the dark sector, namely [74-76]

$$E(DM)=0.2254248\, mc^2 \tag{19}$$

and

$$E(PD)=0.72949016\, mc^2 \tag{20}$$

in addition to the exact E(O) which is independent of coupling $\Lambda$. Now we are in a position to show how the previous result may be obtained from a fractal quasi-Heterotic version of the classical D = 5 Kaluza-Klein spacetime theory. The preceding calculations and conclusions can lead us to consider empty space to be a quasi highly advanced material which could be used in engineering [83].

*b) The fractal Heterotic Kaluza-Klein spacetime theory*

In what follows we will show a remarkable reduction of D. Gross et al's Heterotic superstring [74-76] to a fractal Heterotic Kaluza-Klein theory that we will apply to find the cosmic energy density of the universe in the case of ignoring the coupling $\Lambda$.

Let us recall first that scale invariance converts D = 4 to $4+\phi^3$ as explained earlier on using continued fraction expansion D = 4 + 4 in previous publications. The fractal, self-similar Kaluza-Klein spacetime dimension is subsequently found from adding an extra-compactified dimension leading to our $D=5+\phi^3$ which was the subject of numerous previous publications. The next step is to go back to the three parts dissection characteristic for Gross et al's Heterotic theory by writing that

$$\left(5+\phi^3\right)-1=4+\phi^3 \tag{21}$$

and consequently we have the same opposite sign dimension and corresponding maximal energy density picture as in Gross Heterotic string case [74-76]. To show this more clearly we start from the Newtonian kinetic energy

$$E=\frac{1}{2}mv^2 \tag{22}$$

and let $v \to c$ while remembering that m must be replaced by $\left(5+\phi^3\right)m$ so that

$$\begin{aligned} E &= \frac{1}{2}\left(5+\phi^3\right)mc^2 \\ &= \frac{1}{2}\left(\phi^3+1+4\right)mc^2 \end{aligned} \tag{23}$$

Setting m = 1 and c = $\phi$ as should be, we have

$$E=\frac{1}{2}\left(\phi^3+1+4\right)\phi^2 \tag{24}$$

Introducing the renormalon k one finds

$$E=\frac{1}{2}\left[\phi^3+\left(1+k\right)+\left(4-k\right)\right]\phi^2 \tag{25}$$

That way E$\to$ the energy density $\gamma_{max}$. Consequently we have

$$\begin{aligned} \gamma_{max} &= \frac{1}{2}\left(\phi^5+5\phi^2\right) \\ &= 1 \end{aligned} \tag{26}$$

where $\gamma_{(c)}=\phi^5/2$ and $\gamma_{(D)}=5\phi^2/2$ exactly as should be. The reader must have noticed the versatility of the platonic golden mean theory equivalence to E-infinity quantum set theory and how we move from Newtonian mechanics to relativistic quantum mechanics and visa versa. What is also remarkable is the unit interval Cantor set geometry building blocks of the platonic thinking where the maximal average speed is $\phi$, i.e. exactly equal to the Hausdorff dimension of the pre-quantum particle. Last but by no means least, the triality of the dissection of E into $\left(\phi^5/2\right)$, $\left(1-k\right)\phi^2/2$ and $\left(4-k\right)\phi^2/2$ emulating D. Gross et all's Heterotic theory gives us a clear logic for discriminating between the dark matter energy and the pure dark energy of the dark sector respectively and agree quantitatively completely with the result obtained in the earlier sections using D. Gross et al's Heterotic theory in its transfinite form [74-76].

c) *The interpretive power of the platonic theory and the dark section of cosmic energy*

Without going into much detail within the present work, we would still like to briefly emphasize the interpretive power of our present theory and illustrate it using again the dark section of cosmic energy as an example. The point is that the distinction between dark matter energy and pure dark energy may be explained using the distinction between the Immirzi parameter $\phi^6$ in eight dimensions and the Unruh temperature in ten dimensions. In other words, the maximal E could be rephrased as in the following equation

$$E \cong \frac{1}{2}mc^2\left(\phi^5+8\phi^6+10\phi^4\right) \tag{27}$$

Put in a different way we may write the exact equation

$$\gamma_{(\max)}=\frac{1}{2}\left(\phi^5+5\phi^2\right) \tag{28}$$

approximately as

$$\gamma_{(\max)} \simeq \frac{1}{2}\left(\phi^5+8\phi^6+10\phi^4\right) \tag{29}$$

We stress that here, as before, the approximation stems from ignoring the coupling $\Lambda$ between dark matter energy and pure dark energy and nothing more than that [70-83].

## IV. Conclusion

It would seem that great philosophers of antiquity of the stature of Plato and Pythagoras were asking the right questions, which as is well known, is normally half the right answer. In this way it seem they indeed made greater strides than we initially imagined and in fact we have just started now to realize. There is little doubt, if any as far as the present author is concerned, that these Platonic-Pythagorean ideas and

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ideals are helping us in moving slowly but surely towards understanding nature, particularly cosmology and physics. We feel strongly that this is true even from our highly advance view point of modern sciences such asquantum cosmology, quantum physics and the general theories of unification. We just need to stress more the golden mean number systems and the Cantor sets geometry and topology and presto, we find Plato's theories all of a sudden becoming a highly advanced form of E-infinity Cantorian spacetime theory, string theories, loop quantum gravity, Brane theories and twistors. We conclude that from the viewpoint of deep understanding rather than pragmatic and engineering applications, natural science could not do or advance without a healthy portion of philosophical depth and pure mathematical contemplation. In fact in a forthcoming sequel to the present paper, we will show that given nothing more than an empty set Aether there is simply a probability of 27.316 percent of artificial life and all that it entails to spontaneously appear out of true insubstantial nothingness. It seems that in our universe there is after alla place for Einstein Gods, science and Spinoza's God. The Author willingly admits that he has moved much closer to the views of one of his teachers, Prof. K.F. Weizacher, namely that science and belief are not exclusive but as in quantum mechanics, complimentary, something which he did not embrace particularly in his youth and the roaring 60's of the last century in Germany.

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# Reliability Modelling and Safety Learning Algorithms in Complex Risk Multifunctional Systems

By Kingsley E. Abhulimen
*Department of Chemical Engineering*

*Abstract-* Modelling safety procedures of complex risk systems of multifunctional production systems such as floating production storage and offloading (FPSO) vessels is typically rigorous. Deterministic modelling and Learning algorithms are normally used to generate whole sets of hazard data based on data of intrinsic risk events and safety measures incorporated. The model developed use failure data systems obtained from operator of multifunctional production systems of FPSO to generate fuzzy class surrogates based on learning algorithms to rank safety index. Thus classifications of risk events in a fuzzy set of system is predicted used weighted like hood of failure of human, process, mechanical, electrical, operational, in composite risk system to set the safety thresholds. The model used a learning constraint function in probable risk outcomes to match retroactively weights index of actual scenarios in skewed hazard surrogates to specific risk and safety ratings criteria. The MTBR (Mean Time before Repair) to plan maintainability studies and safety programmes were simulated to an optimal repair range from almost 0.5 yrs for worst case; fuzzy class 1 with safety rating of 0.0 to almost 5 million years for best case when the fuzzy class 5 with safety index rating of 1.0 assume availability is 80%.

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RELIABILITYMODELLINGANDSAFETYLEARNINGALGORITHMSINCOMPLEXRISKMULTIFUNCTIONALSYSTEMS

*Strictly as per the compliance and regulations of:*

# Reliability Modelling and Safety Learning Algorithms in Complex Risk Multifunctional Systems

Kingsley E. Abhulimen

*Abstract-* Modelling safety procedures of complex risk systems of multifunctional production systems such as floating production storage and offloading (FPSO) vessels is typically rigorous. Deterministic modelling and Learning algorithms are normally used to generate whole sets of hazard data based on data of intrinsic risk events and safety measures incorporated. The model developed use failure data systems obtained from operator of multifunctional production systems of FPSO to generate fuzzy class surrogates based on learning algorithms to rank safety index. Thus classifications of risk events in a fuzzy set of system is predicted used weighted like hood of failure of human, process, mechanical, electrical, operational, in composite risk system to set the safety thresholds. The model used a learning constraint function in probable risk outcomes to match retroactively weights index of actual scenarios in skewed hazard surrogates to specific risk and safety ratings criteria. The MTBR (Mean Time before Repair) to plan maintainability studies and safety programmes were simulated to an optimal repair range from almost 0.5 yrs for worst case; fuzzy class 1 with safety rating of 0.0 to almost 5 million years for best case when the fuzzy class 5 with safety index rating of 1.0 assume availability is 80%.

## I. Introduction

Reliability studies and assessments of process plants and production platforms are carried out during preliminary concept design and engineering phases' development to provide engineers and operator's qualitative and quantitative data to plan risk and safety targets during the life of the process or production plant [1, 2]. Qualitative studies such as Hazard and Operability (HAZOP) studies and scenario analysis are most popular in safety design [3, 4]. HAZOP studies offers simple qualitative procedure to exclusively determine initial hazards that may occur in a process production facility and selected utility systems. The practise is to use quantitative studies to determine minimum thresholds for safety and qualitative risk assessments (QRA) to plan future risk scenarios [5, 6]. Complexity in risk events occurring during operations and interrelations of multifunctional systems limits their qualification of hazards and safety categories that may exists. In the example studied, cases of accidents reported on an FPSO could be attributed to the complex interacting units and systems in petroleum production systems

The modelling methods in leaks and reliability analysis have been presented elsewhere [Abhulimen, 2007]. The risk associated with personnel on FPSO is represented in Table 1. Several techniques have been presented in literature for reliability and risk analysis (1). Among the most frequently used are quantitative risk analysis, the probabilistic safety analysis, worst-case methodology and optimal risk analysis (2). Significant advancement has been made in developing newer method for hazard and risk assessment, consequence modelling and user friendly tools. However, while foreseeing worst-case scenarios is common, little attention is paid in envisioning credible scenarios. In engineering safety analysis, intrinsically vague information may coexist with conditions of "lack of specificity" originating from evidence not strong enough to completely support a hypothesis but only with degrees of belief or credibility (Binaghi and Madella, 1999) [(3)]. Dempster-Shafer (D-S) theory of evidence (Dempster, 1968; Shafer, 1976) [(4)] based on the concept of belief function is well suited to modeling subjective credibility induced by partial evidence (Smets, 1988) [(5)]. Reliability Centred Maintenance (RCM and RCM-II) and similar techniques have been introduced recently to improve the reliability of process plants. However data analysis of typical risk and hazard components multifunctional FPSO system are complex accident paths and non-existent. Some equipment can be critical to safe operation. In engineering safety analysis, intrinsically vague information may coexist with conditions of "lack of specificity" originating from evidence not strong enough to completely support a hypothesis but only with degrees of belief or credibility (Binaghi and Madella, 1999). Dempster-Shafer (D-S) theory of evidence (Dempster, 1968; Shafer, 1976) based on the concept of belief function is well suited to modeling subjective credibility induced by partial evidence (Smets, 1988). The D-S theory enlarges the scope of traditional probability theory, describes and handles uncertainties using the concept of the degrees of belief, which can model incompleteness and ignorance explicitly. It also provides appropriate methods for computing belief functions for combination

*Author:* PhD, Department of Chemical Engineering UNILAG Lagos, Nigeria, Syntex Acad Faculty, University Technology System Limited, Syntechsys Corporation Inc. TX77077 USA.
e-mail: kabhulimen@unilag.edu.ng

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of evidence (Pearl, 1988). Besides, the D-S theory also shows great potentials in multiple attribute decision analysis (MADA) under uncertainty, where an evidential reasoning (ER) approach for MADA under uncertainty was developed on the basis of a distributed assessment framework and the evidence combination rule of the D-S theory (Yang and Singh 1994; Yang and Sen 1994, 1997; Yang,2001; Yang and Xu, 2002a, b).The weight concept introduced here allows the possibility of representing a measure of safety Risk ratings asocial with complex interacting risk systems that has safety barriers and controls to prevent loss of containment: The weighting function for each risk classification allows us to do the following1) Determine which equipment and instruments are truly critical to reliability, as well as process

## II. Learning Algorithms in Risk and Safety Modelling

Learning algorithms are useful tools to quantify future risk uncertainty from past risk events and incorporate neural network modelling of Fuzzy Belief linguistic classifications: Figure 6 is a schematic of neural network architecture:

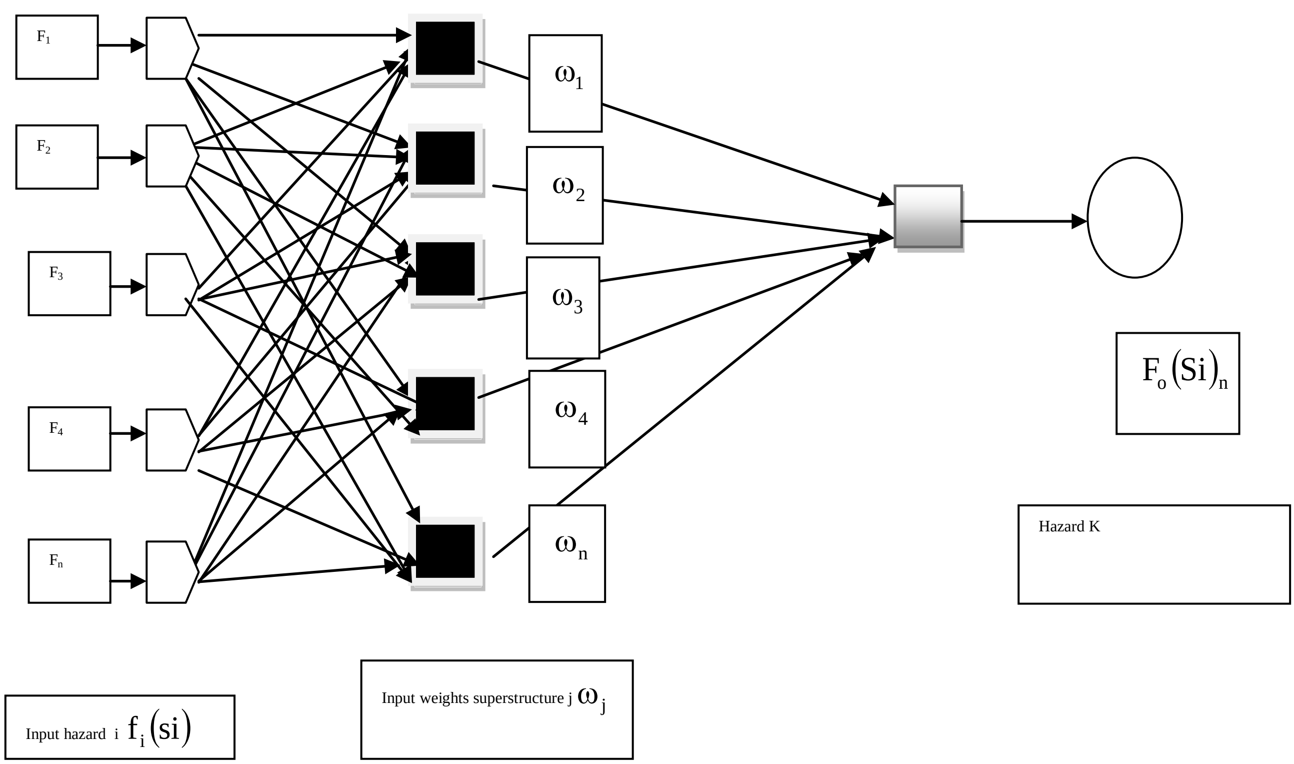



*Figure 1:* Neural Network Architecture

Learning algorithms incorporates neural network design in MATLAB to produce outputs comparable to the desired output and hazard measured and registered numerically. The outputs are then compared to the desired output in a process known as Feed-Forward routine. This feedback-propagating cycle is iteratively executed until the weighting Index factors converge on values or Function that minimize the Average Root Mean Square (ARMS) error within the initial training to establish hazard model trainer balck box. Once the initial training is set to the weighting factors establishing equilibrium baseline are held constant. Typical networks simulates 5000 neural network candidates to determine the optimal neural network. The actual training process involved 50 epochs cycles of back propagation training algorithm to locate the probable solution of the local minimum error. The minimized ARMS error for the training set is expressed in a nested scheme for the hazard function in eqn. 1 below;

$$\mathbf{F}(\mathbf{y}_i = \lambda_i) = \mathbf{f}_1(\mathbf{x}_{1i}, \mathbf{x}_{2i} \ldots\ldots\ldots\ldots \mathbf{x}_{ni}) \qquad (1)$$

$y_i$ represents the overall Hazard containment failure resulting from a combination of several hazard components inputs $x_i$ of the FPSO systems. The mathematical model describing a neural network structure reflecting hazard analysis in FPSO Systems resulting in loss of containment is:

$$(\mathbf{y} = \lambda_i) = \mathbf{a}_1\left(\mathbf{x}_{1i}^{\varpi_{1i}} \bullet \mathbf{x}_{2i}^{\varpi_{2i}} \bullet \ldots\ldots\ldots\ldots \bullet \mathbf{x}_{ni}^{\varpi_{ni}}\right) \qquad (2)$$

$$F_1(x',w) = In(y_k = \lambda_k) = \sum_{j=1}^{M} w_{jk}\varphi_j\left(\sum_{i=1}^{N} w_{ji}x_i - \kappa_j\right) - \kappa_k \quad (3)$$

In the neural network model presented in equation3, $w_{kj}$ is the synaptic weights from the neurons in the hidden layer j to the output neuron k and $w_{ij}$ are the synaptic weights from the neurons in the input layer i to neurons in the hidden layer j and $x_i$ is the i-the element of the input variable of the input vector $\tilde{\mathbf{x}}$. The weight vectors w denote the entire set of synaptic weights ordered by layer, the neurons in the layer and the synapses in a neuron. The thresholds corresponding to the hidden and the output neurons are given by $\boldsymbol{\kappa}$. The activation function

$$\varphi = \frac{1}{1 + \mathbf{e_i}^*} \quad (4)$$

Where: $\tilde{\mathbf{x}} = \mathbf{x} \bullet \xi$ and $\xi$ is the pre-process scaling vector and x is the raw input data and $\tilde{\mathbf{y}} = \mathbf{y} \bullet \xi$ is the post scaling factor

The error associated with output is defined as

$$\mathbf{e_i} = (\lambda_{\mathbf{ipredicted}} - \lambda_{\mathbf{imeasured}})$$

$$\mathbf{i} = 1,2 \ldots\ldots\ldots\ldots\ldots\ldots \mathbf{n} \quad (5)$$

Hazard Outcomes are predicted using Neural Networks used to train the data given by:

Equation 6 can be redefined by the following equation for hazard systems

$$H_o(s_k) = \sum_{j=1}^{N} \omega_{jk} \sum_{i=1}^{N} \omega_{ji}(x_i = H_i) - \kappa_{jk} \quad (6)$$

Hazard System IN Series is given by:

$$y_i(= H_o(s_k)) = \prod_{j=1}^{N} \omega_{jk} \prod_{i=1}^{N} \omega_{ji}\left(x_i = H_i^{\omega_{ji}}\right) - \kappa_{jk} \quad (7)$$

Where the Hazards inputs $H_i^{\omega_{ji}}$ and the Hazard Outputs $H_o(s_k)$ are represented by fuzzy-belief sets described earlier. $\kappa_{jk}$ represents the threshold or the error associated with each training: Equation 8 is given by the following:

$$InH_o(s_k) = \sum_{j=1}^{N} \omega_{jk} \sum_{i=1}^{N} \omega_{ji} Inf_i(Si) - \kappa_{jk} \quad (8)$$

i-input index (1-N input Hazard Synoptic Function)

j-weight index (1-N interacting Hazard Synoptic Neuron functions)

k-output index in times (1-N Hazard Output Synoptic Function).

$$\begin{bmatrix} \breve{y}_1 \\ \breve{y}_2 \\ . \\ . \\ \breve{y}_N \end{bmatrix} = \begin{bmatrix} W_{11} & W_{12} & \ldots\ldots & W_{1N} \\ W_{21} & W_{22} & \ldots\ldots & W_{2N} \\ \ldots & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots \\ W_{M1} & W_{M2} & \ldots\ldots & W_{MN} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \ldots \\ \ldots \\ x_N \end{bmatrix} \quad (10)$$

Where:

$$\begin{bmatrix} \breve{y}_1 \\ \breve{y}_2 \\ . \\ . \\ \breve{y}_N \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \\ . \\ . \\ y_N \end{bmatrix} - \bar{\lambda} \begin{bmatrix} K_1 \\ K_2 \\ \ldots \\ \ldots \\ K_N \end{bmatrix} \quad (11)$$

*The Weights are given by the following Function:*

$$W_{11} = [\bar{\omega}_{11}\omega_{11} + \bar{\omega}_{12}\omega_{21} + \ldots\ldots + \bar{\omega}_{1m}\omega_{m1}] \quad (12)$$

$$W_{MN} = [\bar{\omega}_{N1}\omega_{1N} + \bar{\omega}_{N2}\omega_{2N} + \ldots\ldots + \bar{\omega}_{Nm}\omega_{mN}] \quad (13)$$

$$K_N = (\kappa_{N1} + \kappa_{N2} + \ldots\ldots + \kappa_{NN}) \quad (14)$$

*Equation 24 can be expressed in an Eigenvalue Equation:*

$$|\vec{W} - \lambda I| = 0 \quad (15)$$

$$\begin{vmatrix} W_{11} - \lambda & 0 & 0 \\ 0 & W_{22} - \lambda \ldots\ldots & 0 \\ \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots \\ 0 & 0 & \ldots\ldots W_{MN} - \lambda \end{vmatrix} = 0 \quad (16)$$

$$(W_{11} - \lambda)(W_{22} - \lambda) \ldots\ldots\ldots (W_{MN} - \lambda) = 0 \quad (17)$$

Once Specific Data Sets connecting input hazards with the resulting Hazard outcomes can be predetermined, the synaptic weights constants can be determined or trained, so that any other hazard input can now be determined. Weights associated in each neural network in equation 37 are determined using Linear Network for Regression Analysis.

*Using Regression Method, Equation 37 can be rearranged and solved for W:*

$$\begin{bmatrix} \breve{y}_1 \\ \breve{y}_2 \\ \cdot \\ \cdot \\ \breve{y}_N \end{bmatrix} = \begin{bmatrix} W_{11} & W_{12} & \cdots\cdots & W_{1N} \\ W_{21} & W_{22} & \cdots\cdots & W_{2N} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ W_{M1} & W_{M2} & \cdots\cdots & W_{MN} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \cdots \\ \cdots \\ x_N \end{bmatrix} \quad (28)$$

$$W_{MN} = \frac{\begin{vmatrix} \sum_{i=1}^{N} x_{i1}. & \sum_{i=1}^{N} x_{i2} \cdots\cdots & \sum_{i=1}^{N} y_{iM} \\ \sum_{i=1}^{N} x_{i1}^{2} & \sum_{i=1}^{N} x_{i1} x_{i2} \cdots\cdots & \sum_{i=1}^{N} x_{i1} y_{iM} \\ \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ \sum_{i=1}^{N} x_{i1} x_{iN} & \sum_{i=1}^{N} x_{i2} x_{iN} \cdots\cdots & \sum_{i=1}^{N} x_{iN} y_{iM} \end{vmatrix}}{\begin{vmatrix} \sum_{i=1}^{N} x_{i1}. & \sum_{i=1}^{N} x_{i2} \cdots\cdots & \sum_{i=1}^{N} x_{iN} \\ \sum_{i=1}^{N} x_{i1}^{2} & \sum_{i=1}^{N} x_{i1} x_{i2} \cdots\cdots & \sum_{i=1}^{N} x_{i1} x_{iN} \\ \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ \sum_{i=1}^{N} x_{i1} x_{iN} & \sum_{i=1}^{N} x_{i2} x_{iN} \cdots\cdots & \sum_{i=1}^{N} x_{iN} x_{iN} \end{vmatrix}} \quad (29)$$

The Average Mean Squared Error is computed as Standard Deviation measure to determine whether the weights trained give specific outputs that minimizes error associated with each predicted measurement

$$\mathbf{ARMS} = \left( \frac{1}{\mathbf{N}} \sum_{\mathbf{i=1}}^{\mathbf{N}} \mathbf{e_i}^2 \right)^{\frac{1}{2}} \quad (30)$$

Where the error being the difference between predicted and measured outputs: for example the difference between failure rates predicted by the neural network and failure rates measured for a particular Systems (e.g FPSO) resulting from combination of hazards

$$\mathbf{e_i} = \mathbf{H_{Opredicted}} - \mathbf{H_{omeasured}} \quad (31)$$

*Risk and Safety Modelling.* The risk and safety potential is computed using eqn. 33 and eqn.34

$$\text{Risk Potential} = \frac{\text{Risk}}{\text{Reliability of Safety Systems}} \quad (33)$$

The Risk Potential gives a measure of the True Risk inherent in a System or Sub System

$$\textit{Safety Potential} = \frac{1}{\textit{Risk Potentaial}} = \frac{\textit{Reliability of Safety Systems}}{\textit{Risk to Safety System}} \quad (34)$$

The Safety Potential gives a measure of the Safety of a given System

*Maximum Risk of a System based on New Technique.* The maximum risk can be evaluated from the linear programming model. The maximum risk for a system that follows series configuration is given by

$$In(1-r) = In\left(\prod_{i}(1-r_i)^{wi}\right) = w_1 In\, r_1 + w_2 Inr_2 + \ldots + w_n Inr_n \quad (35)$$

Subject to the constraint equation

$$0 \le r_i \le 1 \qquad \text{for } i = 1,2,\ldots..n \quad (36)$$

Equation 3 subject to eqn. 4 is our model for predicting a series system, which is solved by finding the linear programming model that multiplies the respective weights to the Natural Logarithm of the respective risk events.

However the maximum risk model for a system operating in parallel is given by eqn.38 and constraint functions is given by eqn.39 and eqn.40

$$\text{Max } \; Inr = \omega_1 Inr_1 + \omega_2 Inr_2 + \ldots\ldots + \omega rn\, Inr_n \quad (37)$$

$$0 \le r_i \le 1 \qquad \text{for } i = 1,2,\ldots..n \quad (38)$$

$$0 < \prod_{i}^{n} r_i \le 1 \quad \text{for } i = 1,2,\ldots..n \quad (39)$$

The maximum reliability of the safety systems is evaluated using eqn.8 and the constraint eqn.41 is given by eqn.42 and eqn.43

$$\text{Max } \; InR = \omega R1\, InR1 + \omega R2\, InR2 + \ldots\ldots + \omega Rn\, InRn \quad (40)$$

$$0 \le R_i \le 1 \qquad \text{for } i = 1,2,\ldots..n \quad (41)$$

$$0 < \prod_{i}^{n} R_i \le 1 \quad \text{for } i = 1,2,\ldots..n \quad (42)$$

For a parallel and series system, the maximum risk objective function is translated using the objective function eqn.44

$$r = \prod_{i=1}^{k} r_i^{\omega i} + \sum_{i=k}^{n} \omega_i r_i \quad (42)$$

Thus the above couple system by analysing the series and parallel systems separately. The linearized risk system for parallel couple.

$$\text{Inr}_p = \sum_{i=1}^{k} \omega_i \text{Inr}_i \quad (43)$$

Total linearized risk objective function for the series- parallel couple system

$$r_T = \sum_{i=1}^{k} \omega_i \text{Inr}_i + \sum_{i=k}^{n} \omega_i r_i \quad (44)$$

This is subject to the constraint equation

$$0 \le r_i \le 1 \qquad i = L\ldots k \text{ AND } i = k, \ldots..n$$

$$0 \le \prod_{i=1}^{k} \omega_i r_i \le 1 \qquad i = l,\ldots k \quad (45)$$

$$0 \le \sum_{i=k}^{i=n} \omega_i r_i \le 1 \qquad I = k,..n$$

*Limits of Safety*

In order to find the Limits of Safety in a process system, we now apply the Lyapunov Stability Criteria that results in a matrix equation as follows given by eqn.46

$$\zeta_{i+1j} = H\,\Omega_{ij} \quad (46)$$

Where in

$$\Omega_{ij} = \begin{bmatrix} \xi_{ij} \\ \eta_{ij} \\ \gamma_{ij} \end{bmatrix} \qquad \zeta_{i+1j} = \begin{bmatrix} \xi i+1j \\ \eta i+1j \\ \gamma i+1j \end{bmatrix} \quad (47)$$

$\zeta_{i+1j}$ is Risk Matrix Vector at particular time i and position j and $\Omega_{ij}$, is the Risk Matrix Vector at an advanced time i+1, H=J is the Jacobean or Matrix of Safety and J is the Jacobean of Safety from a stable point as follows:

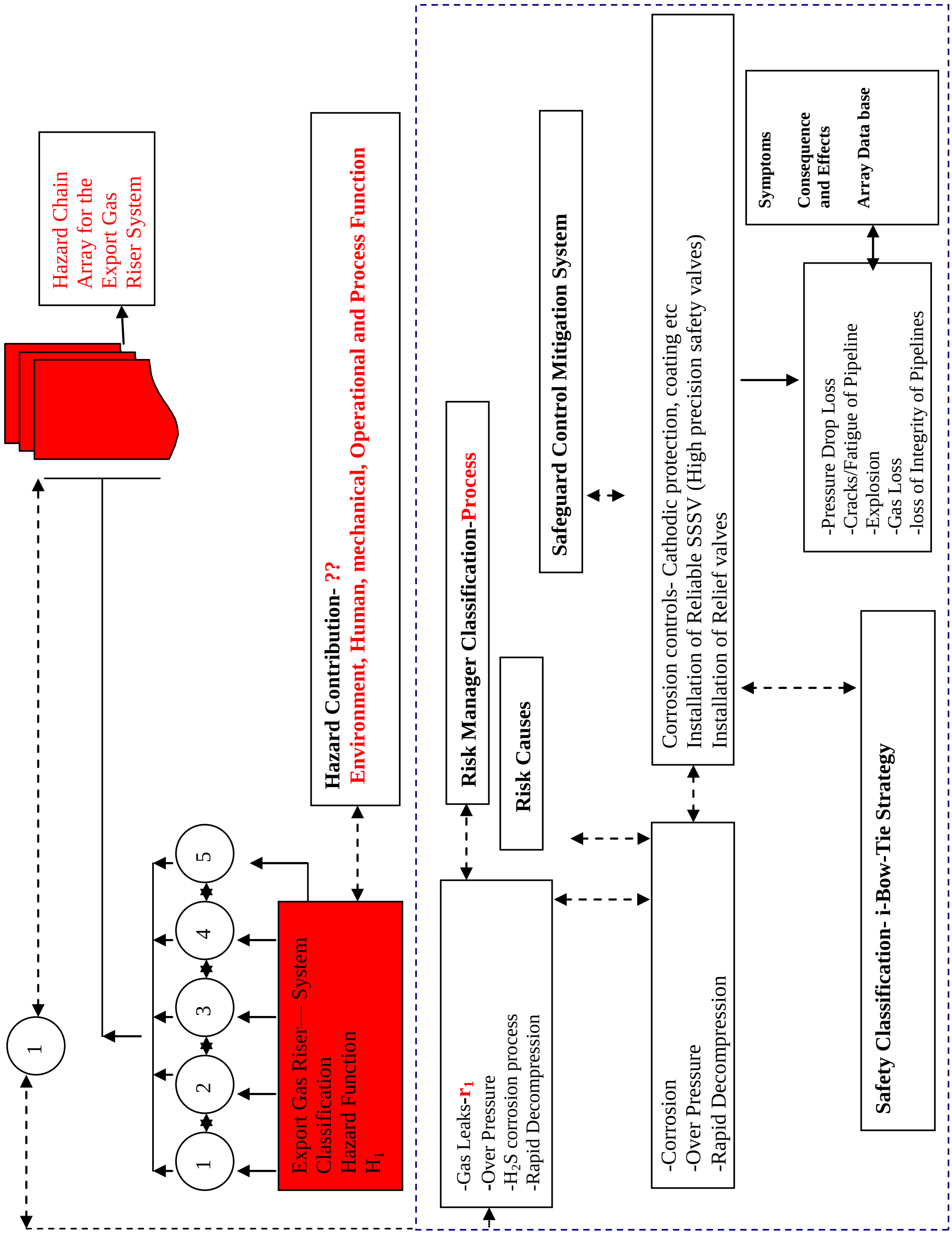
$$J = \frac{\partial(F_1F_2F_3F_4F_5)}{\partial(r, R, \omega, \lambda, S)} \quad (48)$$

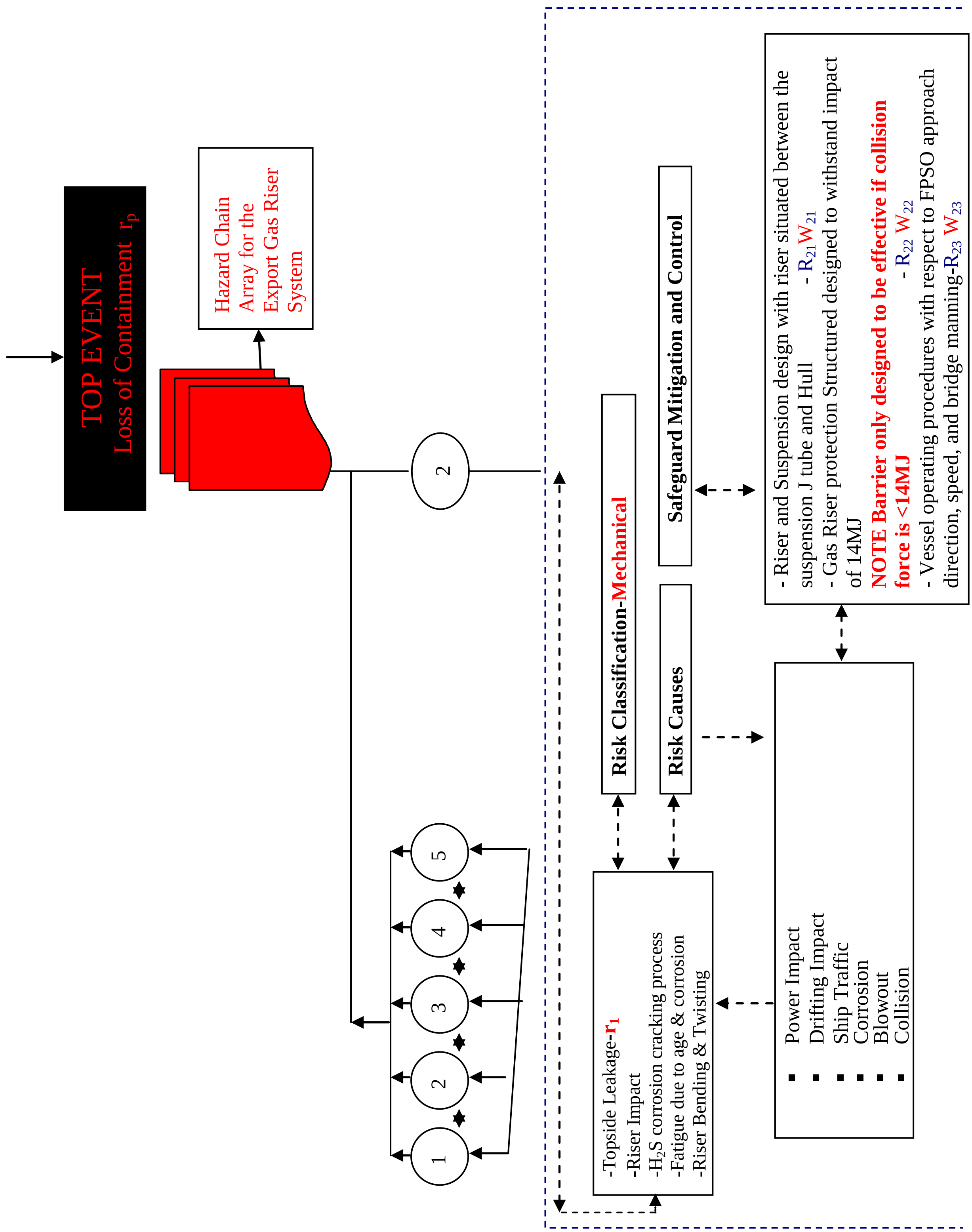
$F_1$ is the Function associated with risk of the Process System, $F_2$ is the Function associated with Reliability of the Safety System, $F_3$ is the Function associated with weights that each Process System carried in a given environment at a given time, $F_4$ is the Function associated with hazard rate of the process system, $F_5$ is the Function associated with Safety of the Process System.

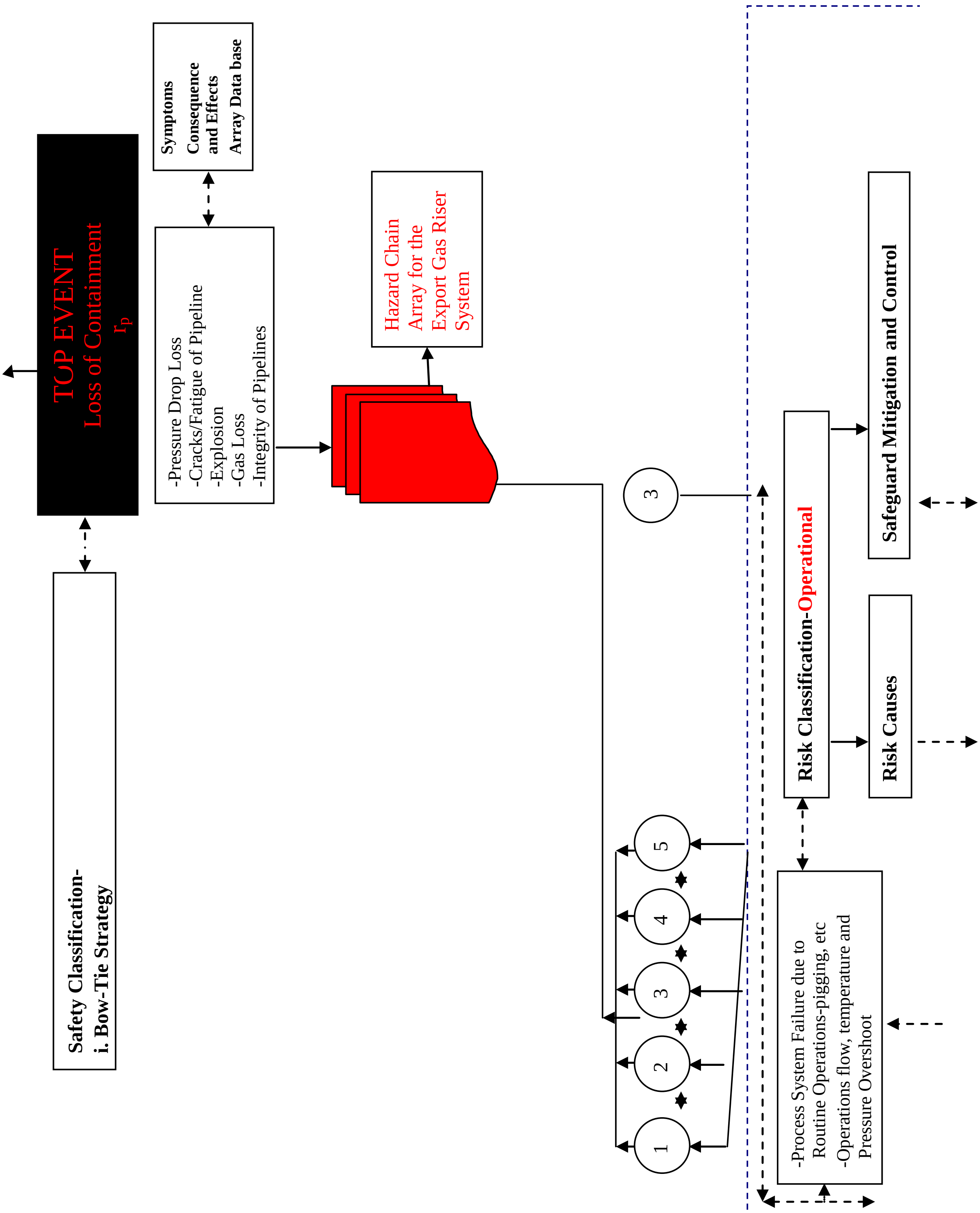
## III. Functional Safety Integrity Level Performance

Safety Integrity Level Performance describe reliability of Safety system instrumentation in medical equipment to provide accurate input and output data, limiting the threshold of risk to data inaccuracy which may lead to loss of life. Safety Life Cycle (SLC) is an approach that addresses all necessary activities to ensure medical equipment achieve functional safety performance in relation of deployment of Leak diagnosis in conformity to IEC 61508 International Standards. This standard covers the requirements use of dedicated medical instruments and automation package solutions in relation to hazards and risk assessment methods defining requirements to SIS design and engineering as well as to testing, installation, commissioning, operation, maintenance, modification, decommissioning and documentation of medical equipment. The performance criteria involved in obtaining safety integrity levels in DSS safety functional performance are:

1. *Reliability:* Should have limited False Alarm thresholds with respect to repeated ability
2. *Sensitivity:* Should detect pinhole deviation and discrepancies in Leak diagnosis
3. *Robustness:* Should be able to adapt to changing Leak cases and environment conditions
4. *Response Time:* Should have a feedback time window to detect leaks in SIS or diagnosis within accepted thresholds should be less than 3minutes.
5. *Cost:* Should have limited damages to warrant repair or replacements is important.
6. Some important terminology, ALAARP is best common practice judgment of the balance of risk and societal benefits.


Hazard Chain Array for the Export Gas Riser System
Export Gas Riser— System Classification Hazard Function $H_1$
1
2
3
4
5
1
Hazard Contribution- ??
Environment, Human, mechanical, Operational and Process Function
Risk Manager Classification-Process
Risk Causes
Safeguard Control Mitigation System
-Gas Leaks-$r_1$
-Over Pressure
-$H_2S$ corrosion process
-Rapid Decompression
-Corrosion
-Over Pressure
-Rapid Decompression
Corrosion controls- Cathodic protection, coating etc
Installation of Reliable SSSV (High precision safety valves)
Installation of Relief valves
-Pressure Drop Loss
-Cracks/Fatigue of Pipeline
-Explosion
-Gas Loss
-loss of Integrity of Pipelines
Symptoms
Consequence and Effects
Array Data base
Safety Classification- i-Bow-Tie Strategy


TOP EVENT
Loss of Containment $r_p$
Hazard Chain Array for the Export Gas Riser System
2
1
2
3
4
5
Risk Classification-Mechanical
Risk Causes
Safeguard Mitigation and Control
-Topside Leakage-$r_1$
-Riser Impact
-$H_2S$ corrosion cracking process
-Fatigue due to age & corrosion
-Riser Bending & Twisting
Power Impact
Drifting Impact
Ship Traffic
Corrosion
Blowout
Collision
- Riser and Suspension design with riser situated between the suspension J tube and Hull - $R_{21}W_{21}$
- Gas Riser protection Structured designed to withstand impact of 14MJ
NOTE Barrier only designed to be effective if collision force is <14MJ - $R_{22}$ $W_{22}$
- Vessel operating procedures with respect to FPSO approach direction, speed, and bridge manning-$R_{23}$ $W_{23}$


TOP EVENT
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Symptoms
Consequence and Effects
Array Data base
-Pressure Drop Loss
-Cracks/Fatigue of Pipeline
-Explosion
-Gas Loss
-Integrity of Pipelines
Hazard Chain Array for the Export Gas Riser System
Safety Classification-
i. Bow-Tie Strategy
3
1
2
3
4
5
Risk Classification-Operational
Safeguard Mitigation and Control
Risk Causes
-Process System Failure due to Routine Operations-pigging, etc
-Operations flow, temperature and Pressure Overshoot

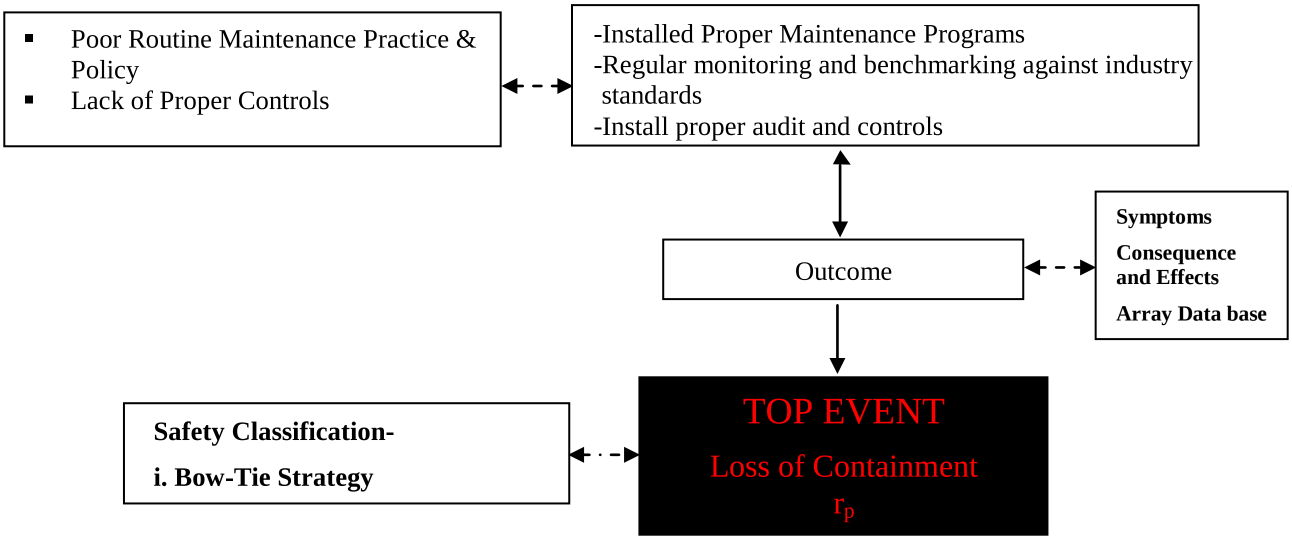
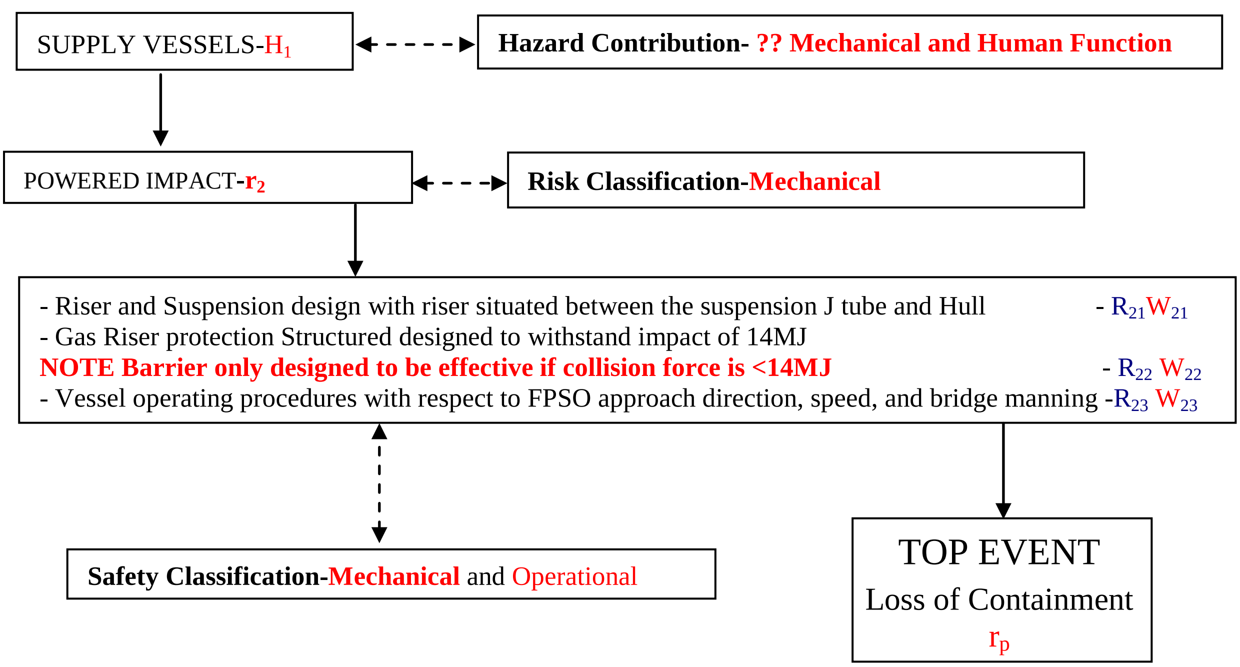



*Figure 2:* Safe Matrix- System

The new modifications to the Bow Tie would include a Safe Matrix System that includes a window of safety using the weighting concept. This superstructure describes the flow path- from Hazard to Top Event outcome of the process systems under a safeguard control system under the accident pathway. The application model for a typical Risk System of a typical FPSO-Export Riser is presented as Figure 3.0




The Procedure of achieving functional safety integrity levels 1) Identification of Possible Hazards and specifications of corresponding safety function 2) The following Hazard methods are normally used 1) Hazard ID, 2) Hazop 3) FMCEA (Failure Mode, Critical Effect Analysis) 4) Fault Tree 1) *Safety Function incorporating the following concepts a)* Weighting Index b) Belief Theory c) reliability d) Fuzzy Logic. Assessment of risks corresponding to safety functions and identification of the required safety integrity level 1) Probability models incorporating weights2) Mean Time before Failure (MTBF) 3) Mean Time before Repair (MTBR) 4) Markov Chain Models 5) Weibull Function 6) Weights Safety Index derived from Weibull

$$w(t) = (1 - SFR_i)\left(\frac{t}{n_i}\right)^{\beta_i - 1} \qquad (13)$$

$$\omega_{avg} = (1 - SFR_i)\left(\frac{\eta}{\beta_i}\right)\left(\frac{\left(\frac{t_{\max}}{\eta}\right)^{\beta_i} - \left(\frac{t_{\max}}{\eta}\right)^{\beta_i}}{T_{\max} - T_{\min}}\right) \quad (14)$$

$$Risk\ Potential = \frac{1 - \prod_{i=1}^{n}(1 - r_i)^{\omega_i}}{\prod_{i-1}^{n} R_{si}^{\ \omega_i}} \quad (15)$$

$$Risk\ Potential = \frac{\prod_{i=1}^{N} r_i^{\ \omega_i}}{1 - \prod_{i=1}^{n}(1 - R_{si})^{w_i}} \quad (16)$$

The exponential distribution used to describe failure

$$r_i(t) = 1 - e^{-\lambda_w t} \quad (17)$$

$$R_{st}(t) = e^{-\lambda_{wt}} \quad (18)$$

The DSS failure rate is expressed as a Homogeneous Poisson Process (HPP) with weight safety function incorporated.

$$f(n) = \frac{(w_{avg}\lambda_t)^n \exp(-w_{avg}\lambda_t)}{n!} \quad n=01, 2\ldots \quad (19)$$

Cumulative Poisson distribution is given to DSS describe failure rate:

$$f(n) = \sum_{i=0}^{n} \frac{(w_{avg}\lambda_t)^i \exp(-w_{avg}\lambda_t)}{i!} \quad (20)$$

Human reliability Models including weights define critical risk caused by human errors by different human or Leak operators

$$R_n(t) = \exp^{-\int_0^{\tau} \omega(\tau) r_e(\tau) dt} \quad (21)$$

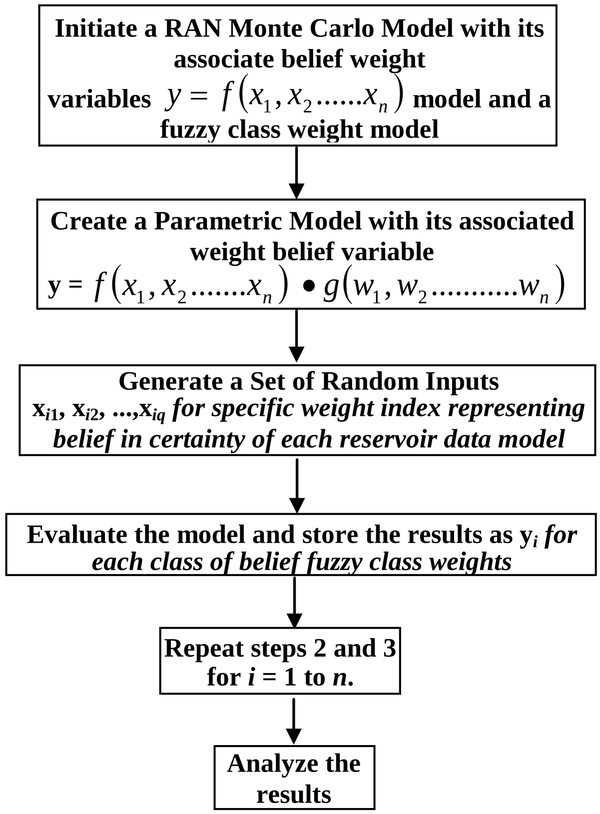
Where by:

$$w(t) = (1 - SFR_i)\left(\frac{t}{n_i}\right)^{\beta_i - 1} \quad (22)$$

Two models are considered in the risk and safety analysis1) Bow Tie Systems 2) Markov Chain Model 3) the model assumes the following A) Subjective assessments and linguistic assessments is one of the measures of safety B) Fuzzy set membership function used to define input variables C) Flexibility Safety or Jacobean Stability matrix in definition of membership D) Application of critical judgment. The probability models adopted for our case is the Bayesian Probability Framework Model. Application of Bayesian Probability Network to randomly predict Risk factors $K_L$ is presented, which is statistically computed by listing all data in a posterior description in the Bayesian context.

$$f(F|d_1, d_2, d_3 \ldots\ldots d_n) = \frac{f(d_1|F)^{w_1}, f(d_2|F)^{w_2} \ldots\ldots f(d_n|F)^{w_n}, f(F)}{f(d_1, d_2 \ldots\ldots d_n)^W = \sum_i w_i f(d_i)} = \frac{f(F) \bullet \prod_{i=1}^{n} f(d_i / F)}{\sum_{i=1}^{n} w_i f(d_i)}$$

For the safety problem, there are two critical Risk stress factor data, the $k_{rs} = d_1$, predicted safety integrity levels, necessary condition and $k_{fs} = d_2$, predicted effect safety stress condition Sufficient Condition.




Rearranging incorporating with thresholds associated with internal and external synaptic weights of Neural Network System:

$$\begin{bmatrix} y_1 \\ y_2 \\ \cdots \\ \cdots \\ y_N \end{bmatrix} = \begin{bmatrix} W_{11}\, W_{12} ............... W_{1N} \\ W_{21}\, W_{22} ............... W_{2N} \\ .............................. \\ .............................. \\ W_{N1}\, W_{N2} ............ W_{NN} \end{bmatrix} \begin{bmatrix} X_1(x_1 - k_1) \\ X_2(x_2 - k_2) \\ ................. \\ ................. \\ X_N(x_N - k_N) \end{bmatrix} - \begin{bmatrix} K_1 \\ K_2 \\ ..... \\ ..... \\ K_N \end{bmatrix} \tag{24}$$

$$W_{11} = \left[\tilde{\omega}_{11}\omega_{11} + \tilde{\omega}_{12}\omega_{21} + ...... + \tilde{\omega}_{1N}\omega_{N_1}\right] \tag{25}$$

$$W_{12} = \left[\tilde{\omega}_{11}\omega_{12} + \tilde{\omega}_{12}\omega_{22} + ...... + \tilde{\omega}_{1N}\omega_{N_2}\right] \tag{26}$$

$$W_{1N} = \left[\tilde{\omega}_{11}\omega_{1N} + \tilde{\omega}_{12}\omega_{2N} + ...... + \tilde{\omega}_{1N}\omega_{NN}\right] \tag{27}$$

Similarly for 2

$$W_{21} = \left[\tilde{\omega}_{21}\omega_{11} + \tilde{\omega}_{22}\omega_{21} + ...... + \tilde{\omega}_{2N}\omega_{N_1}\right] \tag{28}$$

$$W_{22} = \left[\tilde{\omega}_{21}\omega_{12} + \tilde{\omega}_{22}\omega_{22} + ...... + \tilde{\omega}_{2N}\omega_{N_2}\right] \tag{29}$$

$$W_{2N} = \left[\tilde{\omega}_{21}\omega_{1N} + \tilde{\omega}_{22}\omega_{2N} + ...... + \tilde{\omega}_{2N}\omega_{NN}\right] \tag{30}$$

Similarly for N

$$W_{N1} = \left[\tilde{\omega}_{N1}\omega_{11} + \tilde{\omega}_{N2}\omega_{21} + ...... + \tilde{\omega}_{NN}\omega_{N_1}\right] \tag{31}$$

$$W_{N2} = \left[\tilde{\omega}_{N1}\omega_{12} + \tilde{\omega}_{N2}\omega_{22} + ...... + \tilde{\omega}_{NN}\omega_{N_2}\right] \tag{32}$$

$$W_{NN} = \left[\tilde{\omega}_{N1}\omega_{1N} + \tilde{\omega}_{N2}\omega_{2N} + ...... + \tilde{\omega}_{NN}\omega_{NN}\right] \tag{33}$$

$$K_1 = k_{11} + k_{12} + .... + k_{1N} \tag{34}$$

$$K_2 = k_{21} + k_{22} + .... + k_{2N} \tag{35}$$

$$K_N = k_{N1} + k_{N2} + .... + k_{NN} \tag{36}$$

A linear Network for Regression Analysis can be used to determine the weights. The Average Mean Square error is used to train the Network.

$$ARMS = \left(\frac{1}{N}\sum_{i=1}^{N} e_i^{\,2}\right) \tag{37}$$

Where:

$$e_i = H_{opredicted} - H_{oobserved} \tag{38}$$

The error function can be deduced from the Gaussian Function: The Gaussian Function (also referred to as beel-shaped or bell curve) is of the following form

$$G(x) = Ae^{-\frac{x^2}{2\sigma^2}} \tag{39}$$

Where $\sigma$ is referred to as the spread of standard deviation and A is the constant. The function can be a normalized so that the integral from minus infinity to plus infinity equals one yeilding the normalized Guassian

$$G(x)=\frac{1}{\sqrt{2\pi\sigma}}e^{-\frac{x^2}{2\sigma^2}} \quad (40)$$

By using the following definite integral

$$\int_0^\infty e^{-ax^2}dx=\frac{1}{2}\sqrt{\frac{\pi}{a}} \quad (41)$$

The Gaussian function goes to zero at plus and minus infinity while all the derivatives of any order evaluated at x=0 are zero

The error function equals twice the integral of a normalized Gaussian function between 0 and x

$$erfx=\frac{2}{\sqrt{\pi}}\int_0^\infty e^{-u^2}du \quad (42)$$

The relation between the normalizd Gaussian distribution and error function equals:

$$\int_{-x}^{x}G(x)dx=Erf\left(\frac{x}{\sigma\sqrt{2}}\right) \quad (43)$$

A series approximation for small value of x of this function is given by:

$$erfx=\frac{2}{\sqrt{\pi}}\left(x-\frac{x^3}{3.1!}+\frac{x^5}{5.2!}+\frac{x^7}{7.3!}+......\right) \quad (44)$$

While an approximation for large value of x ocan be obtained

$$erfx=\frac{2}{\sqrt{\pi}}\left(x-\frac{x^3}{3.1!}+\frac{x^5}{5.2!}+\frac{x^7}{7.3!}+......\right) \quad (45)$$

$$erfx=1-\frac{e^{-x^2}}{\sqrt{\pi}x}\left(1-\frac{1}{2x^2}+\frac{1.3}{(2x^2)^2}+\frac{1.3.5}{(2x^2)^3}+.....\right) \quad (47)$$

The complementary error function equals one minus the error function yielding

$$erfcx=1-erfx=\frac{2}{\sqrt{\pi}}\int_x^\infty e^{-u^2}du \quad (48)$$

Defining the Limits of functional Safety:The vector field F(x) of the whole phase portrait for all individual safety functions f(x) at the designated nodes is described by the matrix. In difference form, the concept has evolved in the Safety Functional model as presented:

$$\Phi_{1i+1}=F_1(\Phi_{1i},\Phi_{2i}.....\Phi_{ni}) \quad (49)$$

$$\Phi_{2i+1}=F_2(\Phi_{1i},\Phi_{2i}.....\Phi_{ni}) \quad (50)$$

$$\Phi_{Ni+1}=F_1(\Phi_{1i},\Phi_{2i}.....\Phi_{ni}) \quad (51)$$

The Liapunov Stability Criterion is used as basis for evolving functional safety incorproating risks involved in uniform and systematic configuration of all technology process, methods and dedicated medical safety instrument systems (SIS) equipment to core sector specific standards IEC61508, deployed in accessing Leak diagnosis and treatment performance as provided in equation below.

$$\begin{bmatrix}\xi_{1k+1}\\ \xi_{2k+1}\\ ....\\ \xi_{nk+1}\end{bmatrix}=j\begin{bmatrix}\xi_{1k}\\ \xi_{2k}\\ ....\\ \xi_{nk}\end{bmatrix}= \quad (52)$$

Where:

$$J=\begin{bmatrix}\left(\frac{\partial F_1}{\partial\Phi_1}\right) & \left(\frac{\partial F_1}{\partial\Phi_2}\right) & \cdots\cdots & \left(\frac{\partial F_1}{\partial\Phi_N}\right)\\ \left(\frac{\partial F_2}{\partial\Phi_1}\right) & \left(\frac{\partial F_2}{\partial\Phi_2}\right) & \cdots\cdots & \left(\frac{\partial F_2}{\partial\Phi_N}\right)\\ \cdots & \cdots & \cdots & \cdots\\ \left(\frac{\partial F_N}{\partial\Phi_1}\right) & \left(\frac{\partial F_N}{\partial\Phi_2}\right) & \cdots\cdots & \left(\frac{\partial F_N}{\partial\Phi_N}\right)\end{bmatrix} \quad (53)$$

## IV. DSS Performance using Liapunov Stability Function Criteria

The concept of stability and instability of Decision Support systems (Lyapunov equilibrium stability criteria) was applied to a transient flow Leak Detection system; to evolve a model for DSS functional safety defect in SIS. The two dimensional invertible maps in time and space domain for the DSS Leak system is τ→z, t, and are presented for DSS Leak Systems Data, DSS Electronic Systems Data, DSS Blood Flow System Data, in equations (54), (55) and (56), respectively.

$$DSS-CSD(J,K+1)=F1[CSD(J,K),ESD(J,K),BFSD(J,K)] \quad (54)$$

$$DSS-ESD(J,K+1)=F2[CSD(J,K),ESD(J,K),BFSD(J,K)] \quad (55)$$

$$DSS-BFSD(J,K+1)=F3[CSD(J,K),ESD(J,K),BFSD(J,K)] \quad (56)$$

Where, $CSD(J,K), ESD(J,K), BFSD(J,K)$ are the DSS Leak System Output Data, DSS Electronic Systems Output Data and DSS Blow Flow System Output Data in j patient node and k time domain, respectively? For DSS Functional Safety (DSS-FS) to be accurate, DSS-FS is defined as the domain of stability where, CSD, ESD and BSFD are consistently steady, that is not change in output for each patient measurement not related to fluctuation, that is for the same input, the output must be repeatable therefore

$$CSD(J,K+1) = CSD_E(J,K) \quad (71) \quad ESD(J,K+1) = ESD_E(J,K) \quad (57)$$

$$BFSD(J,K+1) = BSFD_E(J,K) \quad (58)$$

54 to 58 in matrix form is given by 74

$$\zeta_{jk+1} = H\Omega_{jk} \quad (59)$$

Where:

$$\Omega_{jk} = \begin{bmatrix} \xi_{jk} \\ \eta_{jk} \\ \gamma_{jk} \end{bmatrix} \zeta_{jk+1} = \begin{bmatrix} \xi_{jk+1} \\ \eta_{jk+1} \\ \gamma_{jk+1} \end{bmatrix} \quad (60)$$

$$H = \begin{bmatrix} A\ B\ C \\ D\ E\ F \\ G\ H\ I \end{bmatrix} = \begin{bmatrix} \left(\frac{\partial F_1}{\partial CSD}\right)_{jK} & \left(\frac{\partial F_1}{\partial ESD}\right)_{jK} & \left(\frac{\partial F_2}{\partial BFSD}\right)_{jK} \\ \left(\frac{\partial F_2}{\partial CSD}\right)_{jK} & \left(\frac{\partial F_1}{\partial ESD}\right)_{jK} & \left(\frac{\partial F_2}{\partial BFSD}\right)_{jK} \\ \left(\frac{\partial F_3}{\partial CSD}\right)_{jK} & \left(\frac{\partial F_3}{\partial ESD}\right)_{jK} & \left(\frac{\partial F_3}{\partial BFSD}\right)_{jK} \end{bmatrix} \quad (61)$$

J is the Jacobean differential given by the formula: For a DSS functional safety to be repeatable $J = 1$

$$J = \frac{\partial[F_1 F_2 F_3]}{\partial[CFD, ESD, BSFD]} \quad (62)$$

$|H-\lambda I|\Omega_i = 0$ is the characteristic equation of the matrix of equation (62) from where the eigenvalues or the roots can easily be evaluated. In this way, the problem is decoupled into three dimensional maps and the stability question is answered once the eigenvalues ($\lambda_{1k}$,$\lambda_{2k}$,$\lambda_{3k}$) for each iteration are known. If the Jacobeans are real and symmetric such that one would expect real eigenvalues, the system is asymptotically stable if $-1<\lambda_{1k}, \lambda_{2k}, \lambda_{3k}<1$, but unstable if $\lambda_{1k}, \lambda_{2k}, \lambda_{3k} > 1$ in absolute terms. If one of the eigenvalues $\lambda_{1k}$or $\lambda_{2k}$ or $\lambda_{3k}$ has modules equal to1 in absolute value, then the critical point is established for stability. A leak in a pipeline causing instability is observed when the simulation results in at least one of the roots $\lambda_{1k}, \lambda_{2k}, \lambda_{3k}<-1$. Similarly a surge causing instability is observed when at least one of the roots $\lambda_{1k}, \lambda_{2k}, \lambda_{3k}>1$. The absolute value of 1 is the critical bifurcating state. If $\lambda_{1k}, \lambda_{2k}, \lambda_{3k}$ is such that, the Jacobean are complex conjugates, (i.e. $\lambda_{1k}, \lambda_{2k}, \lambda_{3k} = \alpha + i\beta$), the stability criterion for three dimensional maps can be solved. The system is stable (for complex conjugates) if all eigenvalues are inside the unit circle, whereas the system is asymptotically unstable, if at least one of the eigenvalues is outside the circle.

The stability boundary is the unit circle itself. If the eigenvalues are real, there are only two points where they can cross the stability boundary at 1 and –1. This concept is similar to saying that the stability condition exists once the Jacobean is equal to 1 in absolute terms. In order to describe the unstable phase portrait, a bifurcation model to assign a relative magnitude to the disturbed phase is proposed, as the standard deviation from the critical point, which gives a robust measure of the width of distribution. These are indicated below in equations (41) to (43) for the eigenvalues.

$$SD(\lambda_{1ij}) = \sqrt{\sum_{i=0}^{n} \frac{(|\lambda_{1ij}|-1)^2}{(n-1)}} \quad (63)$$

$$SD(\lambda_{2ij}) = \sqrt{\sum_{i=0}^{n} \frac{(|\lambda_{2ij}|-1)^2}{(n-1)}} \quad (64)$$

$$SD(\lambda_{3ij}) = \sqrt{\sum_{i=0}^{n} \frac{(|\lambda_{3ij}|-1)^2}{(n-1)}} \quad (65)$$

The standard deviation model evaluates the width of deviation of a typical flow vector point at time i = 0…n. Once a leak is suspected at a time envelope, a relative magnitude of the disturbance can be ascertained. A standard deviation close to zero indicates a small leak, and vice versa. $|\lambda_{1ij}|, |\lambda_{2ij}|, |\lambda_{3ij}|$ are the absolute eigenvalues of velocity, mass and pressure, at a particular time and pipeline node point. Hence, using the standard deviation model, it is possible to classify the leak being considered. This model is useful for assigning a value to a disturbance after the eigenvalue criterion for a leak or surge has been ascertained.

Very Likely

Fuzzy Class 1

| WeibullSigmond Function | Safety Index=0 | Safety Index=0.1 | Safety Index=0.5 | Safety Index=0.8 | Safety Index=0.9 |
|---|---|---|---|---|---|
| 0 | Safety Integrity Levels (Weighted) on the Risk Function | | | | |
| 0.1 | 1.02745 | 0.9247 | 0.5137 | 0.2055 | 0.1027 |
| 0.2 | 0.791344 | 0.7122 | 0.3957 | 0.1583 | 0.0791 |
| 0.4 | 0.938869 | 0.8450 | 0.4694 | 0.1878 | 0.0939 |
| 0.6 | 1.485194 | 1.3367 | 0.7426 | 0.2970 | 0.1485 |
| 0.8 | 2.643102588 | 2.3788 | 1.3216 | 0.5286 | 0.2643 |
| 1 | 5.01734 | 4.5156 | 2.5087 | 1.0035 | 0.5017 |
| 1.2 | 9.921146 | 8.9290 | 4.9606 | 1.9842 | 0.9921 |
| 1.4 | 20.1783 | 18.1605 | 10.0892 | 4.0357 | 2.0178 |
| 1.6 | 41.895 | 37.7055 | 20.9475 | 8.3790 | 4.1895 |
| 1.8 | 88.36478 | 79.5283 | 44.1824 | 17.6730 | 8.8365 |
| 2 | 188.7084 | 169.8376 | 94.3542 | 37.7417 | 18.8708 |

Fuzzy Class 2

| Weibull Sigmoid Constant | Safety Index=0 | Safety Index=0.1 | Safety Index=0.5 | Safety Index =0.8 | Safety Index=0.9 |
|---|---|---|---|---|---|
| 0 | Safety Integrity Levels (Weighted) on the Risk Function | | | | |
| 0.1 | 0.82422 | 0.741798 | 0.41211 | 0.164844 | 0.082422 |
| 0.2 | 0.50925 | 0.458325 | 0.254625 | 0.10185 | 0.050925 |
| 0.4 | 0.388808 | 0.349928 | 0.194404 | 0.077762 | 0.038881 |
| 0.6 | 0.395803 | 0.356223 | 0.197902 | 0.079161 | 0.03958 |
| 0.8 | 0.453289425 | 0.407960482 | 0.226644712 | 0.090657885 | 0.045328942 |
| 1 | 0.553733 | 0.49836 | 0.276867 | 0.110747 | 0.055373 |
| 1.2 | 0.704619 | 0.634157 | 0.352309 | 0.140924 | 0.070462 |
| 1.4 | 0.922237 | 0.830013 | 0.461118 | 0.184447 | 0.092224 |
| 1.6 | 1.232212 | 1.108991 | 0.616106 | 0.246442 | 0.123221 |
| 1.8 | 1.672506 | 1.505256 | 0.836253 | 0.334501 | 0.167251 |
| 2 | 2.298504 | 2.068653 | 1.149252 | 0.459701 | 0.22985 |

Unlikely

Fuzzy Class 3

| Weibull Sigmond Function | Safety Index=0 | Safety Index=0.1 | Safety Index=0.5 | Safety Index=0.8 | Safety Index=0.9 |
|---|---|---|---|---|---|
| | Safety Integrity Levels(Weighted) on the Risk Function | | | | |
| 0.1 | 0.514808 | 0.463327 | 0.257404 | 0.102962 | 0.051481 |
| 0.2 | 0.198671 | 0.178804 | 0.099336 | 0.039734 | 0.019867 |
| 0.4 | 0.059176 | 0.053258 | 0.029588 | 0.011835 | 0.005918 |
| 0.6 | 0.023501 | 0.021151 | 0.011751 | 0.0047 | 0.00235 |
| 0.8 | 0.0105007 | 0.009450063 | 0.005250035 | 0.002100014 | 0.001050007 |
| 1 | 0.005004 | 0.004504 | 0.002502 | 0.001001 | 0.0005 |
| 1.2 | 0.002484 | 0.002236 | 0.001242 | 0.000497 | 0.000248 |
| 1.4 | 0.001268 | 0.001142 | 0.000634 | 0.0000254 | 0.000127 |
| 1.6 | 0.000661 | 0.000595 | 0.000331 | 0.000132 | 6.61E-05 |
| 1.8 | 0.00035 | 0.000315 | 0.000175 | 7.00E-05 | 3.50E-05 |
| 2 | 0.000188 | 0.000169 | 9.39E-05 | 3.75E-05 | 1.88E-05 |

*a) Leak Finder Development Platforms*

The Leak Finder development platforms is presented in eq.1

*Table 1.0:* Leak finder Development Platforms

| # | Requirement | Description | How To Test | Test Result Ok? |
|---|---|---|---|---|
| 1 | Development Platform | Lab VIEW Graphical Development Platform | Verify that the system runs on LabVIEW platform | |
| 2 | Operating System Platform | Window 2000/NT/XP | Verify that the VI runs properly on the OS. | |

$$J = \begin{bmatrix} \frac{\partial F_{1j}}{\partial r_{ij}} & \frac{\partial F_{1j}}{\partial R_{ij}} & \frac{\partial F_{1j}}{\partial \omega_{ij}} & \frac{\partial F_{1j}}{\partial \lambda_{ij}} & \frac{\partial F_{1j}}{\partial S_{ij}} \\ \frac{\partial F_{2j}}{\partial r_{ij}} & \frac{\partial F_{2j}}{\partial R_{ij}} & \frac{\partial F_{2j}}{\partial \omega_{ij}} & \frac{\partial F_{2j}}{\partial \lambda_{ij}} & \frac{\partial F_{2j}}{\partial S_{ij}} \\ \frac{\partial F_{3j}}{\partial r_{ij}} & \frac{\partial F_{3j}}{\partial R_{ij}} & \frac{\partial F_{3j}}{\partial \omega_{ij}} & \frac{\partial F_{3j}}{\partial \lambda_{ij}} & \frac{\partial F_{3j}}{\partial S_{ij}} \\ \frac{\partial F_{4j}}{\partial r_{ij}} & \frac{\partial F_{4j}}{\partial R_{ij}} & \frac{\partial F_{4j}}{\partial \omega_{ij}} & \frac{\partial F_{4j}}{\partial \lambda_{ij}} & \frac{\partial F_{4j}}{\partial S_{ij}} \\ \frac{\partial F_{5j}}{\partial r_{ij}} & \frac{\partial F_{5j}}{\partial R_{ij}} & \frac{\partial F_{5j}}{\partial \omega_{ij}} & \frac{\partial F_{5j}}{\partial \lambda_{ij}} & \frac{\partial F_{5j}}{\partial S_{ij}} \end{bmatrix} \quad (49)$$

*i= time element   j= component under consideration working as a network to other components*

J is the safety matrix function which is tells operators the Limits of Safety, such that If J =1 in absolute terms the Safety status is stable or good, if J < -1, the safety status is unstable and a Fault may exist in the System and an Unsafe position results, if J > 1, the safety function becomes over stable, which indicates the systems functioning above normal or over design for safety. These criteria can be an important tool for Safety operators to mark the limit of design or operation. Any factor that tends to push safety function above or below absolute 1 should be minimized. This technique for determining safety is not available in previous method for safety analysis

## V. Results and Discussions

Table 3 shows the hazard register and the weights for safety. Based on models disclosed in previous section a weights were simulated in a risk management software system developed for purpose. The software simulator is design in visual basic macro scripts of an Excel sheet programme modules and the weights simulated in Excel sheet produce the weights values for different risk/hazard scenarios and events likely to occur. The weights values represents the safety function of the FPSO system subject the maximum hazards risk test analysis of 95% and minimum reliability test of 5% for both process and occupational hazards. These values expressed extreme scenarios and design is computed based on extreme scenarios in the hazard register. The Hazard register contains all possible hazards that is possible in FPSO system. The weights on occupational accidents is 0.36, offloading events 0.24, Hull failure due to extreme wave load is 0.24, Passing vessel collision with FPSO or shuttle tanker 0.959682, Strong collision by supply vessel with FPSO or shuttle tanker 0.206752, Hydrocarbon associated risk (process, turret and riser systems) is 0.454357, Hydrocarbon and Topsides systems accidents is 0.268701, , Leak that may lead to fire or explosion in process plant is 0.272354, Helicopter crash Leak from turret systems that may cause fire or explosion in turret is 0.204447, Leak or rupture of riser is 0.123299, Auxiliary systems accidents, 0.698367, Engine room fire or explosion is 0.566394, Fire or explosion in pump room is 0.718306, Helicopter crash 0.891995, Human and Organisational Factors (HOF) is 0.160624, People is 0.688105, Management systems is 0.71663, Collision risk represents a significant contribution for two of the FPSOs (all potential collision) is 0.005607, *Uncontrolled Release of Hazardous Materials is* 0.769407, Blowouts is 0.142786, Turret and Cargo Tank Release is 0.949124. This cases show the weight values that assumes a value of 1 represent the best case for safety under the scenarios of the risk and reliability of design and weight values that assume close to zero represent the work case for safety. In the few examples selected collision risks represents the worst case of safety with a value of 0.005607 followed by human and organisational factors (HOF) which is 0.160624. The best case for safety are the Turret and Cargo Tank release with a value of 0.949124, followed by Helicopter crash of 0.891995, followed uncontrolled release of hazardous materials 0.769407, followed by Fire or explosion in the pump room of value 0.718306, management system which are typical for most Exploration and production companies that have very strong integrated vertical management systems with a value of 0.71663. The results enable us not only to qualify the hazard register for the worst cases and best cases of safety for all components the FPSO system but allows a risk expert to quantify the amount allotted in each case for design, remedial or repair actions.

*Table 3:* Hazard Register And Weights of Safety

| SN | Hazard Register | |
|---|---|---|
| | FPSO | |
| | Fuzzy Class: General | |
| | Fuzzy Class: Weighted | |
| | Two Class of Safety | |
| | Occupational Related Hazards Risk (95%) | |
| | Process Related Hazards Reliability (5%) | |
| | Occupational Related Hazards Risk (95%) | |
| | Process Related Hazards Reliability (5%) | |
| 1 | Occupational Related Hazards | Weights of Safety |
| 2 | Process fires and explosions | 0.58 |
| 3 | Riser and pipeline releases | 0.30 |
| 4 | Ship collisions | 0.26 |
| 5 | Fires and explosions in accommodation spaces | 0.14 |
| 6 | Fires and explosions in machinery spaces | 0.81 |
| 7 | Fires and explosions in cargo and ballast tanks | 0.06 |
| 8 | Structural failure | 0.54 |
| 9 | Helicopter accidents | 0.37 |
| 10 | Occupational accidents | 0.36 |
| 11 | Offloading Events | 0.24 |
| 12 | Dropped objects | 0.51 |
| 13 | Position loss | 0.48 |
| 14 | Ballasting failures | 0.92 |
| | Fuzzy Class: General | |
| | Fuzzy Class: Weighted | |
| | Two Class of Safety | |
| | Occupational Related Hazards Risk (95%) | |
| | Occupational Related Hazards Reliability (5%) | |
| | Process Related Hazards risk (95%) | |
| | Process Related Hazards Reliability (5%) | |
| 15 | Marine and hull related accidents, structural impacts | Weights |
| 16 | Hull failure due to extreme wave load | 0.245383 |
| 17 | Hull failure or marine accident due to ballast failure | 0.296617 |
| | or failure during loading/offloading Operations | 0.160162 |
| 18 | Leak from cargo tank caused by fatigue | 0.137528 |
| 19 | Accident during tank intervention | 0.785583 |
| 20 | Passing vessel collision with FPSO or shuttle tanker | 0.959682 |
| 21 | Strong collision by supply vessel with FPSO or shuttle tanker | 0.206752 |
| 22 | Other vessels or floating structures operating on the field | 0.704976 |
| | colliding with FPSO or shuttle tanker | 0.081861 |
| 23 | Collision during offloading | 0.130822 |
| 24 | Rapid change of wind direction | 0.583432 |
| 25 | Multiple anchor failure | 0.09615 |
| | Fuzzy Class: General | |
| | Fuzzy Class: Weighted | |
| | Two Class of Safety | |
| | Occupational Related Hazards Risk (95%) | |
| | Occupational Related Hazards Reliability(5%) | |
| | Occupational Related Hazards Risk (95%) | |
| | Occupational Related Hazards Reliability (5%) | |

| | | |
|---|---|---|
| 26 | **Hydrocarbon and Topsides systems accidents** | 0.268701 |
| 27 | Leak that may lead to fire or explosion in process plant | 0.272354 |
| 28 | Leak from turret systems that may cause fire or explosion in turret | 0.204447 |
| 29 | Leak or rupture of riser | 0.123299 |
| 30 | Impacting loads due to crane operations (swinging loads) on a moving vessel | 0.456445 |
| 31 | Dropped object from retrieval of cargo pumps | 0.96504 |
| 32 | Severe rolling during critical operations, such as crane operations | 0.160463 |
| | (considered as included) | 0.401012 |
| 33 | other scenarios, therefore not addressed separately) | 0.92856 |
| 34 | "Topside" fire threatening cargo tank resulting from gas leaks | 0.191856 |
| 35 | Emergency flaring with approaching shuttle tanker or during off-loading | 0.494471 |
| 36 | Unintended release of gas or oil from riser | 0.862935 |
| 37 | Gas and oil release from other sources | 0.585676 |
| 38 | **Auxiliary systems accidents** | 0.698367 |
| 39 | Failure of cargo tank explosion prevention function during normal operation | 0.460309 |
| 40 | Fire or explosion in pump room | 0.718306 |
| 41 | Spill from off-loading system. | 0.366799 |
| 42 | Engine room fire or explosion | 0.566394 |
| 43 | Helicopter crash | 0.891995 |
| 44 | **Human and Organisational Factors (HOF)** | 0.160624 |
| 45 | People | 0.688105 |
| 46 | Equipment (e.g. hardware) | 0.344732 |
| 47 | Management systems | 0.775929 |
| 48 | Culture and environment | 0.58924 |
| 49 | **Management systems Failure** | 0.694851 |
| 50 | Procedures | 0.973734 |
| 51 | Communication | 0.408983 |
| 52 | Training | 0.505835 |
| 53 | Management of change | 0.71663 |
| 54 | Risk assessment Policy and Procedures | 0.991488 |
| 55 | **Hydrocarbon associated risk (process, turret and riser systems)** | 0.454357 |
| | **is the highest contribution for all FPSOs considered.** | 0.694676 |
| 57 | Collision risk represents a significant contribution for two of the FPSOs (all potential collision) | 0.005607 |
| 58 | Scenarios are included, but shuttle tanker impact is the dominating contribution. | 0.527423 |
| 59 | Occupational accidents and accidents during helicopter transport were only included for one | 0.25107 |
| 60 | All the cases. | 0.261401 |
| 61 | **Uncontrolled Release of Hazardous Materials** | 0.769407 |
| 62 | Blowouts | 0.142786 |
| 63 | Turret and Cargo Tank Release | 0.949124 |
| 64 | Release of Non-Process Materials | 0.901016 |
| 65 | Topside Process Release | 0.769164 |
| 66 | Bunkering Operations | 0.800986 |
| 67 | **Natural Adverse Occurrences Hazards** | 0.430831 |
| 68 | Earthquakes | 0.519753 |
| 69 | Subsidence | 0.846755 |
| 70 | Severe Storm | 0.033608 |
| 71 | Tornadoes | 0.900927 |
| 72 | **Physical Impacts Hazards** | 0.419685 |
| 73 | Vessel Collisions | 0.562891 |
| 74 | Drilling Jackup Collision | 0.356217 |
| 75 | Fixed Wing Aircraft | 0.806782 |

| | | |
|---|---|---|
| 76 | Missile | 0.66652 |
| 77 | Submarine Collisions | 0.198745 |
| 78 | Helicopter Collisions | 0.402451 |
| 79 | Dropped Objects | 0.531651 |
| 80 | **Structural Failures** | 0.054705 |
| 81 | FPSO Structural Failure | 0.064833 |
| 82 | Crane Structural Failure | 0.300675 |
| 83 | Process Vent Stack Failure | 0.342143 |
| 84 | **Fires Hazards within Enclosed Areas** | 0.489227 |
| 85 | Indirect Events | 0.314163 |
| 86 | Communications Failure | 0.055235 |
| 87 | Process Control Failure | 0.206388 |
| 88 | Operations or Maintenance Error | 0.607366 |
| 89 | Power Supply Failure | 0.183286 |
| 90 | Construction Error | 0.465601 |
| 91 | **Other Hazards** | 0.893934 |
| 92 | Diving Hazards: | 0.843267 |
| 93 | Process Analysis | 0.757956 |
| 94 | Occupational Hazards | 0.555226 |
| 95 | Environmental Hazards | 0.03813 |
| 96 | Offloading Operations | 0.113766 |
| 97 | FPSO Mooring System Failure | 0.147519 |
| 98 | Marine Operations | 0.532911 |
| 99 | Stability and Water Tightness | 0.511993 |
| 100 | Sea Keeping | 0.418401 |
| 101 | Structural Failure | 0.921399 |
| 102 | Personnel Transfer | 0.600707 |
| 103 | **TR Impairment** | 0.770934 |
| 104 | process/deck piping pool fire | 0.391826 |
| 105 | non-field vessel collision | 0.629452 |
| 106 | mooring line failure | 0.905579 |
| 107 | offloading vessel collision | 0.992711 |
| 108 | cargo tank fire/explosion | 0.342772 |
| 109 | others | 0.237412 |
| 110 | **Electrical Failure /Blackout** | 0.102311 |
| 111 | Power Management Systems | 0.918463 |
| 112 | Blackout | 0.828628 |
| 113 | 1.Load Demands | 0.865375 |
| 114 | 2.Generator Trips | 0.605228 |
| 115 | **Subsea Flowlines and Risers Failure** | 0.803487 |
| 116 | **Gas Lift/Export Flowline and Riser Systems** | 0.864006 |
| 117 | **Process Risks Causes** | 0.49596 |
| 118 | **Gas Leaks** | 0.888224 |
| 119 | a. Over Pressure | 0.249184 |
| 120 | b. Corrosion | 0.648887 |
| 121 | c. Blowout | 0.402292 |
| 122 | **2. Over Pressure** | 0.651338 |
| 123 | a. Rapid Valve Closure | 0.342516 |
| 124 | b. Pump Over Pressure | 0.476087 |
| 125 | **3. H2SCracking** | 0.955437 |
| 126 | a. Presence of H2S conditions | 0.811973 |
| 127 | **4. Rapid Decompression** | 0.800665 |
| 128 | **Mechanical Risks** | 0.563077 |

| | | |
|---|---|---|
| 129 | 1. Fatigue | 0.846947 |
| 130 | a. Age | 0.832021 |
| 131 | b. Pipeline Wear | 0.252996 |
| 132 | 2. Riser Movement | 0.916733 |
| 133 | a. Water Current | 0.750846 |
| 134 | b. Movement of FPSOs | 0.381637 |
| 135 | Operational Risks | 0.767096 |
| 136 | 1. Safety Valves Failure | 0.92734 |
| 137 | 2. Operational Maintenance Negligence | 0.617795 |
| 138 | Human Risks | 0.461933 |
| 139 | In experience Operators | 0.675503 |
| 140 | Operational Negligence | 0.790135 |
| 141 | Design Oversight | 0.402744 |
| 142 | Lack of Training | 0.493624 |
| 143 | Poor Work Ethics | 0.039122 |
| 144 | Management Oversight | 0.138692 |
| 145 | Process Risks | 0.757267 |
| 146 | 1. Wax Formation | 0.421924 |
| 147 | a. Operating Conditions at or below pour Temperature | 0.069952 |
| 148 | 2. Hydrate Formation | 0.445984 |
| 149 | a. Operating Below Cloud Temperature | 0.577469 |
| 150 | 3. Surges | 0.074496 |
| 151 | a. Over pressure | 0.328886 |
| 152 | 4. Scaling | 0.432894 |
| 153 | a Presence of Barium Sulphate | 0.320005 |
| 154 | b. Corrosion materials | 0.508234 |
| 155 | 5. H2S Corrosion | 0.219939 |
| 156 | a. H2S present | 0.114418 |
| 157 | b. Corrosion Environment | 0.653914 |
| 158 | 6. CO2 Corrosion | 0.989972 |
| 159 | a. CO2 Present | 0.605648 |
| 160 | b. Corrosion Environment | 0.561565 |
| 161 | Mechanical Risks | 0.522539 |
| 162 | 1. Dynamic Loading of FPSOs | 0.948076 |
| 163 | a. Movement of FPSOs | 0.047636 |
| 164 | b. Water or Ocean Currents | 0.698753 |
| 166 | 2. Stress Corrosion Cracking , SCC | 0.557259 |
| 167 | a. H2S present | 0.031665 |
| 169 | 3. Bending Load at Interfaces | 0.474349 |
| 170 | a. Operating Conditions | 0.180089 |
| 171 | b. Movement of FPSOs | 0.099551 |
| 173 | 4. Leaks | 0.572271 |
| 174 | a. Over Pressure | 0.6867 |
| 175 | b. BlowOut | 0.383203 |
| 176 | c. Corrosion | 0.916813 |
| | | |
| 178 | 5. Operational Risks | 0.819863 |
| 179 | a. Pigging Operations | 0.159734 |
| 180 | b. Depressurization and Blow Out | 0.585767 |
| 181 | | 0.616658 |
| 182 | Human Risks | 0.377874 |

| | | |
|---|---|---|
| 183 | In experience Operators | 0.783507 |
| 184 | Operational Negligence | 0.033003 |
| 185 | Design Oversight | 0.45068 |
| 186 | Lack of Training | 0.475881 |
| 187 | Poor Work Ethics | 0.283339 |
| 188 | Management Oversight | 0.252755 |
| 189 | Turret Design Failure | 0.943661 |
| 190 | The passive nature of the turret design minimizes | 0.46419 |
| 191 | the station-keeping risk but increases the fire and explosion | 0.302457 |
| 192 | risks as the wind direction tends to align with the dec | 0.290569 |
| 193 | 1.Damage to equipment caused by dropped objects | 0.117465 |
| 194 | 2.Fishing gear impacts | 0.86409 |
| 195 | 3.Leaks in the flexible piping because of aging riser | 0.799673 |
| 196 | 4.Latent defects in design or manufacturing. | 0.67855 |
| 197 | Process Fires and Explosions. | 0.051717 |
| 198 | Note that because of the | 0.252564 |
| 199 | passive turret design, the wind tends to align with the deck, and a | 0.201168 |
| 200 | gas leak would reach the turbine intakes 77% of the time. | 0.778077 |
| | | 0.542618 |
| | Fuzzy Class: General | |
| | Fuzzy Class: Weighted | |
| | Two Class of Safety | |
| | Occupational Related Hazards Reliability (95%) | |
| | Occupational Related Hazards Reliability(5%) | |
| | Occupational Related Hazards Reliability (95%) | |
| | Occupational Related Hazards Reliability (5%) | |
| 203 | Human Personnel Resourse Hazards | 0.785607 |
| 204 | OIM | 0.511124 |
| 205 | Production Supervisor | 0.865187 |
| 206 | Maintenance Coordinator | 0.180422 |
| 207 | Shift Supervisor | 0.8816 |
| 208 | Production Operators Staff (oil, gas, utilities) | 0.148113 |
| 209 | Instrument Engineer | 0.498624 |
| 210 | Instrument Technician | 0.060353 |
| 211 | Electrical Staff | 0.850599 |
| 212 | Mechanical Engineer | 0.803781 |
| 213 | Mechanical Technician | 0.119317 |
| 214 | Subsea Staff | 0.181005 |
| 215 | Berthing Master (Also Tanker Safety Supervisor) | 0.995288 |
| 216 | Marine Supply | 0.796298 |
| 217 | Offloading Support Staff | 0.583852 |
| 218 | Telecoms Engineer | 0.111915 |
| 219 | Medics/Admin | 0.093324 |
| 220 | Core Offshore Crew | 0.668866 |
| 221 | Crane Operator | 0.612093 |
| 222 | Facility Management (including Catering) | 0.356764 |
| 223 | Core Offshore Services Crew | 0.838698 |
| 224 | Specialist Operations Staff (including Loading) | 0.034068 |
| 225 | Intergated Service Contractor Staff | 0.091184 |
| 226 | Revenue Engineering | 0.287148 |
| 227 | Commisioning Allowance | 0.000236 |
| 228 | Total Services and Suport | 0.562159 |

| | | |
|---|---|---|
| 230 | Campaign Offshore Crew | 0.073438 |
| 231 | Government Reps | 0.785982 |
| 232 | Human Hazards | 0.138105 |
| 233 | Human errors are of Seven Types | 0.144795 |
| 234 | 1. Design Errors | 0.229739 |
| 235 | 2. Operators Error | 0.294726 |
| 236 | 3. Fabrication Error | 0.171199 |
| 237 | 4. Maintenance Error | 0.818781 |
| 238 | 5. Inspection Error | 0.32683 |
| 240 | 6. Contributory Error | 0.893129 |
| 241 | 7. Handling Error | 0.615725 |
| 242 | 1. Poor Training or Skill | 0.171947 |
| 243 | 2. Poorly documented or Lack of Documented and Updated Operational Procedures | 0.213275 |
| 244 | 3. Environmental Factors and Occupational Safety | 0.733409 |
| 244 | 4. Poor Incentives by Management | 0.661781 |
| 244 | 5. Negligence and Organizational Attitudes | 0.543797 |

*a) Safety Factors Design*

The plot of failure rate and reliability rate as revealed in Figure 7 and Figure 8 respectively show a parabolic curve with a peak maximum at five years. The measure of failure rate determined as number of failures per year of personnel for the FPSO predicted a peak of 2 fatalities within 5 years which is good performance and tapers down due to improve performance. Whereas the predicted reliability FPSO degrades over a period of time reaching all time high of 2.7% poor performance. The poor performance of reliability may be due to over design of some facilities. Figure 9 and Figure 10 are the predicted safety and risk potential which is the net risk and safety factors put in place based on all possible scenario of Table 3.0, we have a net average risk potential to FPSO increasing slowly in a parabolic fashion reaching a threshold after 15 years and peaking at a maximum. The risk potential is the measure of risk over the reliability of the safety systems. Since the studied FPSO risers, hull and production facilities have been overdesign against risk by putting in place the safety measures, the relative risk profile is low and therefore risk potential is a good measure to determine the measure of risk. A cursory look at the safety potential shows a continual degrade of safety measures of time. The complicated interrelated threats all work to undermine facility and therefore recommended repair operations is recommended. The plots presented in Figure 7, Figure 8, Figure 9 and Figure 10 are based on the simulated table based on Monte Carlos simulation of the hazard data supplied by operators assuming occupational related hazard risks of 95%, process related hazards reliability of 5%, and their measures of safety simulated by the deterministic model and learning algorithm disclosed in our work.

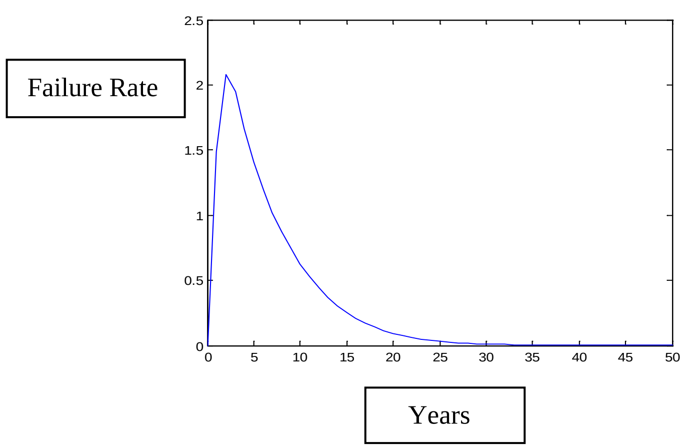



*Figure 3:* Plot of Reliability rate with time of Riser System

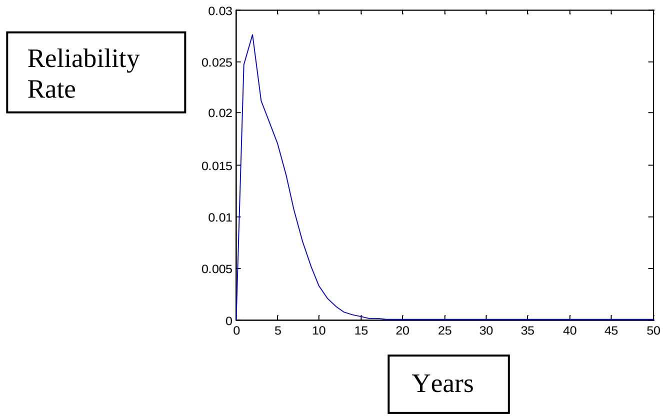



*Figure 4:* Plot of Reliability Rate with time of FPSO Riser System

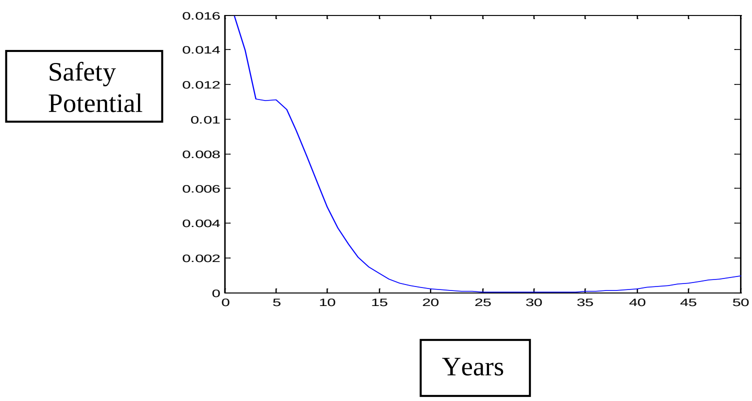



*Figure 5:* Plot of Safety Potential with time of FPSO Riser System

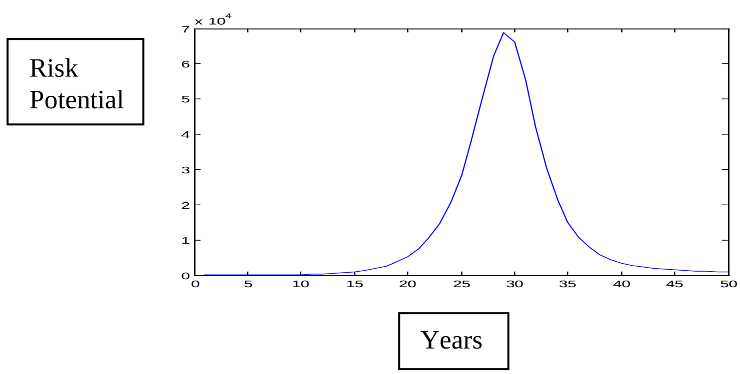



*Figure 6:* Plot of Risk Potential with time of FPSO Riser System

*b) Weighted Hazard Rate and the Belief Function*

This section discusses plots of weighted hazard rated and belief function. Thus Figure 11 shows the weighted hazard rate with the hazard shape function. The hazard shape function describes the nature of risk. A hazard shape function of 1 is a constant hazard rate, below 1, is a decreasing hazard rate and above is the increasing hazard rate. The weighted hazard rate shows increasing hazard rate is significant. By the term weighted hazard rate implies a safety measures have been incorporated and takes into consideration change in hazard behaviour. A safety fraction of 0 shows a hazard rate at its minimum and decreases as safety fraction increases. The belief function describes the level of confidence an operator views the reliability of such systems. A reliability of 90% at fuzzy class 1, very likely to occur, a linguistic term shows a belief function that is parabolic with time.

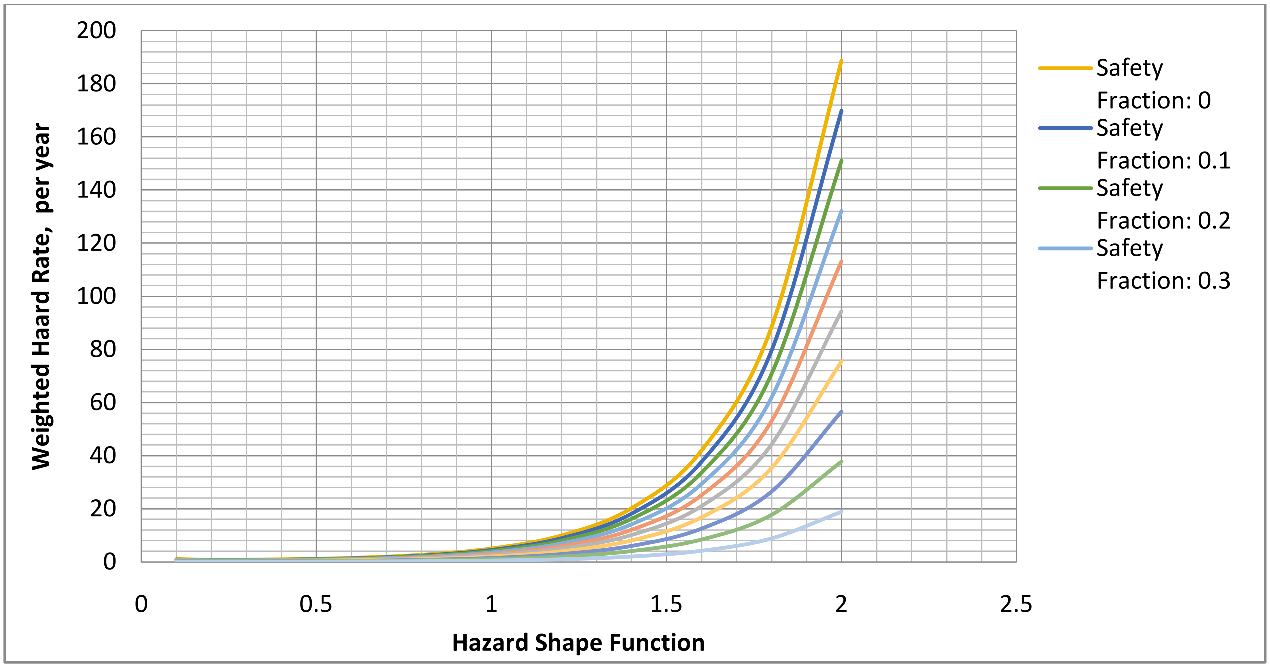



*Figure 7:* Weight Hazard Rate with Hazard Function for Fuzzy Class 1

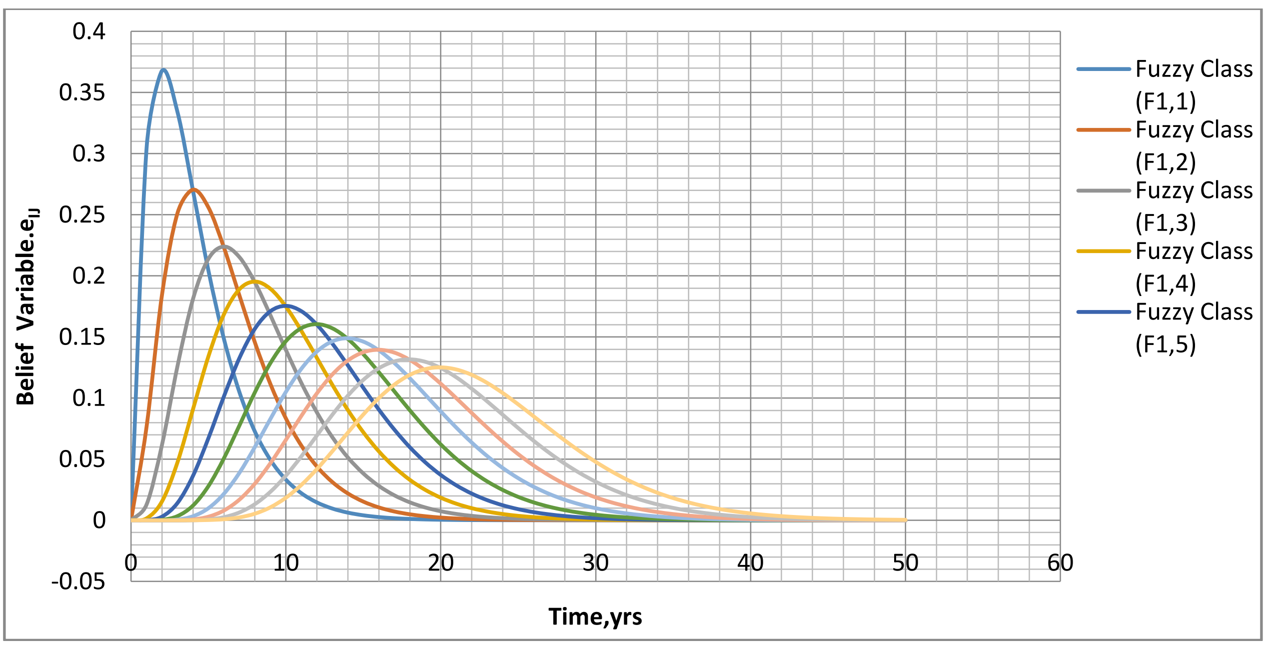



*Figure 8:* Plot of Belief Variable $e_{ij}$ with Time (yrs) for Fuzzy Class 1 for 90% Safety Level Protection for different fuzzy failures F1(1,-10)

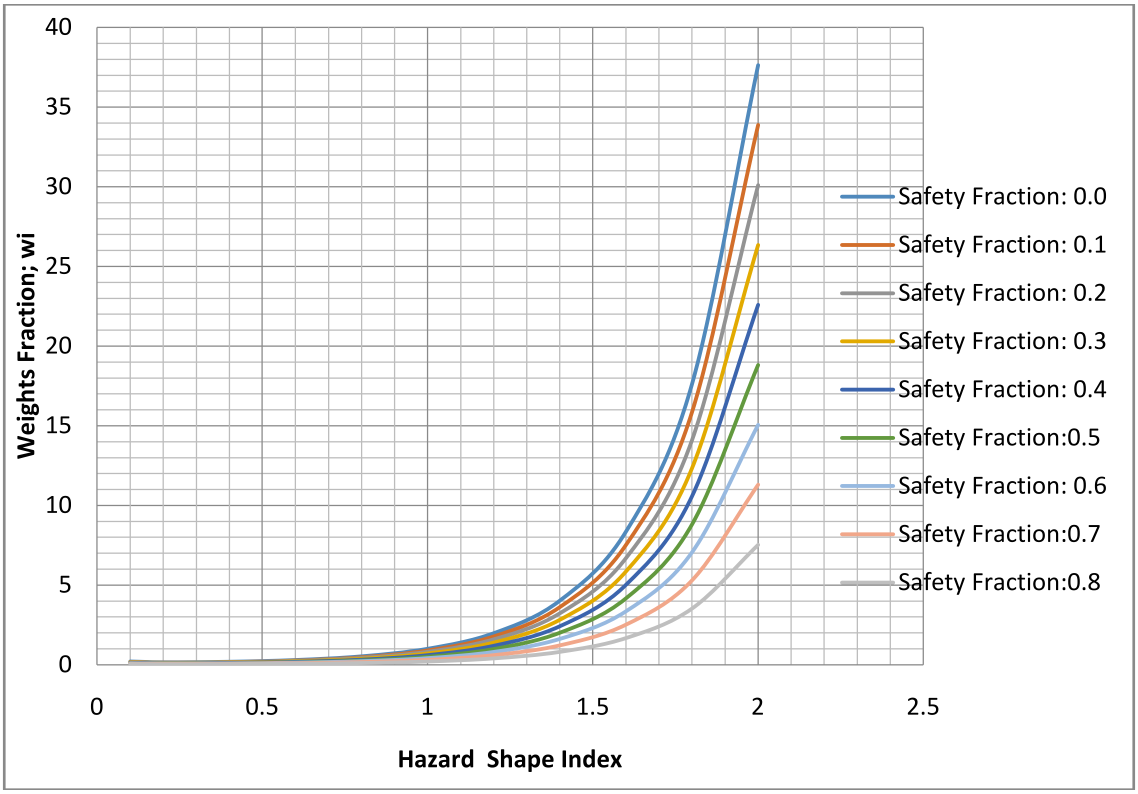



*Figure 9:* Weight Index Variation with Hazard Shape Index for Different Class of Safety Fraction for Fuzzy Class 1

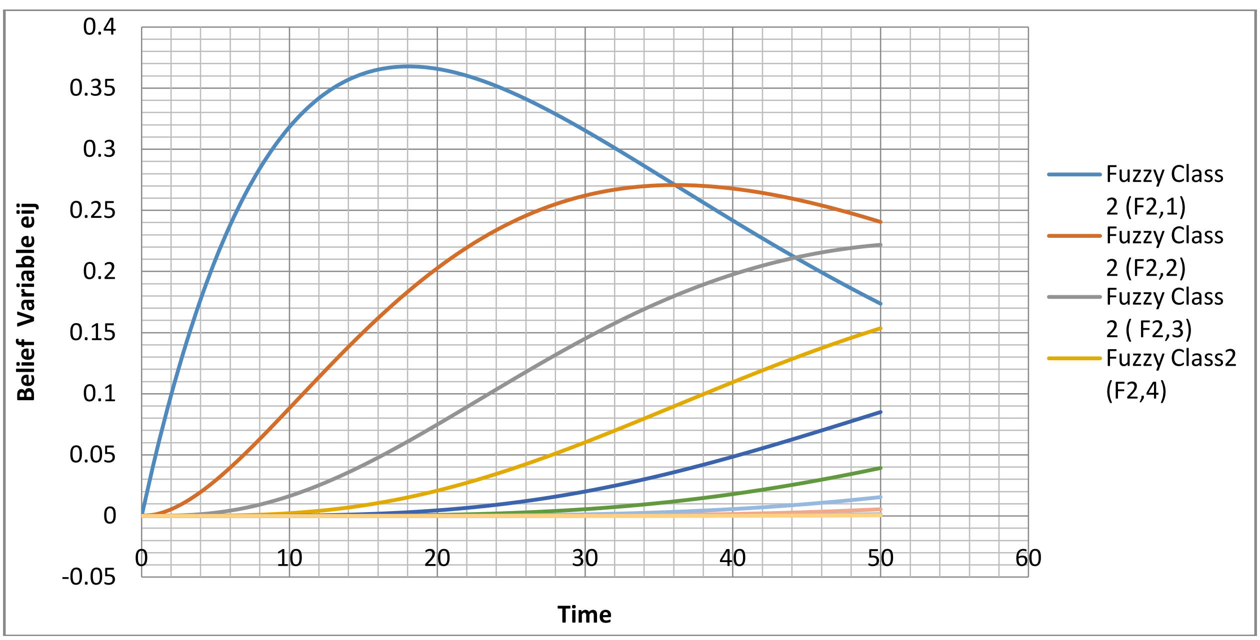



*Figure 10:* Plot of Belief Variable $e_{ij}$ with Time for 90% Safety Protection for Fuzzy Class 2 for Fuzzy Failures 1-10

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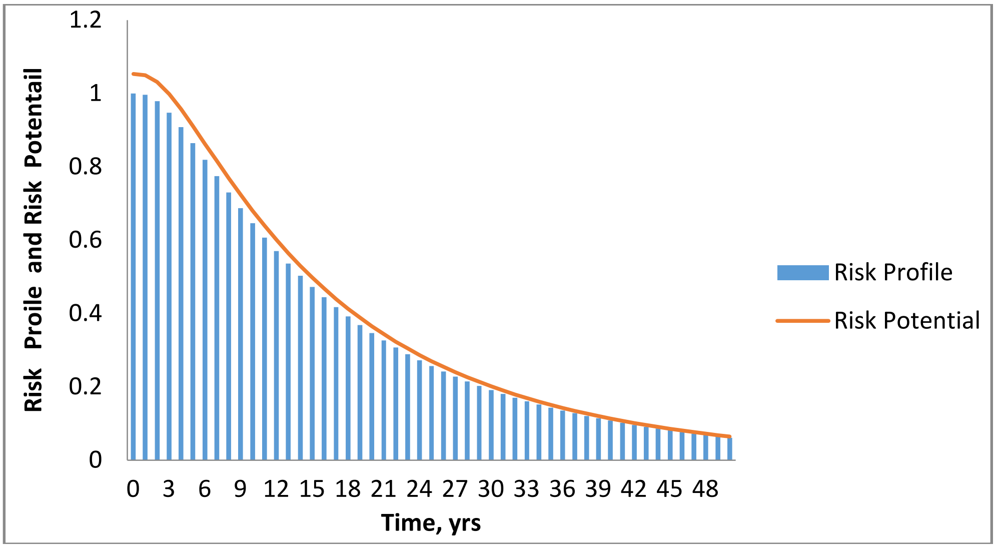


*Figure 11:* Plot of Risk Profile and Risk Potential for 0.95 Safety Reliability

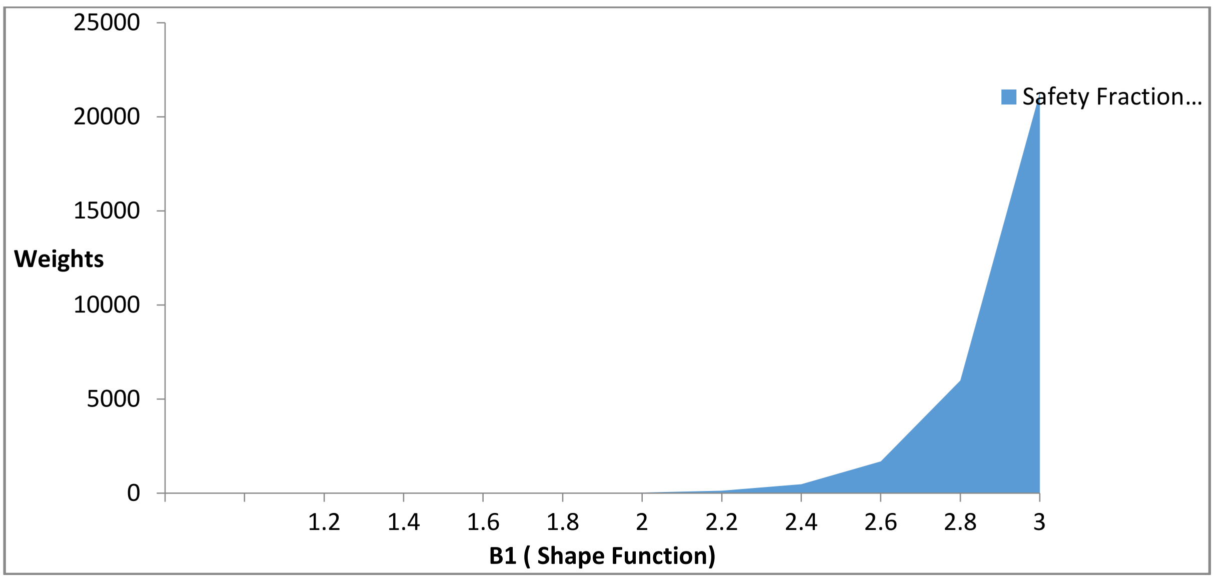


*Figure 12:* Weights Function against Hazard Shape Function B1 for Safety Fraction of 0.9

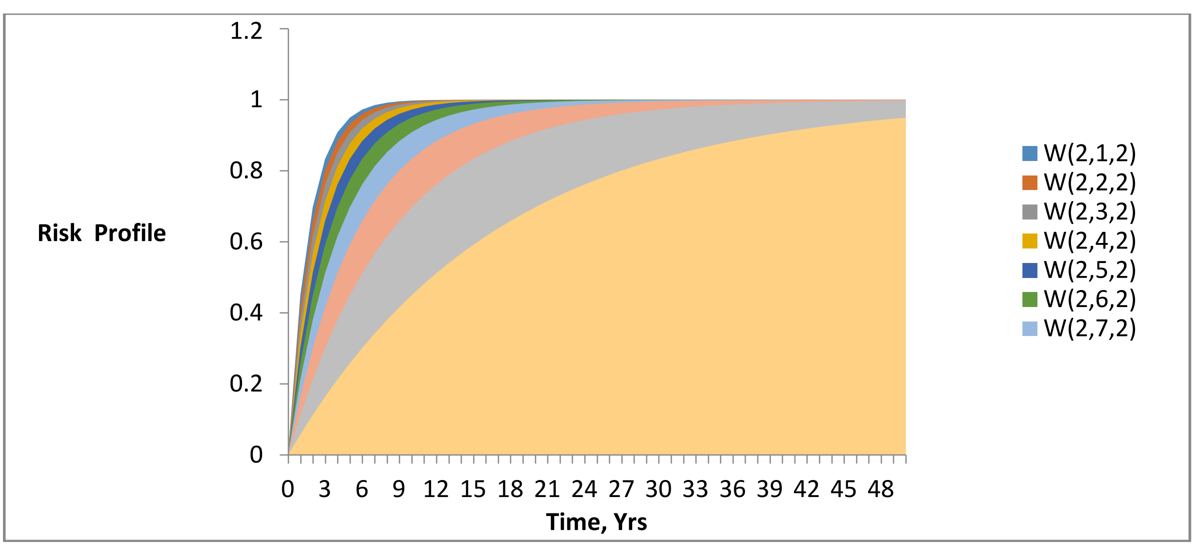


*Figure 13:* Risk Profile with Time for B (1.8) , Fuzzy Class 2 and Weight Function (B1, SRFi) : SFRi (0,0.1, 0.2......0.9)

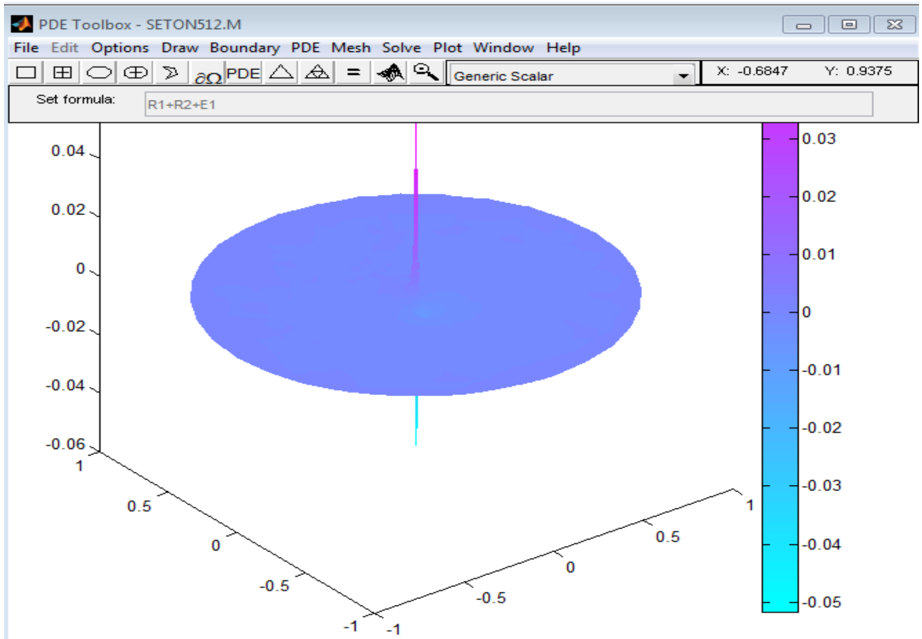


*Figure 14:* PDE tool box displaying a plot of the initial boundary conditions

The MAT file derived from the PDE tool is feed into the neural networks tool box as a source of raw data in other for the fitting networks, Perceptions and predictive control networks to be trained. In this work, it was saved as data.mat

For the curve fitting networks

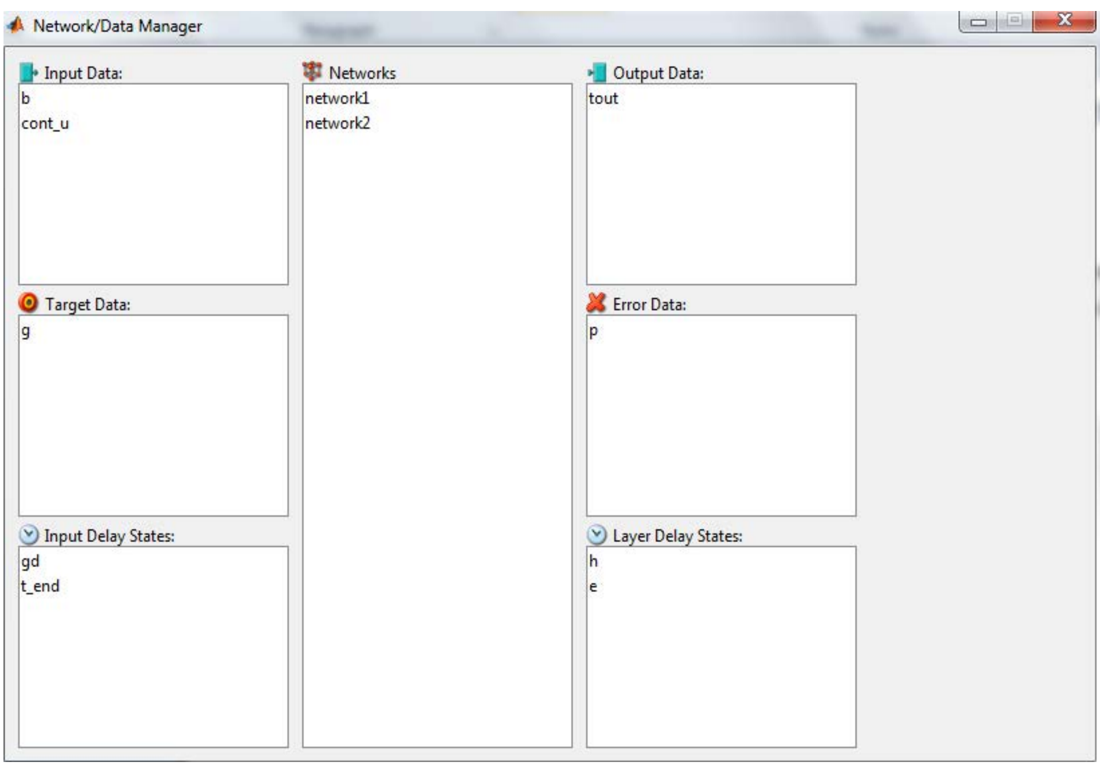


*Figure 15:* MATLAB neural networks data manager

Here is the neural networks data manager showing the functions and data imported from the model in the PDE tool. All variables represented by letters in the network/data manager signify various vectors and matrices derived from the risk that have been further simplified with learning algorithms.

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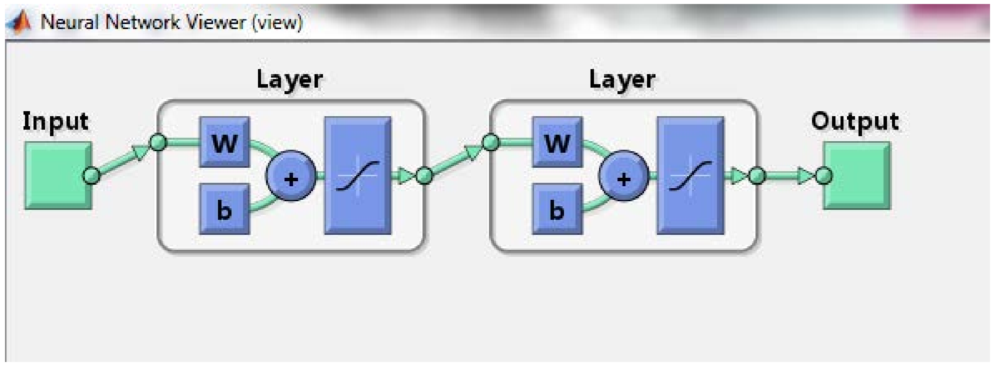


*Figure 16:* MATLAB neural network viewer

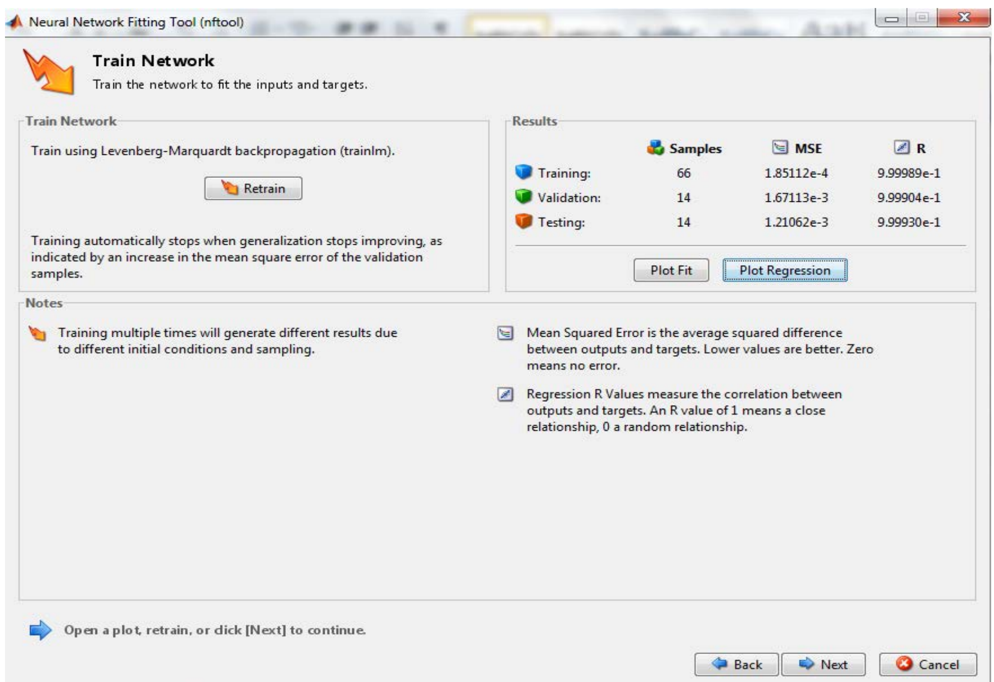


*Figure 17:* MATLAB neural network fitting tool

The network is to be trained using levenberg-Marquardt back propagation. Levenberg-Marquardt is the best training algorithm adopted for .complex problems and the application of multiple networks in solving problems like Risk system in oil and gas riser systems

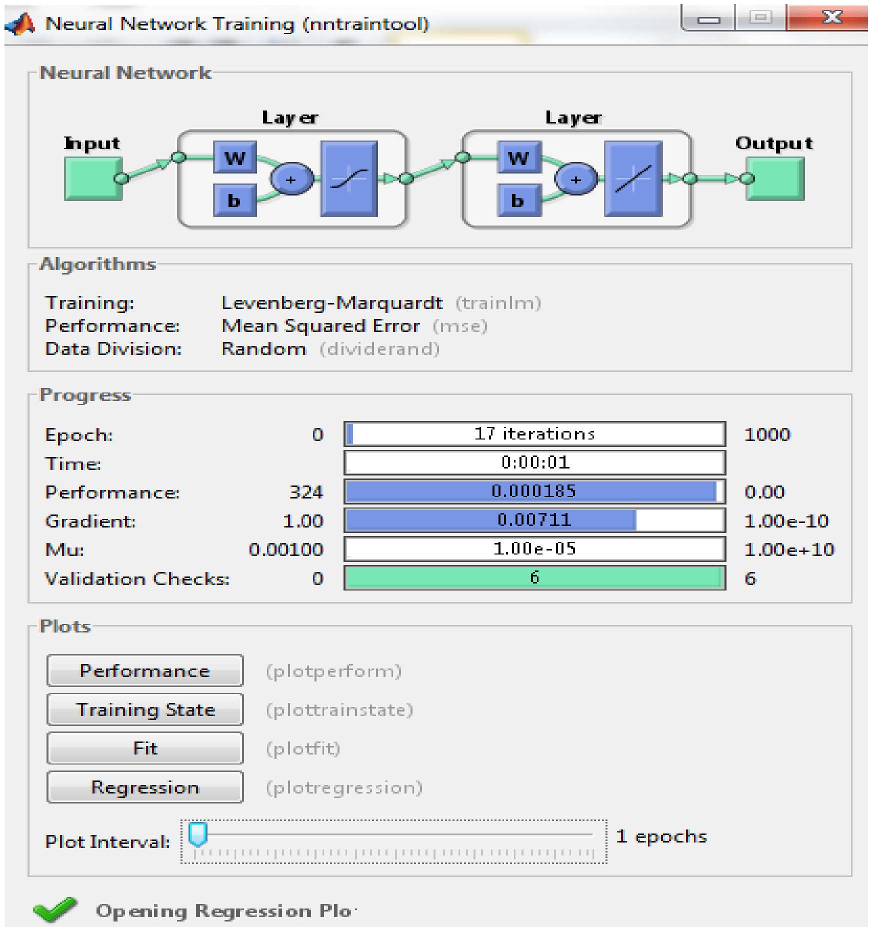


*Figure 18:* MATLAB neural network training tool

The general graphic user interface (GUI) for the neural network in training showing the training procedures and a link for the outcomes of the training like the performance, training state, fit, regression Here is the performance plot for the performance.

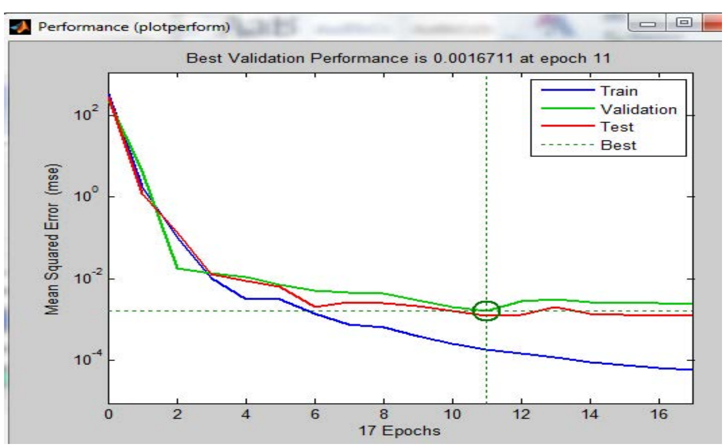


*Figure 19:* performance plot

This is for 11 iterations known as epochs

This training stopped when the validation error increased for six iterations, which occurred at iteration 23. If you click Performance in the training window, a plot of the training errors, validation errors, and test errors appears, as shown in the following figure. In this example, the result is reasonable because of the following considerations: The final mean-square error is small. The test set error and the validations set error have similar characteristics. No significant over fitting has occurred by iteration 17 (where the best validation performance occurs).

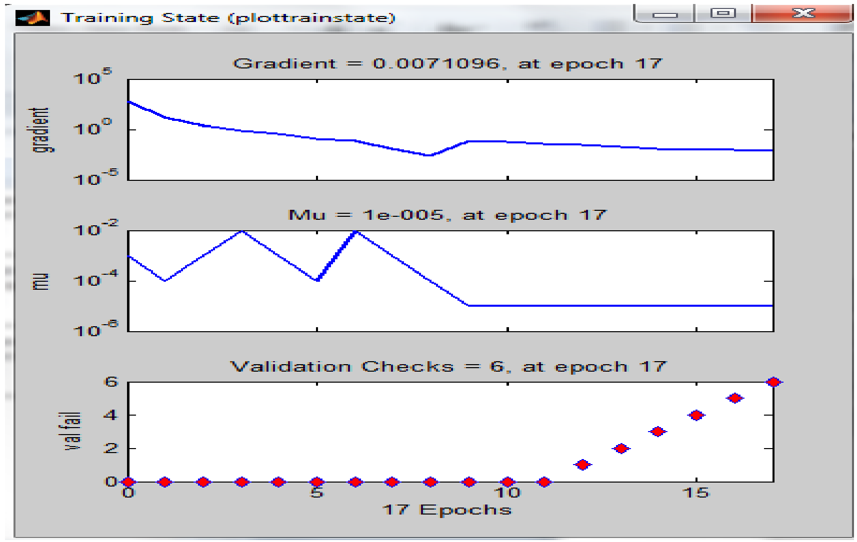


*Figure 20:* Training state

This is the training state. These plots are characteristic to a group of distributions of vectors fed from the model to be used in predictive control and decision support. Any deviation from this plot will be recorded and seen as anomaly during Risk system.

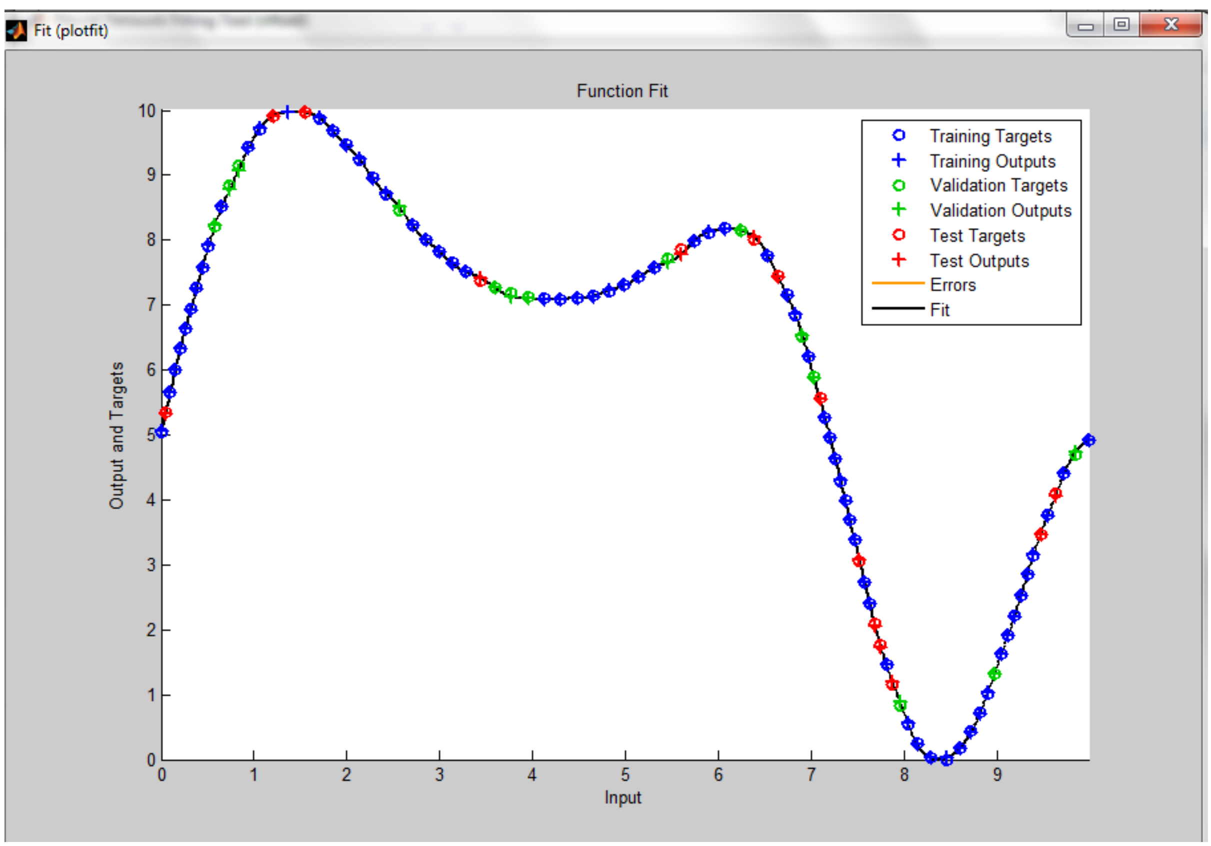


*Figure 21:* Neural Network Fit

This is a plot fit between the input functions (the pressure distribution data of the field during Risk system production) and the output data which is the Risk systeming factor $C_f$ and the targets which is the true value the dimensionless pressure used in the IMPES PDE model. The training targets are shown by the blue circles while training inputs are the blue +, validation targets and Output d is green respectively while test details are red, Errors appear orange the fit is black.

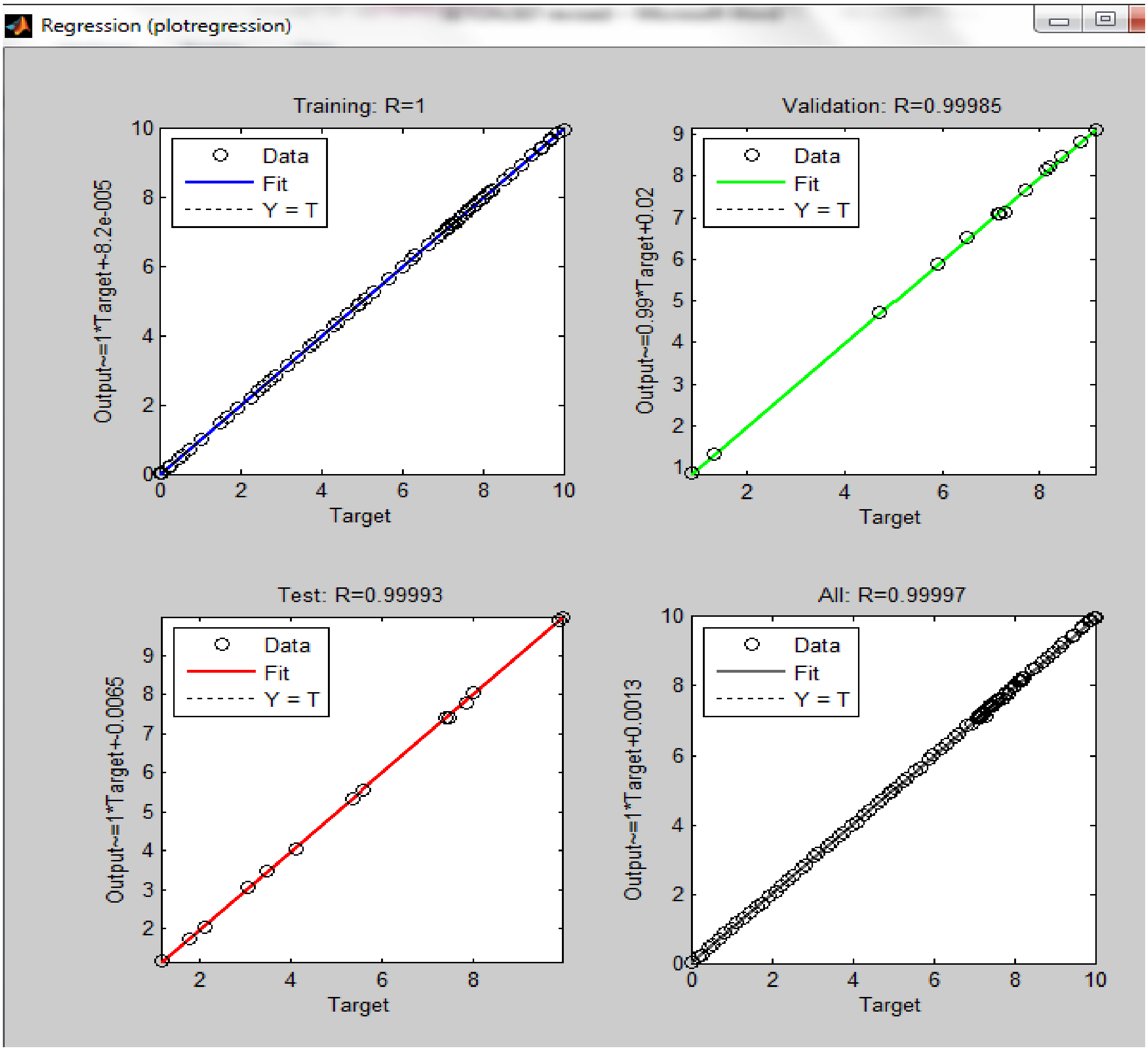


*Figure 22:* Regression plot

Here is the regression analysis for the network trained. An interpretation of these reports can be used for the decision support system. Further production process management can be conducted to a point where each Risk systeming rate and Risk systeming factor will be identified separately by a Regression pattern of two characteristic to it. This can help in predicting future rate of Risk system. And in the decision making process of a production team. All the output from the neural networks can be used to design a hardware system that has been programmed to generate these output when fed with data from the production system, this system generates output, stores them in its memory and compares them with the previous output generated as production continues. A transition from a point of minimal Risk systeming to a critical Risk systeming can be noticed by this system. The system would trigger an alarm or other forms of communications (probably red light) to inform the Production Personnel.

## VI. Conclusion and Recommendation

The Learning algorithms provides a method of resolving risk modelling of complex production systems. The production platforms, storage and riser/flowline systems was considered for distribution of risk factor at different times and along the. Data is obtained from the production system and fed into the neural networks the difference in patterns signifies a difference in the condition of the production system. This project involves a series of projects starting from Risk system production modelling, to Risk system management technologies, Risk system transportation modelling and simulations etc. it is recommended that the background of Risk systeming problems be taught in Petroleum Production Engineering courses. The knowledge of various tools for this kind of simulation should be introduced to the engineering curricular.

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# A Step Forward Progress in Physics and Cosmology with an Alternative Approach to General Relativity

By Prince Jessii
*Trasker Institute of Scientific Research*

*Abstract-* A property of spacetime which is the ability for more space to come into existence was first discovered by Albert Einstein with his General Theory of Relativity (GTR). This theory had predicted some observations like gravitational waves, black holes, orbital movements etc. Another property of spacetime is the fact that empty space can possess its own energy. As more space comes into existence, more of this energy of space appears, this form of energy regarded as dark energy would cause the universe to expand and accelerate at a fast rate. GTR had predicted some cosmological observations we see today but its still unable to account for the nature of dark energy, this has resulted into theorists insisting that there could be something wrong with GTR and a new theory could include a field that creates this cosmic acceleration.

*Keywords:* *space; dark energy; energy; fabric; universe.*

*GJSFR-A Classification:* *FOR Code: 020103*

ASTEPFORWARDPROGRESSINPHYSICSANDCOSMOLOGYWITHANALTERNATIVEAPPROACHTOGENERALRELATIVITY

*Strictly as per the compliance and regulations of:*

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Prince Jessii

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With a view that GTR has a way to account for the nature dark energy if traced back to the nature of spacetime just before cosmic inflation. I mainly review GTR and its subject equation. Also, with the view that all properties of spacetime are linked, I review major observatory points from LIGO project on gravitational waves, results from photometric observations of type Ia supernovae on the expansion of the universe. Finally, dark energy's fellow; normal energy (Electromagnetic radiation, EMR) must not be left out from solving the puzzle and must take a review. I present a theoretical concept from GTR awaiting experimental prove. This concept accounts for the nature of dark energy arising from a non-stretched spacetime just before the cosmic inflation, relating the vacuum energy as true a property of the non-stretched spacetime which has an opposite effect as EMR. This concept emerging from GTR gives the experimentalists/cosmologists an idea on nature of dark energy.

*Keywords: space; dark energy; energy; fabric; universe.*

## I. Introduction

Physics and cosmology welcome the idea that more space can come into existence by expansion. Hubble space telescope observations of very distant supernovae showed that a long time ago, the universe was expanding slowly than its rate today. The nature of spacetime at the outer-space is observed to be very thick and a better illustration of its expansion is like the expansion of an elastic rubber, if two points are marked apart on an elastic rubber, the distance between the two points increases by stretching (expansion) the elastic rubber, stretching the elastic rubber increases the length of the elastic rubber itself and reduces its thickness depending on how far the elastic rubber is stretched. This simple illustration is the idea behind the observational discovery of the expansion of the universe. The summary of the illustration implies that although the elastic rubber is stretched or expanded, there was a default length and thickness of the elastic rubber just before it was stretched. Using this illustration in cosmology, the universe is expanding which means the distance between two points will increase over time, the elastic rubber in this case is spacetime. Although spacetime is expanding, theorists and astronomers have refused to indicate or observe that spacetime itself is alsolosing its thickness. It can only be regarded as magical if more space can come into existence without emerging from its previous form. This implies that from the point of cosmic inflation, spacetime kept stretching up to this point creating expansion. However, there is a default nature of spacetime that was present just before cosmic inflation, the fact that dark energy had driven the expansion of spacetime right from the big bang means that the nature of dark energy can be easily described if that default nature of spacetime is presented. In this paper, as an attempt to present this default nature that'll lead to the description of dark energy, I review the main concept of GTR that describes gravity as a property of space from its curvature, this review of GTR discovers a missing function of gravity that is similar to that of dark energy, this is presented in Section 2.0. Gravitational wave effect on spacetime itself is linked to this missing function of gravity, observatory points on the origin and behavior of gravitational waves from LIGO to check for this effect is presented in Section 2.1. With the observatory points, the new alternative approach to GTR is presented in Section 2.2. A test to prove this new concept is done mathematically in Section 2.3. Section 3 and 3.1 presents points and evidences on the expansion and acceleration of the universe from the type Ia and High z supernovae team. As related to dark energy, possible properties of this energy fluid are also presented. The stars are the main source of EMR. Other than the death of a planet or any other planetary body, the death of stars results into black holes causing the deformation of spacetime exhibiting a strong

*Author: Trasker Institute of Scientific Research.*
*e-mail: princejessii8@gmail.com*

gravitational acceleration. A view that EMR will provide a huge lead to dark energy is presented in Section 4 and 4.1. Section 5 presents a new theoretical concept from GTR with the summary of all the major points from other sections and describing the nature of dark energy leaving a clue for the astronomers/experimentalists on how to prove this concept.

## II. General Relativity

General theory of Relativity (GTR) is the latest description of gravitation in modern physics. It is a geometric theory of gravitation proposed and published by Albert Einstein in 1916 [2,4].

Einstein also derived his field equations describing the relation between the geometry of a four-dimensional pseudo-Riemannian manifold representing spacetime, and the energy momentum in spacetime, this was different from the Newtonian concept in terms of the source. In Newtonian gravity, the source is mass. In GTR, mass is described as a general quantity known as the energy-momentum tensor. Newton's law has since been suspended by Albert Einstein's Theory of General Relativity, but it is still used as an approximation of the effects of gravity in most applications.

Newton described gravity as a force of attraction between two bodies; tugging between two bodies depends on how far apart the two bodies lie and how massive they are. As a small object of mass on the surface of the earth, the center of the earth will pull you toward it keeping you to the ground. However, GTR introduces empty space as an entity that has properties instead of nothing. GTR describes gravity as actually the result of a mass bending spacetime resulting into a curvature, the curvature of space-time then influences how mass-energy are spread. With this concept, GTR had predicted some observational evidence that we see today such as gravitational lensing, changes in the orbit of Mercury, Gravitational redshift, gravitational waves etc.

Introducing the field equation of GTR, the subject equation of GTR is

$$G_{\mu\nu} + g_{\mu\nu}\Lambda = 8\pi G/c^4(T_{\mu\nu})$$

$g_{\mu\nu}$- Metric tensor
$\Lambda$- Cosmological constant
G - Newton's gravitational constant
$G_{\mu\nu}$-Einstein tensor
c - Speed of light
$T_{\mu\nu}$- Stress-energy tensor

In this part review, with the aim of not condemning any part of GTR but adding modifications with prove, some review points are presented for readers to access before introducing this new concept. These review points are as follows;

1) With the existence of the Newtonian concept of gravity and General Relativity, the nature of gravity is not yet understood completely. In terms of its quantum form.
2) The Newtonian constant (G) is present in the field equation of GTR, this implies that at some point, the Newtonian concept of gravity is correct.
3) Why do we have gravitational waves as ripples in spacetime predicted by GTR, but its theory has not emphasized on the fact that gravity is not just a consequence of spacetime curvature.
4) In the view of the nature of space inside a planet. Why does mass/energy curve spacetime at the outer space while an object of mass inside a planet will fall freely which GTR claims to move along a geodesic.
5) Why is the nature of space inside a planet different from that of the outer space?

Based on this pre-review points, the alternative approach to GTR introduced in this paper will be based around these 5 points and backed up by the discovery of gravitational waves.

Einstein field equation describes the geometry of spacetime, and its curvature caused by mass/energy. Einstein equation involves matrices, calculus, tensors etc.

In this review for an alternative approach, the geometry of spacetime or spacetime curvature is not needed, the modifications do not involve matrices or calculus. Therefore, we eliminate the tensors and scalar curvature in the field equation. Thus, there is need for the Newtonian constant (G) and the speed of light (c). The discovery and detection of gravitational waves plays an important role in developing this new approach.

### *a) Gravitational Waves*

Some review points from the detection and discovery of gravitational waves must be presented to aid this new concept.

LIGO (Laser Interferometer Gravitational- Wave Observatory is a large-scale physics experiment to detect cosmic gravitational waves. With the aim of detecting gravitational by laser interferometry, two observatories were built in United States at Hanford site, Washington and Livingston, Louisiana[9].

Four years ago, the LIGO and Virgo collaborations announced the first observation of gravitation waves (GW150914) matching the predictions of GTR.

The flickering distortions of spacetime called gravitational waves are not easy but tricky to detect, and only managed to detect in recent years.

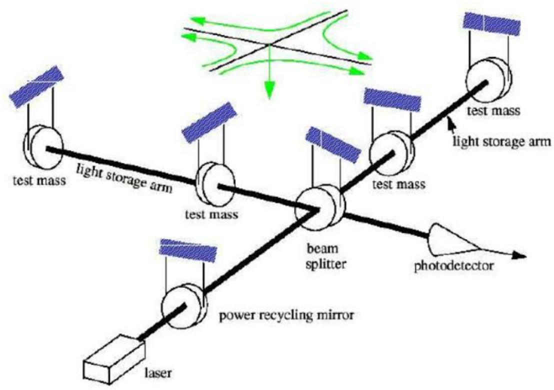


*Figure 1:* Basic schematic of LIGO's interferometer with an incoming gravitational wave depicted as arriving from directly above the detector

The LIGO's two four-kilometer-long arms is in L-shape, as a wave passes through, one arm is stretched and the other is shortened. Lasers moving up and down the arms will measure the change in length indicating that a gravitational wave has passed through.

Points used from the detection of gravitational waves from LIGO in [3,9,10,21];

1) The velocity, acceleration, trajectories of object changes as ripples in spacetime propagate.
2) You can't see the effects of gravitational waves but can measure how they affect an object as they pass through.
3) As a gravitational wave travels through space-time, it causes it to stretch in one direction and compress in the other.
4) Gravitational wave causes any object that occupies that region of spacetime to stretch and compress as it passes.

*The Question is, what exactly is the root of gravitational wave?*

Gravitational waves are emitted by accelerated masses. They propagate at the speed of light and are transverse waves much as electromagnetic waves, but rather than exerting forces on charges, they distort the space perpendicular to the direction along which they propagate, alternatively stretching space in the east-west direction while simultaneously compressing space in the north-south direction (Rainer Weiss. Nobel Lecture, Rev Mod Phys 90(4), 040501, 2018) [21].

A major instance of a wave is Light (EMR). There was a debate on the movement of Electromagnetic radiation. This was either as a wave or a particle. But at the end of the 19th century, Albert Einstein revived it as a dual nature (as both a particle and a wave)[12]. However, the waves as particle combined comes from a source.

In terms of gravitational waves, based on this new approach, gravitational waves can exist as both a particle and a wave. These particles or waves propagate from a source known as spacetime. Gravitational waves only emerge when distortion takes place on spacetime due to pressure either by a mass or energy.It is an unknown fact that gravitational waves prove that gravity is not only as a result of spacetime curvature but also as a result of distortion of spacetime by mass/energy.

A majorreview point is presented from the observations from the LIGO observations on gravitational waves from[9, 21]. The major point is "When gravitational waves travel, it causes spacetime to stretch in one direction and compress in the other".

*b) New Alternative Approach to General Theory of Relativity*

With this major point, the new approach to GTR can be presented. An aspect of cosmology which is the stretching/expansion of spacetime hasn't been given much attention over the years.

Again, it'll be magical if more space of the same nature just seems to appear instead of emerging from its initial form. There is only one default nature of spacetime, it is the nature of spacetime before cosmic inflation. Spacetime exist with two major properties known as gravity and a positive energy. The same way, there are two ways that spacetime can be stretched/expanded; naturally by the effect of its positive energy and by provoking spacetime to unleashing gravity by the application of pressure/stress through mass/energy on spacetime. Gravity then in turn stretches the spacetime in the same direction from the pressure/stress. This is the exact effect of the waves of gravity (gravitational waves) on spacetime.

This definition of gravity describes its actual nature as an effect of distortion and curvature of spacetime. Hence, deep explanation and prove is needed.

The discovery and detection of gravitational wave[3,9]is an experimental prove. Thus, proving of this new concept mathematically is needed. To prove this concept mathematically, the nature of spacetime before cosmic inflation must be present mathematically. An attempt to discover the nature of spacetime before cosmic inflation will result into an illustration.

In this alternative approach, spacetime has only one true nature as a very thick or stiff entity. "One way to say it is, the stiffness (Young's modulus) of space at a distortion frequency of 100Hz is $10^{20}$ larger than steel")(Rainer Weiss. Nobel Lecture, Rev Mod Phys 90(4), 040501, 2018)[21]. Any other nature of spacetime besides this default nature is a stretched spacetime. The nature of spacetime on earth is observed to very free because spacetime initially on earth on the point of creation was the default nature but was stretched to a very free space.

An illustration (with figures) describing how spacetime insideplanetary bodies are stretched.

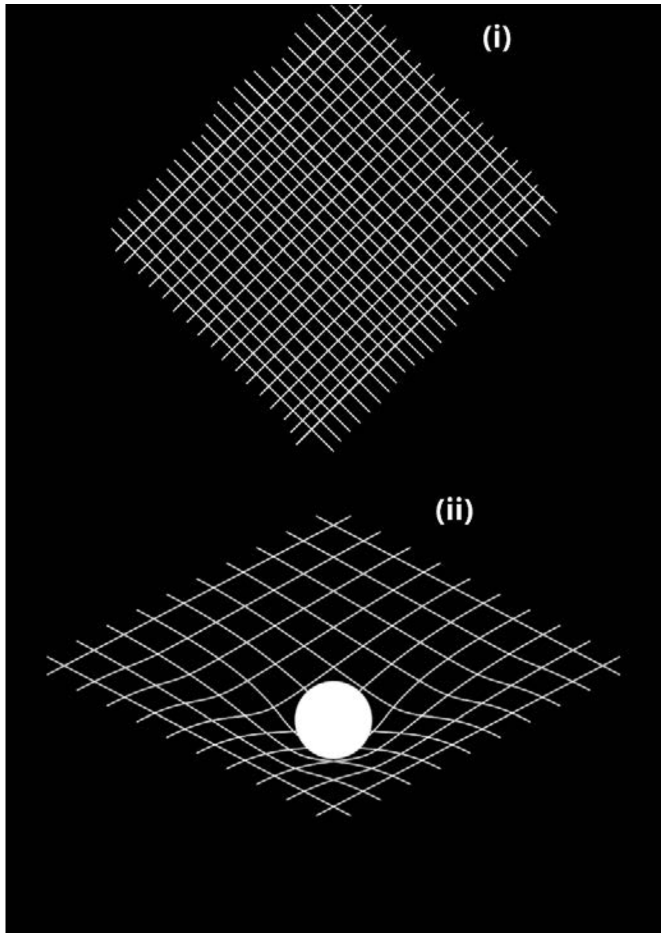


*Figure 2:* The image (i) in Figure 2 will represent the default nature of spacetime. (ii) shows a spherical body exerting pressure on the default nature of spacetime

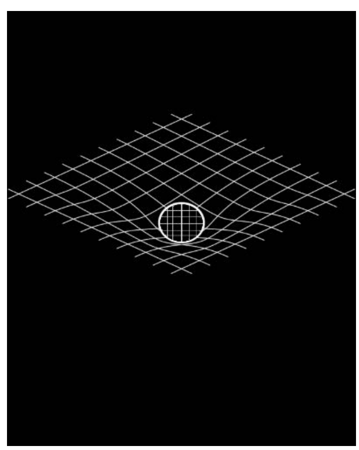

*Figure 3*

At the point of creation of the universe, the default nature of spacetime was everywhere, these planets or planetary bodies that exerted pressure on the default spacetime also contained the same default spacetime inside them (shown in figure 3). Distortion means that a referred thing or entity has gone out of shape. From figure 3, it is seen that a spherical body exerting pressure on the default spacetime creates curvature of spacetime, the fact that a curvature emerges means that a distortion due to pressure has taken place. Thus, resulting to the release of gravity.

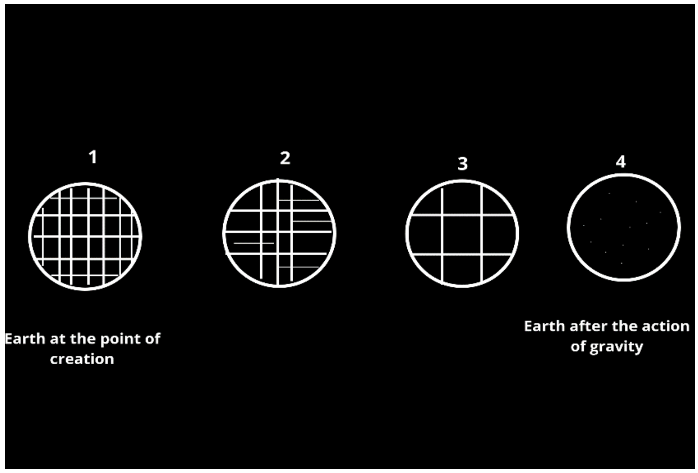


*Figure 4*

There are many bodies that exerted pressure on the default spacetime at the outer space during the point of creation. Using earth as an example, figure 4 shows the stretching of the default nature of spacetime inside earth by gravity the moment it was found to exert pressure. 2 & 3 in figure 4 shows the stretching of spacetime process done by gravity, 4 shows the final nature.

The only way more space can come into existence is by stretching (expansion). This can be done either by gravity or spacetime energy fluid. Just like an elastic rubber instance, stretching of spacetime results into a reduction in thickness. Unfortunately, an instrument or device that can measure the thickness of spacetime in different places doesn't exist. However, a mathematical prove of this concept will also help in the invention of that device.

General Theory of Relativity suspended the application of the Newtonian gravity concept. Have Physics asked this question; Why can we use the Newtonian concept to find the mass of a planet with a given acceleration due to gravity but not GTR. This is simply because equations of GTR are more complex, explaining basically about curvature which requires the use of tensors and leaving the details for distortion. Why don't we use a simpler approach to solve problems about our universe? Solutions to problems about our universe might be looking at us, but we choose to go deep and get stocked.

At the outer space, we have a thick spacetime nature, but the discovery of the expansion of the universe means that although the nature of spacetime is still thick and might not be noticed but it is a stretched version of the default nature.

However, here's the clue. A contained stretched spacetime cannot be reversed back to its default nature. Hence, this implies that the present nature of spacetime inside earth and other planets exerting pressure on spacetime has been stretched a long time ago by gravity. These planets with these stretched natures of spacetime just rotate about at the outer space and the effect of gravity goes unnoticed because the stretching has been done a long time ago(once it was found to exert pressure).

The bigger the mass, the higher the pressure exerted on spacetime, the more stretched the spacetime inside that object/planet of mass is, involving the area of the planet.

*c) Mathematical Test*

Since the stretching inside a planet has been done a long time ago, this implies that we can find the value of the default nature of spacetime before or at cosmic inflation.

The parameters needed to find the default nature of spacetime are;

Mass of a planet (M)

Radius of a planet (r)

Value of stretched spacetime inside a planet ($s_{stretched}$)

Default nature of spacetime ($S_{default}$)

There's still one more problem, to get the default nature of spacetime, we must get the value of a stretched spacetime in a planet. GTR addressed object in free fall as moving along a geodesic. In Newtonian concept, all object in free fall accelerates towards the center with the same speed. In this alternative approach to GTR, the nature of the stretched spacetime inside a planet is the main reason why objects accelerate towards the center with the same speed. Thus, the value of the nature of stretched spacetime inside a planet is (1/g) i.e the inverse of acceleration due to gravity of a planet.

Parameters for earth will be used for first trial to test for the default nature of spacetime.

Presenting parameters for earth from[13];

g for earth: $9.8ms^2$

Mass of earth: $5.97 \times 10^{24}$kg

Radius of earth: $6.38 \times 10^6$m

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$s_{stretched}$ of earth (1/g): 1/9.8 = 0.102

$S_{default}$: ?

I formed a formula with these four parameters for a planet. Spacetime is of one nature ($S_{default}$). At cosmic inflation, it was initially everywhere and inside a planet also. Since it was everywhere, the aim is to find out if stretching of the default spacetime occurs on the line of pressure. Automatically, all planets exert pressure on spacetime due to their mass. The technique from this formula is that the value of the $S_{default}$ will be reduced to a lower value to signify that stretching(expansion) has been done. Spacetime inside a planet is based on its area, we are dealing with spherical planets, the radius will be squared ($r^2$). Representing the area, $r^2$ will be multiplied by $S_{default}$. Since the mass exerts the pressure, a division sign must be between $S_{default}$ multiplied by $r^2$ and the mass, this will result into a stretched value of spacetime. The planet is on the line of pressure.

$$S_{default} \times r_2 / M = s_{stretched}$$

Thus, the value of $S_{default}$ is the unknown, the formula will now be;

$$S_{default} = s_{stretched} \times M / r^2$$

Using the values for earth, we have

$S_{default} = 0.102 \times 5.87 \times 10^{24} / (6.4 \times 10^6)^2$

$S_{default} = 1.50 \times 10^{10}$

Since all planets exerts pressure on spacetime, parameters for more three planets must be used to confirm this value.

Presenting parameters for mars from [13];

g for mars: 3.72ms$^2$

Mass of mars: $6.46 \times 10^{23}$kg

Radius of mars: $3.39 \times 10^6$m

$S_{stretched}$ of mars: (1/g) = 1/3.72 =0.268

$S_{default}$=?

Using values for mars, we have

$S_{default} = s_{stretched} \times M / r^2$

$S_{default} = 0.268 \times 6.46 \times 10^{23} / (3.39 \times 10^6)^2$

$S_{default} = 1.50 \times 10^{10}$

Presenting parameters for Neptune from[13];

g for Neptune: 13.3ms$^2$

Mass of Neptune: $1.03 \times 10^{26}$kg

radius of Neptune: $2.27 \times 10^7$ m

$s_{stretched}$ of Neptune (1/g): 0.075

$S_{default}$ =?

Using values for Neptune, we have

$S_{default} = s_{stretched} \times M/r^2$

$S_{default} = 0.075 \times 1.03 \times 10^{26} / (2.27 \times 10^7)^2$

$S_{default} = 1.50 \times 10^{10}$

The last test will be with parameters for sun from [13];

g for sun: 274ms$^2$

Mass of Sun: $1.989 \times 10^{30}$kg

radius of Sun: $6.96 \times 10^8$m

$s_{stretched}$ of Sun (1/g): 0.00364

$S_{default}$ =?

Using values for Sun, we have

$S_{default} = s_{stretched} \times M/r^2$

$S_{default} = 0.00364 \times 1.989 \times 10^{30} / (6.96 \times 10^8)^2$

$S_{default} = 1.50 \times 10^{10}$

The result of this mathematical test with the parameters for three planets and the sun shows that with this concept of stretching by the waves of gravity, the value of the default nature of spacetime before cosmic inflation is approximately($1.50 \times 10^{10}$) as a constant. Hence, with the value of the default nature of spacetime as $1.50 \times 10^{10}$, the value of the nature of stretched spacetime in any planetary body can be calculated.

From the mathematical results, earth at the point of creation contained the default nature of spacetime ($1.50 \times 10^{10}$), once earth exerted pressure on the default spacetime at the outer space, this value ($1.50 \times 10^{10}$) of spacetime was reduced (stretched) to 0.102 by the action of gravity (line of pressure). This value (0.102) signifies a very free space.

Parameters for different planets and planetary bodies can be applied to get this default nature of spacetime before cosmic inflation. This is to prove this new concept of stretched spacetime by gravity. With these results, it is revealed that when a given mass and radius of a spherical planet exert pressure on the default nature of spacetime, the default nature of spacetime at the line of pressure (inside the planet) stretches.

*Note:* The usual unit of $S_{default}$ is $m^{-3}.kg^1.s^2$ and the unit of $s_{stretched}$ is $ms^{-2}$, but approved unit will be decided in future. For non- spherical planets or planetary bodies, the area of the body will be replaced with $r^2$.

GTR defines gravity as a result of curvature of spacetime, this curvature explains a smaller planet's rotation around a bigger planet, and the attraction of the smaller planet to the big one. GTR and the Newtonian gravitational concept does not specifically explain why objects are attracted to their planet's center. It is known that gravity is the reason why an object on the surface of a planet is attracted to its center but there's no specific reason and it is not curvature. For example, imagine a planet contains a very thick spacetime just like the default nature, the curvature outside will enable the

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attraction of an object to it, but once that object gets inside the planet, the object will float. Therefore, it cannot move downwards talk less of reaching the center. However, planet formation during the big bang is not known, only our creator can say but the only way the lands of planet earth and everything beneath the lands does not fall through is due to the presence of the default spacetime at the core of earth. The same applies to other planet and this is the reason why objects are attracted to the center and proves the fact that only the default nature of spacetime existed. When an object on the surface of a planet is attracted, once it gets inside the planet, it falls through the stretched spacetime to the center, this is a way of the stretched spacetime indicating that the original spacetime is around leading the object to it. Therefore, during planet formation at the point of creation of the universe, it could be there was a hot fluid around the core of planets that refused to solidify to form an empty space. Hence, the stretching of the default spacetime inside a planet due to line of pressure is done in a way that the default nature around the center of the planet will be untouched. Figure 5 and Figure 6 shows an illustration.

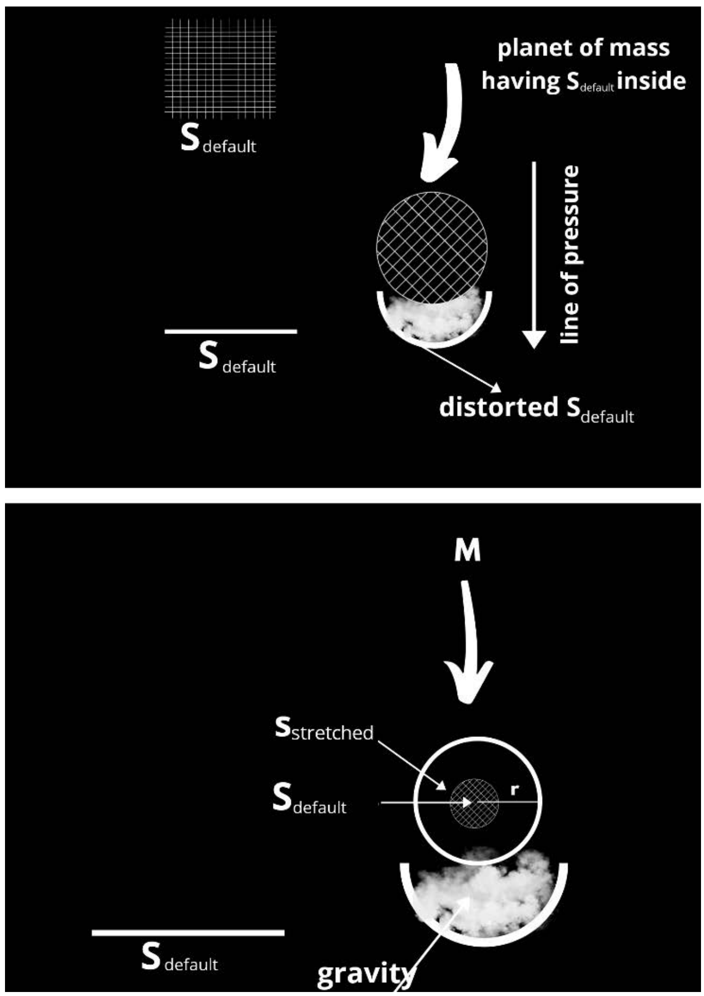


*Figure 5*

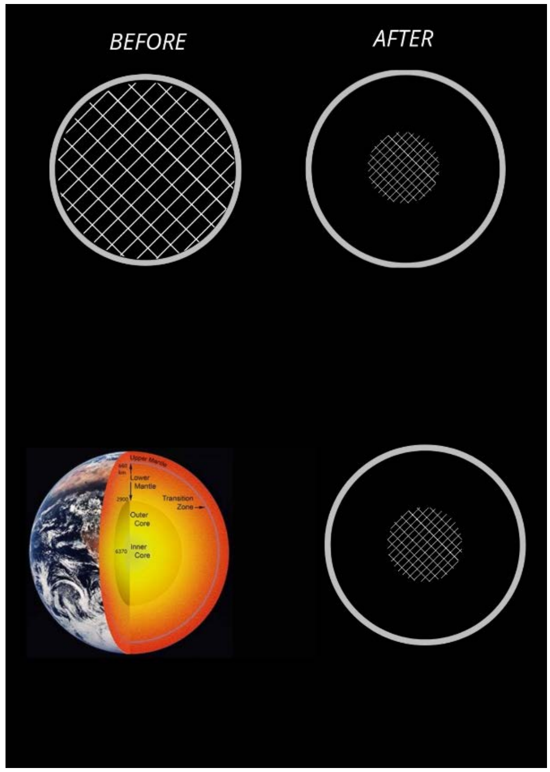


Figure 6

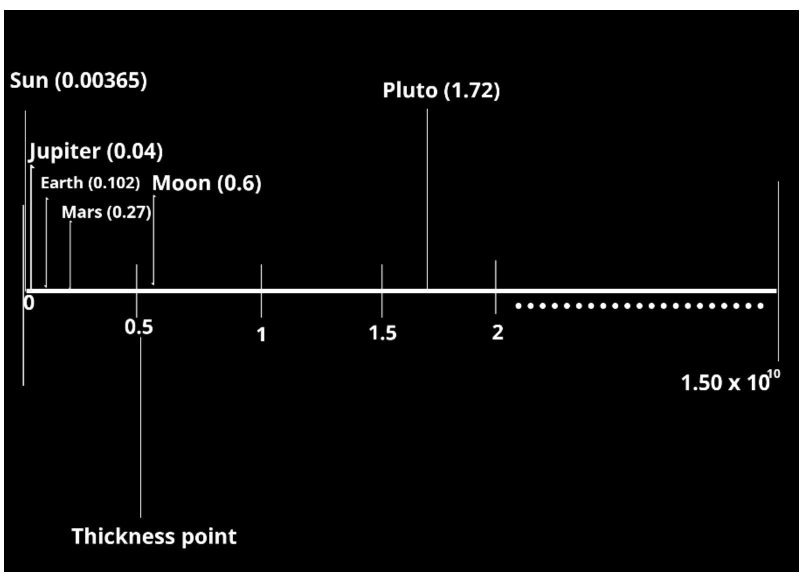


Figure 7

The mass of a planet will determine the pressure that'll be applied. As shown in Figure 7, the Sun and Jupiter are bigger masses than earth and mars. Also, earth and mars are also bigger masses than the moon andpluto. Figure 7 shows the difference between the nature of spacetime in different planets. The nature of spacetime decreases as the mass increases. An object inside a planet will start feeling slight thickness from a spacetime nature of 0.5. The thickness increases as the value increases from 0.5. The expansion of the universe has been proven from observations, therefore the current nature of spacetime at the outer space is not the default nature but its value is not reduced far from $1.50 \times 10^{10}$. Hence, its value still describes a nature of spacetime thick enough to hold the planets from falling. The values of the nature of space for planets in our solar system is shown in [16].

A question can be asked this way; If the effect of gravity stretches the spacetime towards the line of pressure. Why doesn't the effect of gravity keep stretching the spacetime inside rotating planets on the outer space. The answer to this question will bring about an understanding in quantum gravity. Thus, if we call the gravitational effect that comes from the default spacetime, a default gravitational effect. This default gravitational effect can only stretch the default spacetime. Since the default spacetime initially inside the planets has been stretched to a new nature, a corresponding gravitational effect similar to the new nature will only be authorized to stretch the new nature. This means, no matter how free the nature of space is, just like earth, an object in free fall can cause a distortion on the slightest little particle of spacetime which will bring about a slight gravitational effect (Quantum Gravity). The gravity sequence continues.

## III. Expansion of the Universe

The expansion of the universe is the increase in distance between any two given parts of the observable universe with time. Spacetime is the geometry of the universe. Expansion of the universe means "Expansion of spacetime" and expansion of spacetime is the stretching of spacetime. In this new concept, the two causes of the stretching of spacetime were presented. One of the causes have been discussed, its problem has been eliminated by getting the value of the default nature of spacetime before cosmic inflation.

The acceleration/expansion of the universe was discovered in 1998 by the supernovae cosmology project and the High-z supernovae search team, both with the use of type Ia supernovae to measure the acceleration[7,23].

The method in this project involved a type Ia supernovae with the brightness of a standard candle. This kind of supernova is an explosion of an old compact star like the sun, it emits light as a whole galaxy. As objects go further away, they appear dimmer, we can now use the observed brightness to measure the distances. Nobel laurates Saul Perlmutter and Adam Riess of the U.S and Brian Schmidt of Australia contributed to the discovery that the universe is expanding and speeding up. With the help of the best telescopes in the world, their team found over 40 distant supernovae whose light was weaker than expected indicating that the expansion of the universe was accelerating.

You could take the brightness of a supernova as an indicator of how far away it is; the fainter it is, the further away it is from us and hence its light has taken more time to reach us. So, with the fainter supernovae, you are looking farther and farther back in time. You can also use the colors of the spectral features of a supernova; a supernova would look blue if it were seen nearby, but when you see it very far away, it looks red. How red it gets tells you how much the Universe has stretched since the supernova exploded, because while the light is travelling to us, its wavelength stretches by the exact same proportion as the Universe stretches (Saul Perlmutter. Nobel Lecture. Rev. Mod. Phys. 88,1127 2012)[24].

Major review points from the discovery project from [7,23];

1) Objects in the universe are moving away from one another at an accelerated rate
2) The accelerated expansion of the universe is thought to have begun since the early stage of the universe.
3) With GTR, an accelerated expansion can be accounted for by a positive value of the cosmological constant, equivalent to the presence of a positive vacuum energy known as dark energy.
4) The finding has led to the now widely accepted theory of dark energy. Our finding that the universe was presently accelerating, immediately suggested a profound conclusion. The Universe's cosmic energy budget is dominated by a type of smooth distributed "dark energy" (Adam.G.Riess. Nobel Lecture. Rev. Mod. Phys. 84,1165)[1].

*a) Major Evidence of the Expansion of the universe*

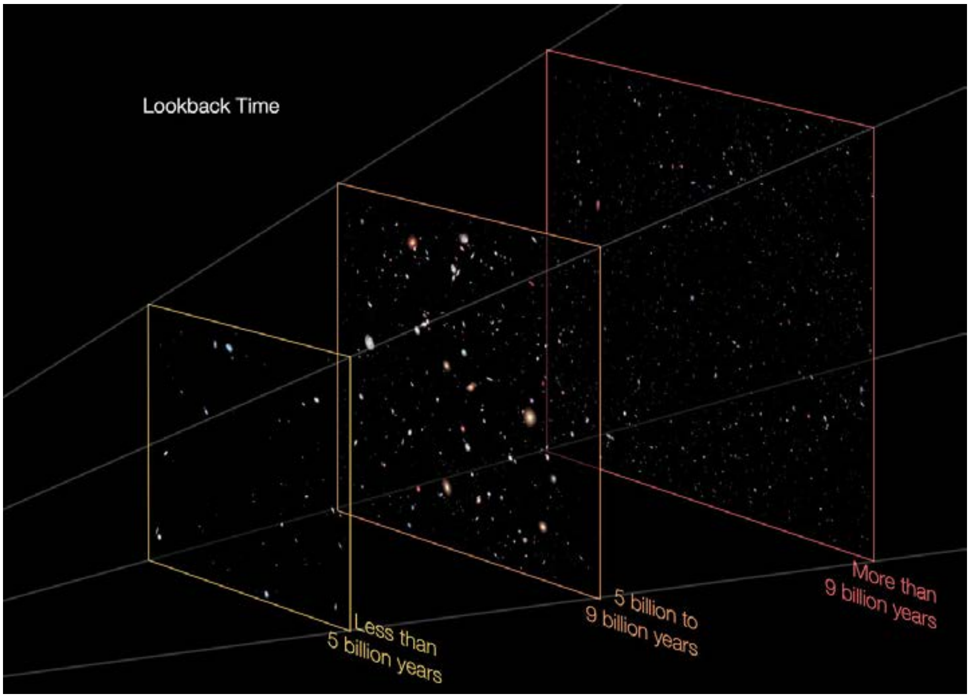


*Figure 8:* Hubble eXtreme Deep Field, the photo was assembled by combining NASA/ESA Hubble Space Telescope observations taken of a patch of sky within the original Hubble Ultra Deep Field

One of the major evidences of the expansion of the universe is the galaxy clusters decrease in density[25]. Figure 8 shows the decrease in cluster density from less than 5 billion years to more than 9 billion years. This is a prove that spacetime is also losing its thickness as it expands. If more space of the same nature would magically appear, it wouldn't have to affect the density of galaxy clusters rather it will add to the increase in area of the universe. The only way the density of galaxy cluster will be affected is if the spacetime around them stretches (expands) which will also result in reduction in thickness to enable the bodies to move apart.

From these observations and experiments, the other cause (dark energy) of the stretching of spacetime has been proven. As an attempt to reveal the nature of dark energy, a neglection in the discovery of EMR must be fixed.

## IV. Electromagnetic Radiation

The nature of dark energy has become a very important question in physics. Dark energy might be a lot different from normal energy (EMR). Why do we know the nature of normal energy and not dark energy? Could dark energy be the same as normal energy but an unseen version. In this new concept, there's a clue which is the fact that dark energy is a property of spacetime. From observations and theoretical concept, it is a positive energy.

For the nature of dark energy to be discovered in this new concept, the details of EMR must be reviewed deeply.

In physics, electromagnetic radiation (EMR) refers to the waves (photons) of the electromagnetic field, propagating through space. It includes radio waves, infrared, visible light, microwaves, ultraviolet, X-rays, and gamma.

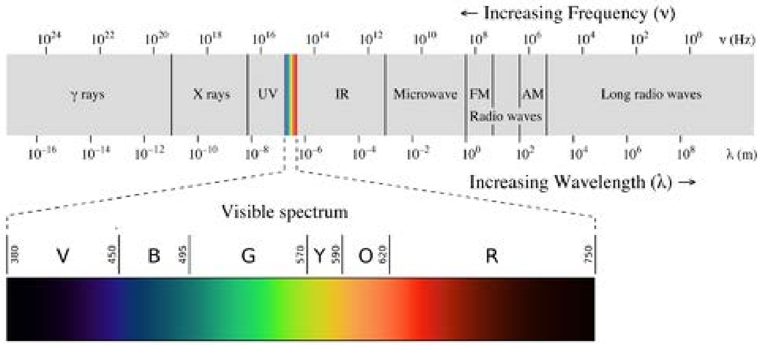


*Figure 9:* Is an electromagnetic spectrum indicating all types of EM waves characterizing them by their frequency and wavelength

Electromagnetic radiation consists of electromagnetic waves, which are synchronized oscillations of electric and magnetic.

Electromagnetic waves do travel at the speed of light (c). The position of an electromagnetic wave within the electromagnetic spectrum can be characterized by either its frequency of oscillation of its wavelength. In quantum mechanics, an alternative way of viewing EMR is that it consists of photons. The energy of an individual photon is quantized and is greater for photons of higher frequency. This relationship is given by Planck's equation E=hv where E is the energy per photon, v is the frequency of the photon a h is Planck's constant.

There can be other sources of the waves of EMR, but the natural source is from the stars. In this paper, to discover the nature of dark energy, the stars as the source of EMR is the description. Therefore, the term "EMR" or "EM radiation" further mentioned in this paper is defined as the whole energy picture from a star as figure 10 shows

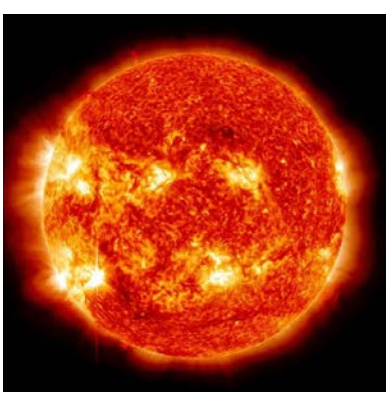

*Figure 10*

Planets in different solar systems rotate around their star. These stars are the source of light to their planets. However, these planets have a layer that do absorb harmful rays from their star. This layer called the ozone layer was discovered in 1913 by French Physicists Henri Buisson and Charles Fabry. The ozone layer found in the region of stratosphere contains high concentration of ozone ($O_3$). The average ozone concentration in Earth's atmosphere as a whole is about 0.3 parts per million. Measurements showed that with the presence of the ozone layer, there was no radiation below a wavelength of about 310nm at the ultraviolet end of the spectrum.

The ozone layer absorbs 97 to 99 percent of the Sun's medium frequency ultraviolet light (from about 200nm to 310nm wavelength) which otherwise would damage exposed life.

The thickness of the ozone layer varies. It can be thinner near the equator and thicker at other parts of the planet.

EMR from the stars are the closest to dark energy because they are the only natural source of energy existing. At the outer space where the effect of dark energy is observed is the same environment where the death of a star happens.

Major points from observations of EMR[5].

1) Electromagnetic waves do travel at the speed of light
2) The position of an electromagnetic wave within the electromagnetic spectrum can be characterized by either its frequency or its wavelength.
3) Relationship between energy per photon and its frequency is given by E=hv.

It is known that EM radiation propagate/move in particles (photons) as illustrated in figure 11

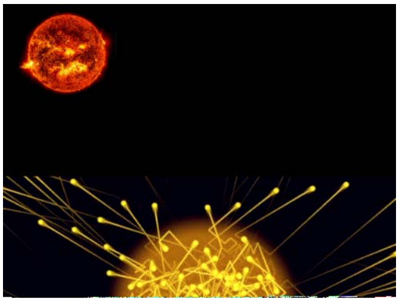

*Figure 11*

Using the sun (star) as an example for this explanation; radiation from the sun is known as sunlight, it is a mixture of electromagnetic waves. EM waves or rays ranging from gamma to radio waves of spectrum are produced by the sun, these rays are characterized by their frequency. For example; Gamma rays are produced from fusion at the core, getting to the surface of the sun, they are absorbed by the solar plasma and re-emitted to lower frequencies. Reaching the surface of the earth, the frequency will be within the range of infrared to UV in the spectrum. Therefore, a photon from a sun making its journey to the surface of the earth can be a gamma ray photon or an ultraviolet ray photon or the nature of any rays of the spectrum but there's a relationship between quantum mechanics and classical mechanics. To a dinosaur, humans appear like ants. To ants, humans appear like dinosaurs. This relationship with both mechanics is the fact that the whole energy picture of the sun is a photon at a macroscopic view. The sun can emit different types of photon of the EM spectrum, but it can often emit a photon that represents its nature comprising of the whole EM rays.

*a) Pack Photons*

In this concept, as related to the stars, a term called "Pack Photons" is introduced, the reason for this is demonstrated with figure 12

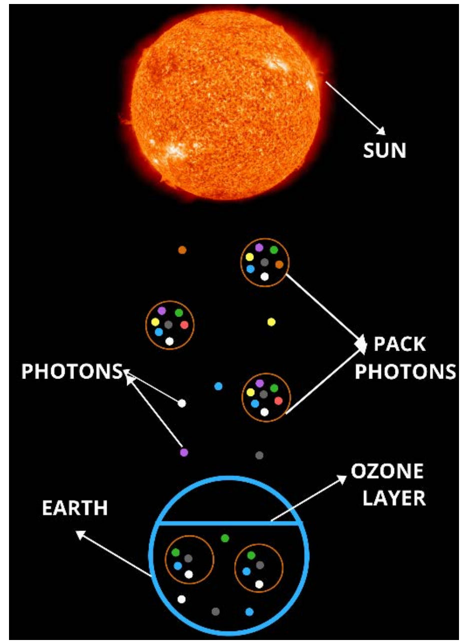


*Figure 12*

A pack photon represents the whole energy picture of a star in quantum form. Remember, stars consist of a mixture of all EM rays and can emit photons of different rays but can often emit photons that represents itself. Thus, a pack photon consists of sub-particles of all EM rays. From figure 12, it is seen that the UV photon (purple), Infrared photon (green), X-ray photon (red), Gamma ray photon (yellow), radio wave photon (blue) microwave photon (black) and visible light photon (white) can all find their way to the earth's surface but there exist a photon that contains all, it is been emitted often.

From figure 12, it is seen that the UV particle light and other harmful particles disappears after the pack photon has crossed the ozone layer. The ozone layer simply filters the harmful sub-particles from the pack photon.

Figure 12 also shows the release of pack photons from the sun which is a star. Each of these pack photons contains sub-particles of each rays of the electromagnetic spectrum. The idea behind this pack photons is backed up with the measurement of the fine structure constant. The fine structure constant $\alpha$, is a dimensional constant that characterizes the strength of the electromagnetic interaction between charged particles. It also describes the tendency of an electron to absorb a photon.

Providing a clue to an experimental prove of this new theoretical concept of EMR will be done mathematically

The energy of a photon is given as E

Electromagnetic waves move with the speed of light (c)

The relationship between an energy of a photon (E) and its frequency (f) is (h)

The medium through which the photons propagate is defined with (k)

Speed of light (c) = 3 x $10^8$m/s

Planck constant (h) = 6.582 x $10^{-16}$eV.s

Coulomb constant (k) = 8.9 x $10^9$N.$m^2$.$c^{-2}$

In this new concept, the energy of a pack photon is given as$E_{packphoton}$= k/hc

$E_{packphoton}$ = 4.5 x $10^{16}$ J

Thus, the energy of a pack photon is given as 4.5 x $10^{16}$ J. Before initiating the idea of a pack photon, this value was found to also have a meaning in quantum mechanics in this way, the value of a pack photon together with the value of the charge of an electron or elementary charge (1.60 x $10^{-19}$C) gives the exact or approximate value of the measurement of the fine structure constant i.e 4.5 x $10^{16}$ x 1.60 x $10^{-19}$ = 0.0072.

The fine structure constant $\alpha$, is a dimensional constant that characterizes the strength of electromagnetic interaction between charged elementary particles, a precise determination of $\alpha$ allows for a test of the standard Model of particle physics.

Parker et al used matter-wave interferometry with a cloud of cesium atoms to make the most accurate measurement of $\alpha$ to date.

Using the recoil frequency of cesium-133 atoms in a matter-wave interferometer, we recorded the most accurate measurement of the fine structure constant to date: $\alpha$ = 1/137.035990046(27) at 2.0 x $10^{-10}$ accuracy. (Richard.H.Parker et al. Measurement of the fine structure constant as a test of the Model 2018 Vol. 360 Issue 6385, pp 191-195)[22].

The confirmation of the value of a pack photon has not been done experimentally. A photometer is an instrument that measures the strength of electromagnetic radiation in the range from ultraviolet to infrared. An advanced photometer can be used to confirm this value but can only be done at the outer space or the surface of the earth above the ozone layer. There's not a complete pack photon on earth except one manage to escape through the ozone layer.

However, this energy of a pack photon might just lead us to dark energy.

*Note:* In this paper, when the term EM radiation or EMR is mentioned, it is referred toas a higher (classical) form of a pack photon i.e the whole energy picture from the sun (star).

## V. Dark Energy

In cosmology, dark energy is described as an unknown form of energy that affects the universe on a large scale.

The major evidence of dark energy's existence was through the expansion of the universe discovered from supernovae measurement.

It is known that dark energy contributes 68% of the total observable energy in the universe.

Dark Energy is thought to be very homogenous and not very dense and is known to interact through any of the fundamental forces other than gravity.

Dark energy was discovered in 1998 by two teams of astronomers who measured light coming from exploding stars. The striking result was that distant supernovae were dimmer that they would be in a universe that was slowing down. It was thought that dark energy was the cause of an accelerated universe. This acceleration is thought to have begun about 5 billion years ago. Although the first discovery of the effect of dark energy was in 1929 by Edwin Hubble when he noticed that the further a galaxy is from the earth, the faster it is moving away from us.

Major concluding points from the discovery of dark energy[1,6,7,23,24,25,27];

1) It is a positive vacuum energy.
2) Dark energy causes the expansion (stretching) of space which is also the expansion of the universe.

In this paper, to reveal the nature of dark energy, a modified concept of the creation of the universe (Big bang) must be presented. Earlier in this paper, we discovered mathematically the value of the default nature of spacetime (the thickest form).

Matter is in one way or the other, a form of radiation (EMR). Matter and Energy(Radiation) are two forms of the same thing with Einstein famous equation ($E=Mc^2$).

This concept provides a mathematical prove of the relationship between spacetime and dark energy with the relation. If dark energy is presented as $E_d$ and the value of the default nature of spacetime from Section 2.0 is $S_{default}$= 1.50 x $10^{10}$. Thus, one thing is certain, dark energy must move with the speed of light (c). With the relation $E_d$ = S x c

The value of dark energy as related to the default spacetime before cosmic inflation 4.5 x $10^{18}$ as a constant.

There's a term called black hole evaporation. This describes the fact that black holes that do not gain mass through other means are expected to shrink and alternatively varnish. The bottom line is that all black holes do vanish and where do their radiation or burst go?

In standard cosmology, there are four entities that makes up the universe, they are energy (radiation), matter, dark matter, dark energy. A star is in possession of EMR in full scale, the death of a star leads to a black hole on spacetime producing Hawking radiation[8]. The whole concept of black hole evaporation/Hawking radiation is a prediction without observational/verified proof. It can only be observed that black holes evaporate after some time, but conclusions have not been made as to what causes the evaporation.

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Let's face the reality, radiations (EMR) from black holes do not vanish in space just like that unless it is regarded as magical. There exists a reason why a death star will tear spacetime to create a black hole, which will be understood at the end of this section.

With this new concept, I choose to educate the world on the big bang of the universe. The Scientific and Physics environment and every other person must follow the reality that dark energy and radiation (EMR) were the same thing at some point at the creation of the universe and these two together form a major light which set-up the creation.

The combination of these two (dark energy and energy) can be termed "Omni" – The highest energy form but it is simply energy (EM radiation) taking the form of dark energy. Dark energy is superior to EM radiation from their values. Thus, if these two are combined, EM radiation takes the form of dark energy and they both exist as one light. Otherwise, if these two are split, EM radiation takes its own form and dark energy remains as its. Hence, when a black hole is formed and vanishes later, its radiation goes back to form one body with dark energy as "Omni" – the light used during the big bang. Although this is done in space, dark energy and space cannot be seen but it's effects can be observed or felt resulting into the fact that human eyes or observations can't see the re-uniting of EM radiation back to dark energy through black holes rather we can only feel or observe a radiation that just vanishes in space(Black hole evaporation).

However, dark energy is the energy fluid of spacetime. Hence, if dark energy and spacetime are one body, then it means that spacetime, dark energy and energy (radiation) were one body at the point of the big bang. These are the three entities used in the creation of the universe.

The explanation behind Albert Einstein's famous equation ($E = mc^2$) is the fact the solidification of EM radiation formed the planets which is a classical state of matteri.eIf all matter in this universe are traced to their natural source, it will result to EM radiation. This makesmatter and EM radiation two forms of the same thing. Dark matter is a form of matter that is known to not interact with light just like dark energy. There is no doubt that dark matter and dark energy are also two forms of the same thing, dark energy and EM radiation were also the same thing at a point during the creation of the universe. Since dark energy is superior to EM radiation, the question of how the big bang happened sums up to one thing; the creation of the universe was done with spacetime and its energy fluid (dark energy).

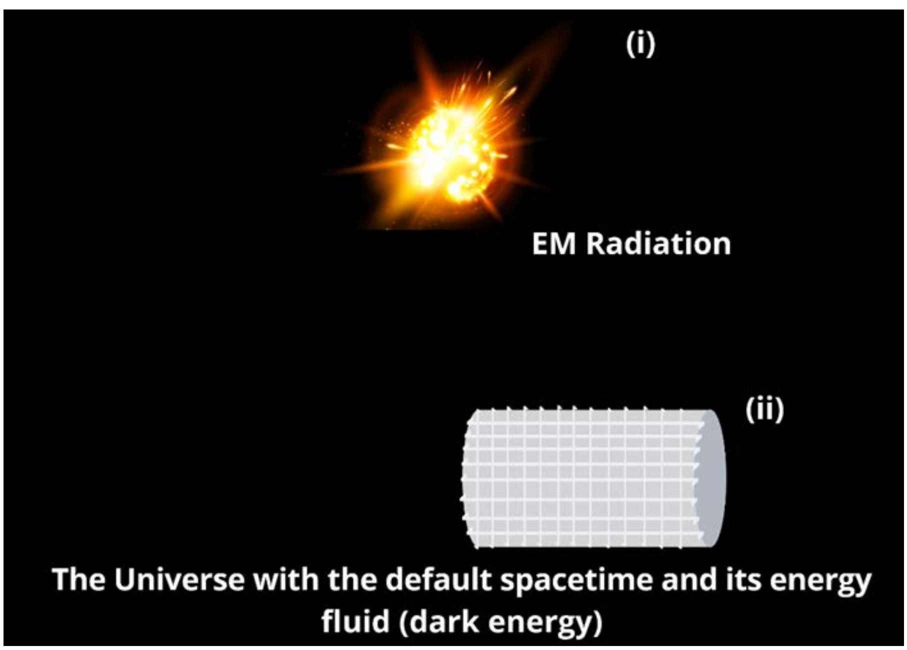


*Figure 13*

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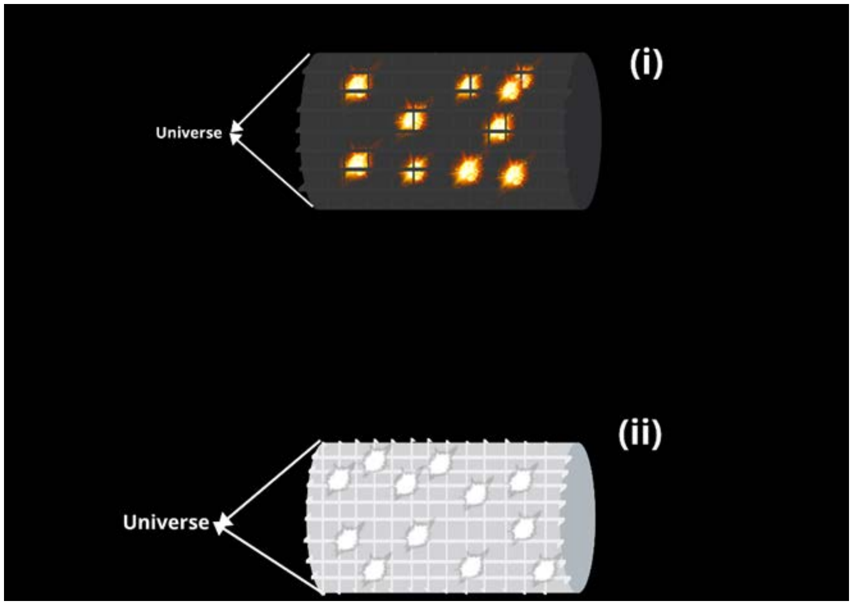


*Figure 14*

During the creation of the universe, spacetime was used everywhere as the entire geometry and structure of the universei.e the universe itself is the default spacetime along with its energy fluid just like (ii) in Figure 13, this also implies that dark energy was also everywhere. The solidification of EM radiation formed all planetary body we see at the outer space. However, 13 billion years ago at the point of creation, although these bodies were formed with EM radiation, if a human existed then, he/she would not see or observe these bodies as EM radiation or a form of EM radiation, rather he/she will observe these bodies as dark energy or a form of dark energy.

Using (i) in Figure 13 as EM radiation and (ii) in Figure 13 as the universe with the default spacetime and its energy fluid. In Figure 14, (ii) explains the situation at the creation of the universe. Although there were EM radiations and forms of EM radiation, they didn't exist as EM radiation rather they existed as dark energy or forms of dark energy. This reason is because dark energy is superior to EM radiation and both entities were merged at the point of creation. The things made from EM radiation (matter) have a property of fading after a certain period and on the other hand, dark energy has an opposite property to that. Although, at the creation of the universe, an explosion was done with EM radiation in an environment of spacetime and dark energy, to ensure a universe where things will not have to fade, EM radiation has to take the form of dark energy due its unique property of being unable to fade.

Everything that involves matter and the way it behaves is Physics, but some things do happen that we consider as magic simply because we don't see what happens on the other side. 50% of physics involving matter has only being studied, the other 50% of physics that involves the unseen is yet to be studied. It's simple, dark energy is not invisible or unknown, one of the brothers is no longer in unity with the other, proceeding to create a whole new dimension that is not dark energy dimension as described in(i), Figure 14. One dimension existed at the point of creation (dark energy dimension). Since the splitting created a new dimension, the superior dimension (dark energy) will be invisible to EM radiation dimension Therefore all things matter will not be able to see and observe the other. In (i) (Figure 14), it is seen that a dimension of EM radiation has been formed and it no longer takes the form of dark energy as (ii) (Figure 14) shows, resulting into dark energy dimension being invisible. Thus, EM radiation and its forms will not be able to see, observe or interact with dark energy. Furthermore, it is spacetime that leads any free EM radiation back to dark energy through the help of a black hole. Dark energy is not meant to stretch or expand spacetime (universe). This is just like the statement; Spacetime separates both dimensions, "Dark energy lost his twin brother long ago and is in search for all of it", thereby stretching spacetime as an attempt to reunite with it. On the other hand, EMR from a death star tears spacetime at one end as an attempt to re-unite with dark energy, signifying the fact that energy cannot be destroyed. As long as dark energy doesn't reunite with all of its lost twin brother, dark energy will continue to stretch the nature of spacetime at the outer space until it eventually gets to a nature of spacetime like the one on earth and we all know what that means. Planets will crash with one other, the EM radiation from stars will consume several planets, this is exactly how the universe will end. The existing EM radiation from stars will consume planets thereby increasing its mass, when all existing matter are consumed by the existing EM radiations, the universe will be left with just EM radiation si.e just like the EM radiations exploded long ago, scattering at different places, they'll all come back together this time. However, what caused the splitting of EM radiation from dark energy is biblically revealed to be as result of a mistake from the first man.

This theoretically concept of dark energy is the result from the similarity between the value of a pack photon and dark energy of a default spacetime. The presence of 4.5 in both values represents the fact that EM radiation can always reunite with dark energyi.e take the form of dark energy but presently both entities differ by 100.

Hence, this concept has been proven mathematically and theoretically. Experimentally, the value of dark energy will be difficult to prove. However, if the energy value of a pack photon can be measured exactly as ($4.5 \times 10^{16}$J), then this theoretical concept will just be complete and approved. (i) in Figure 14 represents an unstable universe while (ii) in Figure 14 represents a stable universe.

## VI. Conclusion

In standard cosmology, the universe is made up of Energy (radiation), matter, dark energy, and dark matter. Albert Einstein made it clear that matter and energy (radiation) are two forms of the same thing ($E=Mc^2$)[12]. With the new concept in this paper, dark energy and energy (radiation) where one body during the big bang. Hence, dark energy and dark matter are two forms of the same thing illustrated in Figure 15. With the help of ($E= Mc^2$), if the value of dark energy is ($4.5 \times 10^{18}$), replacing matter and energy with dark matter and dark energy with the equation ($E=Mc^2$), the resulting value of dark matter will be "50". The description of this number as dark matter is not yet clear but the value "50"(100/2) signifies that there are two dimensions in the universe presently, a dimension of dark matter and dark energy and a dimension of matter and energy (radiation).

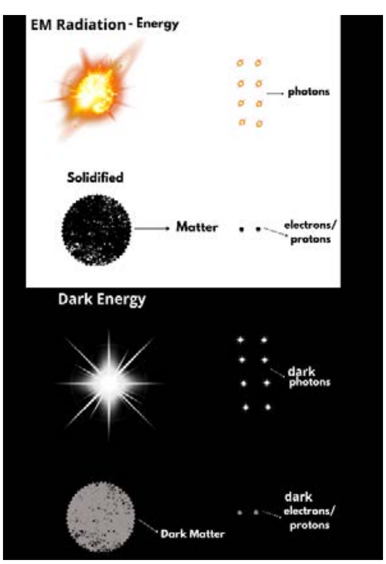


*Figure 15*

There are hidden answers in the puzzle of this universe, calculations in physics can help us get those answers which I demonstrated in this paper. Thus, physics and cosmology a wait experimental prove of all the new concepts proposed in this paper.

## Acknowledgement

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- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

***Structure and Format of Manuscript***

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

## Format Structure

***It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.***

All manuscripts submitted to Global Journals should include:

**Title**

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

**Author details**

The full postal address of any related author(s) must be specified.

**Abstract**

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

**Keywords**

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

**Numerical Methods**

Numerical methods used should be transparent and, where appropriate, supported by references.

**Abbreviations**

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

**Formulas and equations**

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

**Tables, Figures, and Figure Legends**

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

**Figures**

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

## Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

## Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

***1. Choosing the topic:*** In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

***2. Think like evaluators:*** If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

***3. Ask your guides:*** If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

***4. Use of computer is recommended:*** As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

***5. Use the internet for help:*** An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

***6. Bookmarks are useful:*** When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

***7. Revise what you wrote:*** When you write anything, always read it, summarize it, and then finalize it.

***8. Make every effort:*** Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

***9. Produce good diagrams of your own:*** Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

***10. Use proper verb tense:*** Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

***11. Pick a good study spot:*** Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

***12. Know what you know:*** Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

***13. Use good grammar:*** Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

***14. Arrangement of information:*** Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

***15. Never start at the last minute:*** Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

***16. Multitasking in research is not good:*** Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

***17. Never copy others' work:*** Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

***18. Go to seminars:*** Attend seminars if the topic is relevant to your research area. Utilize all your resources.

***19. Refresh your mind after intervals:*** Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

***20. Think technically:*** Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

***21. Adding unnecessary information:*** Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

***22. Report concluded results:*** Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

***23. Upon conclusion:*** Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

## Informal Guidelines of Research Paper Writing

***Key points to remember:***

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

**Final points:**

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

*The introduction:* This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

**The discussion section:**

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

**General style:**

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

**To make a paper clear:** Adhere to recommended page limits.

*Mistakes to avoid:*

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

**Title page:**

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

**Abstract:** This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

*Reason for writing the article—theory, overall issue, purpose.*

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

**Approach:**

- o Single section and succinct.
- o An outline of the job done is always written in past tense.
- o Concentrate on shortening results—limit background information to a verdict or two.
- o Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

**Introduction:**

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

*The following approach can create a valuable beginning:*

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

**Approach:**

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

**Procedures (methods and materials):**

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

**Materials:**

*Materials may be reported in part of a section or else they may be recognized along with your measures.*

**Methods:**

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

**Approach:**

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

**What to keep away from:**

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

**Results:**

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

**Content:**

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

**What to stay away from:**

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

**Approach:**

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

**Figures and tables:**

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

**Discussion:**

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

**Approach:**

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

## The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

*Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection*.

*Segment draft and final research paper:* You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

*Written material:* You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

## Criterion for Grading a Research Paper (Compilation) by Global Journals

**Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.**

| Topics | Grades | | |
|---|---|---|---|
| | **A-B** | **C-D** | **E-F** |
| ***Abstract*** | Clear and concise with appropriate content, Correct format. 200 words or below | Unclear summary and no specific data, Incorrect form<br><br>Above 200 words | No specific data with ambiguous information<br><br>Above 250 words |
| ***Introduction*** | Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited | Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter | Out of place depth and content, hazy format |
| ***Methods and Procedures*** | Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads | Difficult to comprehend with embarrassed text, too much explanation but completed | Incorrect and unorganized structure with hazy meaning |
| ***Result*** | Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake | Complete and embarrassed text, difficult to comprehend | Irregular format with wrong facts and figures |
| ***Discussion*** | Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited | Wordy, unclear conclusion, spurious | Conclusion is not cited, unorganized, difficult to comprehend |
| ***References*** | Complete and correct format, well organized | Beside the point, Incomplete | Wrong format and structuring |

# Index

save our planet

# Global Journal of Science Frontier Research

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or email us at helpdesk@globaljournals.org

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