Online ISSN : 2249-4626
Print ISSN : 0975-5896
DOI : 10.17406/GJSFR

# Global Journal

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**Discovering Thoughts, Inventing Future**

VOLUME 20 ISSUE 7 VERSION 1.0

Global Journal of Science Frontier Research: A
Physics & Space Science

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Volume 20 Issue 7 (Ver. 1.0)

Open Association of Research Society

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## Global Journal of Science Frontier Research

# Contents of the Issue

Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 7 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

# Platonic Golden Network Theory for High Energy Physics and Quantum Cosmology

By Mohamed S. El Naschie
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*Keywords: E-infinity, cantorian spacetime, fractal spacetime, G. ord, L. nottale, golden mean number system, platonic set theory, pythagoras mathematical music, 8 exceptional lie symmetry group, dark energy density of the cosmos, noncommutative geometry, penrose fractal cosmos, 'thooft-veltman-wilson fractal spacetime.*

*GJSFR-A Classification: FOR Code: 020103*


*Strictly as per the compliance and regulations of:*

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## I. Introduction

E-infinity theory is a fundamental and comprehensive theory [1-25] that purports to describe the small and the large scale structure of the universe using exact equations based on the golden mean number system [10-15]. The very idea of a system based on the golden mean is already suggestive of a combination of science and art [20],[23],[25]. The present short paper continues this E-infinity research program [1-25] by emphasizing the golden network feature or aspect of the E-infinity methodology. To do that, we could not find a better and simpler way than applying the present golden network to the major research field of cosmic dark energy [8],[12],[24] as we will demonstrate in the following sections.

## II. The E-Infinity Platonic Network

*a) The basic equation*

The present work is structured with the intention that the reader will do the walking and fill in the gaps by consulting the literature [1-25]. Consequently we give here the equations which we will use without much explanation except the assertion that all these equations are similarly connected with literally infinite precision due to the infinitely fine structure of the transfinite golden mean number system [10-26]. In short, we require the following equation:

a. The reconstruction equation of the exact E-infinity inverse electromagnetic fine structure constant, as is well known, is given by [1],[3],[11],[14]

$$\bar{\alpha}_o = \left(1/\phi\right)\bar{\alpha}_1 + \bar{\alpha}_2 + \bar{\alpha}_3 + \bar{\alpha}_4 \tag{1}$$

where $\phi = \left(\sqrt{5}-1\right)/2$, $\bar{\alpha}_1 = 60$, $\bar{\alpha}_2 = \left(\bar{\alpha}_1\right)/2 = 30$, $\bar{\alpha}_3 = 1+8 = 9$, $\bar{\alpha}_4 = \alpha\left(QG\right) = 1$. We remind the reader that $\bar{\alpha}_1, \bar{\alpha}_2, \bar{\alpha}_3$ are all found experimentally to be very close to these theoretical E-infinity values, the only exception being $\bar{\alpha}\left(QG\right) = 1$ which is simply the maximal coupling that can logically exist, being the coupling of a Planck mass to the Planck field and thus it is a logical imperative. The result for $\bar{\alpha}_o$ is equally close to the experimental value and may be written in the compact form [1-3]

$$\begin{aligned} \bar{\alpha}_o &= \left(20\right)\left(1/\phi\right)^4 \\ &= 137 + k_o \\ &= 137.082033989 \end{aligned} \tag{2}$$

where $k_o = \phi^5\left(1-\phi^5\right)$ and $\phi^5$ is the experimentally found exact value of Hardy's quantum entanglement of two quantum particles [2,4]. In other words once we have the exact experimental results for dark energy as the experimental results for Hardy's quantum entanglement, then E-infinity becomes a true theory of nature without any doubt [20-26].

b. From (a) we can conclude that the core total topological dimensionality of E- infinity theory is simply given by [1],[3-4],[24]

$$\begin{aligned} \sum_{i=1}^{4} \bar{\alpha}_i &= \bar{\alpha}_1 + \bar{\alpha}_2 + \bar{\alpha}_3 + \bar{\alpha}_4 \\ &= 60 + 30 + 9 + 1 \\ &= 100 \end{aligned} \tag{3}$$

This exact equation will play, besides $\bar{\alpha}_o$, a pivotal role in our analysis.

c. Einstein gravity will be presented by a quasi dimension equal to the number of Riemannian tensor components for D = 4 which is given by [10-15]

$$R^{(4)} = 20 \tag{4}$$

d. While the dimension of E8 is equal to 496, the same E8 has an intrinsic core dimension equal to DE8(intrinsic) = 57 [16-19]. Both values must be

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harmonized in the sense of E-infinity so-called transfinite correction [1-16]. This correction is equivalent to the fundamental notions of harmony which are central to Pythagoras theory of cosmic music of numbers and platonic solids of Plato [23-25]. The final result is to find the following true values, namely [16-19]

$$\dim E8 = 496 - k^2 \tag{5}$$

and

$$\dim E8(\text{intrinsic}) = 57 + k_o \tag{6}$$

where $k = \phi^3\left(1-\phi^3\right)$, $\phi^3 = 1/\left(4+\phi^3\right)$, $k_o = \phi^5\left(1-\phi^5\right)$ and $\phi^5$ is Hardy's quantum entanglement probability [2],[4],[12].

e. The old string theory as well as the heterotic Gross et al superstring theory has the dimensions D = 26, D = 16, D = 10 respectively [12],[24]. These values correspond in E-infinity theory to the harmonized values D = 26 + k, D = 16 + k and D = 10 where $k = \phi^3\left(1-\phi^3\right)$

f. Similar to the above, the 'tHooft-Veltman-Wilson renormalization [8] leads to a fractal spacetime given in E-infinity theory by $D = 4 - k$. It should be noted that [1-2],[21]

$$D = 26 + k,\ D = 16 + k,\ D = 10,\ D = 6 + k,\ D = 4 - k \tag{7}$$

are obtained by golden mean scaling of $\bar{\alpha}_o = 137 + k_o$ and that $\bar{\alpha}_o$ and $\dim E8 = 496 - k^2$ are linked by the scaling

$$\dim E8 = \left(3+\phi^3\right)\left(\bar{\alpha}_o\right) \tag{8}$$

The reader can thus easily realize why E-infinity is truly seamless [1-26].

*b) Analysis*

From what we discussed so far and with regard to equations (1) to (8) we see that by invoking self-similarity and scale invariance we are lead to what we call analogical semi-duality outlined in Table 1 [16-19]. From this table, and on reflection and pondering the deep meaning of the Penrose-Connes fractal tiling model of our noncommutative universe[2],[4],[5], we see that the following is not only numerically and experimentally correct but far more than that and it makes a great deal of sense, particularly for the theory of dark energy which we feel should be renamed as the beautiful reality of cosmic pure dark energy, ergo

$$\left(\sum_{i=1}^{4}\bar{\alpha}_i\right)\Big/\bar{\alpha}_o \equiv \left(\bar{\alpha}_o\right)\left(\phi 3\right)\Big/\left(D^{(26)} - D^{14}\right) \tag{9}$$

In other words

$$\begin{aligned}\left(100/13 + k_o\right) &= \left(16 + k/22 + k\right)\\ &= 0.7294901688\\ &= \gamma\left(PD\right)\end{aligned} \tag{10}$$

where

$$\begin{aligned}\gamma\left(PD\right) &= 0.7294901688\\ &= 72.94901688\%\end{aligned} \tag{11}$$

is the uncoupled pure dark energy density of the universe [12]. The exact coupled value is of course $\gamma\left(PD\right) = 73.3111\%$ which together with the dark matter energy density $\gamma\left(DM\right) = 22.18033$, comes to [2],[12],[24]

$$\begin{aligned}\gamma\left(D\right) &= 95.49\\ &\simeq 95.5\%\end{aligned} \tag{12}$$

The reader who is familiar with E-infinity theory will recall that $\gamma\left(D\right)$ is the energy of the empty set of the pre-quantum wave and is given exactly by the compact formula [2],[24]

$$\begin{aligned}\gamma\left(D\right) &= \left(5\phi^2\right)/2\\ &= 95.49150289\%\end{aligned} \tag{13}$$

## III. Conclusion

There are no new results in the present paper that were not reported in earlier ones. However the point of view is novel in stressing the intimate relationship between science and musical harmony of the infinitely large and the infinitely small, i.e. the infinite in all directions as exemplified by the idea of the ancient theories of Socrates, Pythagoras and Plato that flourished in Alexandria, Egypt which the present author calls home with a great deal of affection.

## Acknowledgment

The Author is deeply indebted to his colleagues and collaborators without whom E-infinity theory would not have been possible. He is in particular thankful for the help and stimulating discussions with Prof. Ji-Huan He, O.E. Rössler, Hermann Otto, Leila Marek-Crnjac, M.A. Helal, A. Harb and the golden mean philosopher Scott Olsen.

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*Table 1:* Semi Duality of E-Infinity Cantorian Fractal Spacetime Theory (See Refs. [16]-[19])

| | |
|---|---|
| Electromagnetism<br>$\bar{\alpha}_o = 137 + k_o$<br>$= 137.082033989$ | Compactified dimension of Bosonic strings<br>$22 + k = 22.1803398$ |
| Einstein-Riemannian tensors Component in four dimensions<br>$R^{(4)} = 20$ | Einstein spacetime dimensions<br>$D = 4$ |
| $\bar{\alpha}_o + R^{(4)}$<br>$= 137 + k_o + 20$<br>$= 157 + k_o$<br>$= 157.08203389$ | The spacetime dimension of old string Theory<br>$26 + k$<br>$= 22 + k + 4$ |
| The dimension of the core of E-infinity theory + the intrinsic dimension of E8 spacetime<br>$= 100 + (57 + k_o)$<br>$= 157 + k_o$ | Euler constant<br>= curvature<br>= inverse coupling of quantum gravity<br>= 26 + $k$ |

Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 7 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

# Theory of Everything - Unification

By Prince Jessii
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*Abstract-* Quantum Mechanics and Relativity are undoubtedly the two major pillars of Modern Physics. In this paper, I present an official unification of both major twin pillars with the "Theory of Everything" (TOE) which I discovered in (2019). Uniting both major pillars will in turn unite other areas of physics and display the physics of the dark dimension.

*Keywords:* *theory of everything; relativity; quantum mechanics; dark energy; energy; spacetime*

*GJSFR-A Classification:* *FOR Code: 240599*


*Strictly as per the compliance and regulations of:*

# Theory of Everything – Unification

Prince Jessii

*Abstract-* **Quantum Mechanics and Relativity are undoubtedly the two major pillars of Modern Physics. In this paper, I present an official unification of both major twin pillars with the "Theory of Everything" (TOE) which I discovered in (2019). Uniting both major pillars will in turn unite other areas of physics and display the physics of the dark dimension.**

*Keywords: theory of everything; relativity; quantum mechanics; dark energy; energy; spacetime.*

## I. Introduction

Since 2018, I've presented six "Theory of Everything" related papers to the science environment [16,17,18,19,26,28]. This paper (seventh) is the TOE itself; this is the reason I decided not to give it any other name than itself.

General Relativity (GR) played a very important role in this discovery/unification. It can be said that without GR, I wouldn't have discovered the "TOE". However, much credit goes to Albert Einstein and his concept, but not the equation. General Relativity was supposed to lead scientists/physicists right to the TOE. It shouldn't take up till this time for the TOE to be discovered. The TOE should have been discovered at most 10years later from that year in which GR was proposed because "GR" is the door to the "TOE". What happened? Why did it take this long? This is as a result of deceit from the subject equation of GR [$G_{\mu\nu} + g_{\mu\nu}\Lambda = 8\pi G/c^4(T_{\mu\nu})$], tricking upcoming scientists/physicists (from 1920 to now) into paying much attention to the subject equation for more solutions to unsolved problems in physics. The whole concept of GR which describes big masses distorting spacetime leading to curvature, resulting to gravity is perfectly correct. Predictions of GR actually came to reality, resulting into the acceptance of GR. Explaining the TOE doesn't require complications, resulting into the delay in arrival of the TOE. It turned out to be that the subject equation of GR is from an approach that describes the curvature of spacetime (movement of mass) resulting into the use of tensors which will require calculus, matrices etc., to solve. That approach will lead physicists to a dead end with no result, if used to seek for more answers in physics.

Again, explaining the universe does not require complications. Physics requires mathematics for validity but the fact is that a theory can be proposed with a complicated math or wrong math in some cases.

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I imagined that a theory like GR can never be wrong but I also said to myself; "GR is a correct theory because of its predictions that we now observe but why is the same theory not giving us more answers about some related unsolved problems in physics"?

I had to review the whole concept of GR and introduce a different approach to GR that lead the way straight to the TOE [26]. In the TOE, quantum mechanics was already waiting for GR to arrive so they can unify.

In this paper, with the six related papers of the TOE, I officially unite the major areas of physics. The fact that the aim of the TOE is to unite quantum mechanics with relativity means that all other areas of physics will be unified and solutions to all related unsolved problems will be revealed.

First, I present a brief detail on the creation of this Universe and how it was formed in Section (II). Section III presents relativity (Special and General) with a new approach from [26]. Section (IV) presents Quantum Mechanics alongside Electromagnetism. Section (V) is the official Unification. Section (VI) presents details on the next phase of physics. Section (VII) presents a major prove and further explanation of the TOE.

Language level in this paper is reduced to ease explanation.

## II. Brief Detail on the Formation of the Universe

The full information on the how the universe was formed is presented in [27] which is the blueprint of the universe, a summary of that will be presented in this section. The full blueprint can be purchased on Amazon. The universe is all about light and its solidified form. During creation, there were two lights used. The first is the superior light, the other is the inferior light. The Superior light exists with an attachment called "Space". The reason for this attachment (space) is the fact that the inferior light fades and the superior light exist forever. Its straight, for the inferior light not to fade, it has to be merged with the superior light. To be merged, it has to proceed to the attachment (space) which exist inside the superior light.

Apart from that space, everything in the universe can be represented as the lights or a form of the lights as shown in Figure 1

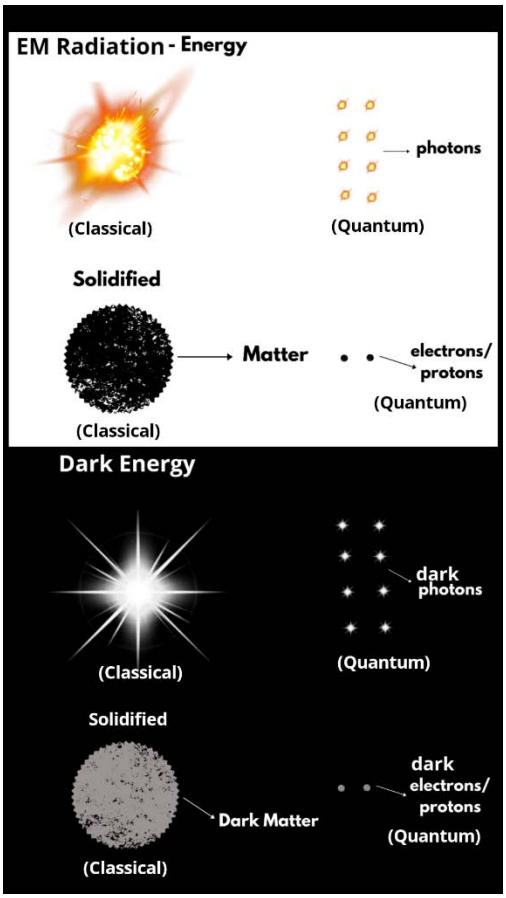


*Figure 1*

The Inferior Light and Superior Light are Energy and Dark -Energy respectively.

Energy (Inferior Light) was basically used to form planets/planetary bodies and stars. Planets cooled and solidified to form a combination of land and water basically. All these happened in an environment of the superior light with that space. Everything made from the inferior light was merged with the superior light which means energy took the form of dark energy.
However, both entities split later.
Have this in mind and proceed to section III.

## III. Relativity (Special & General)

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]. Special relativity is a theory describing the structure of spacetime.

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 concept 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 given as;

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

$g_{\mu\nu}$- 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 the new approach to GR.

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 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 waves 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.

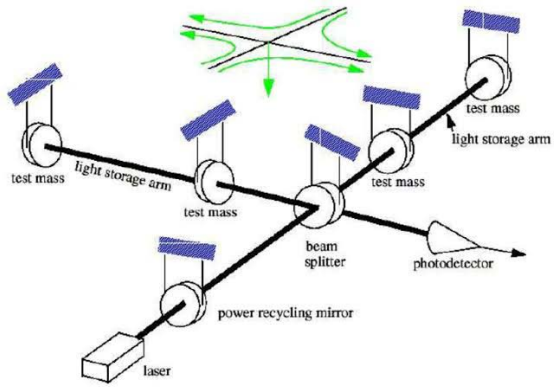


*Figure 2:* Basic schematic of LIGO's interferometer with an incoming gravitational wave depicted as arriving from directly above the detector

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 particles 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 a 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 major review 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*

This new approach to GTR is based on the statement "Where there is gravity to some extent, the nature of spacetime in that area is free" and "In an area where there is little or no gravity, the nature of spacetime is thick". Thus, the amount of thickness of spacetime in an area depends on the level of gravity in that area.

Keep the above statement in mind to understand this new approach with proves.

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.

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.

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/observational 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 the 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 figure 3,4&5) describes how spacetime inside planetary bodies were stretched.

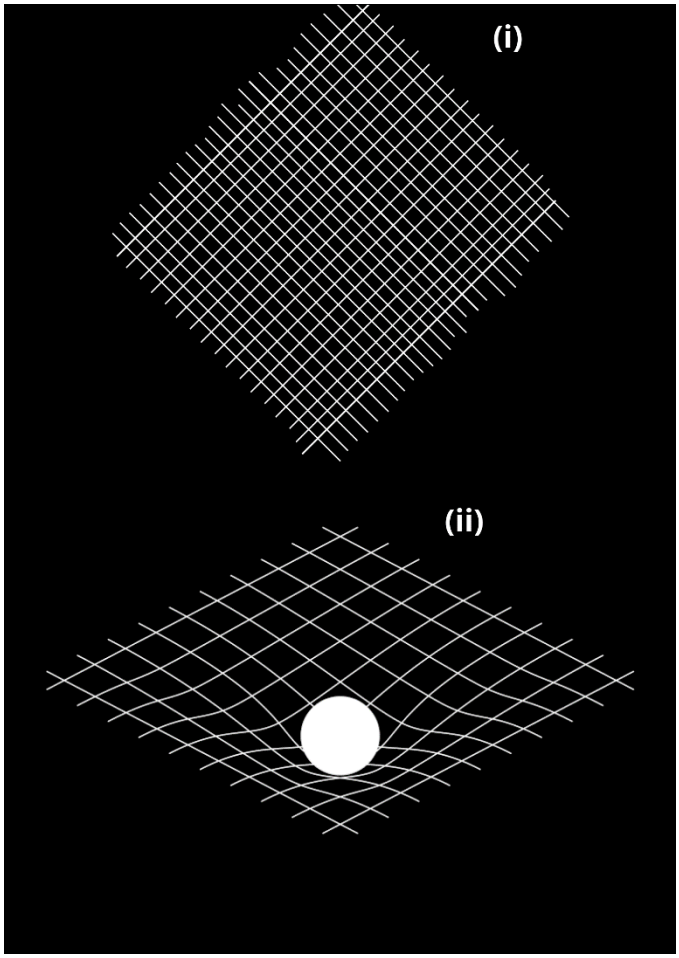


*Figure 3*

The image (i) in Figure 3 will represent the default nature of spacetime. (ii) shows a spherical body exerting pressure on the default nature of spacetime.

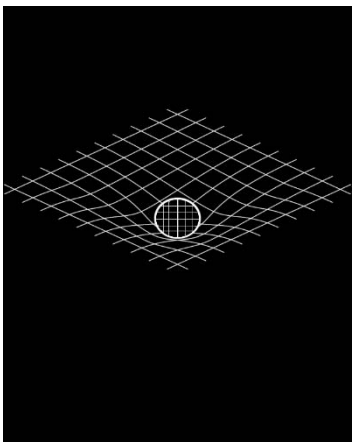

*Figure 4*

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 4).

Distortion means that a referred thing or entity has gone out of shape. From figure 4, 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 gravity.

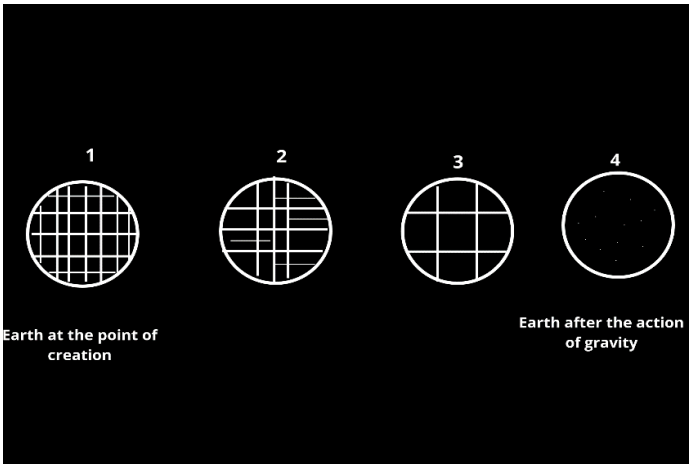


*Figure 5*

There are many bodies/planets that exerted pressure on the default spacetime at the outer space during the point of creation. Using earth as an example, figure 5 shows the stretching of the default nature of spacetime inside earth by the effects of gravity the moment it was found to exert pressure. In figure 5, 1 represents earth containing the default spacetime, 2 & 3 in figure 5 shows the stretching of the default spacetime process, 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 at different areas doesn't exist. However, a mathematical prove of this concept which I'll present will also help.

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 body applying pressure on spacetime 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 are looking at us, but we choose to go deep with no result.

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 the effects of 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 for New Approach*

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 body applying pressure (planet) (M)

Radius of a body applying pressure(planet) (r)

Value of stretched spacetime inside the body applying pressure (planet) ($s_{stretched}$)

Default nature of spacetime in which the bodies are applying pressure on ($S_{default}$)

There's still one more problem, to get the default nature of spacetime, we must get the value of a stretched spacetime inside a planet applying pressure. 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 of different masses in free fall 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

$s_{stretched}$ 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/effect 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 same default spacetime (figure 4) at the outer space, this value ($1.50 \times 10^{10}$) of spacetime was reduced (stretched) to 0.102 by the effect 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 effect of 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 unit of $S_{default}$ is supposed to be $m^{-3}.kg^1.s^2$ 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 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 were the default spacetime can be found. 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 core of the planet will be untouched. Figure 6 and Figure 7 shows an illustration.

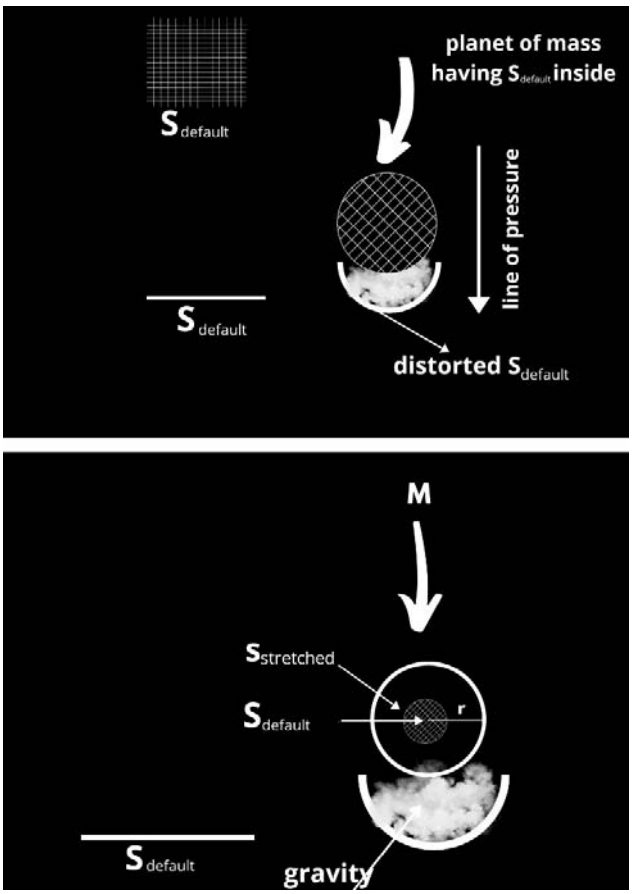


*Figure 6*

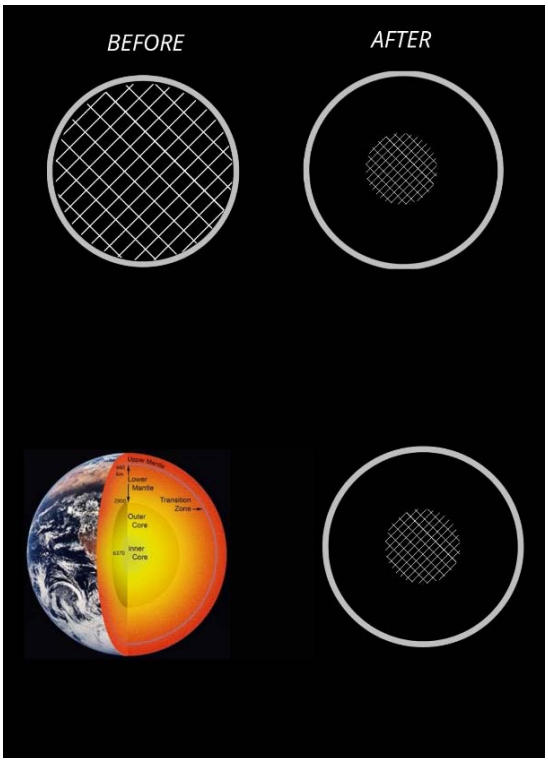


*Figure 7*

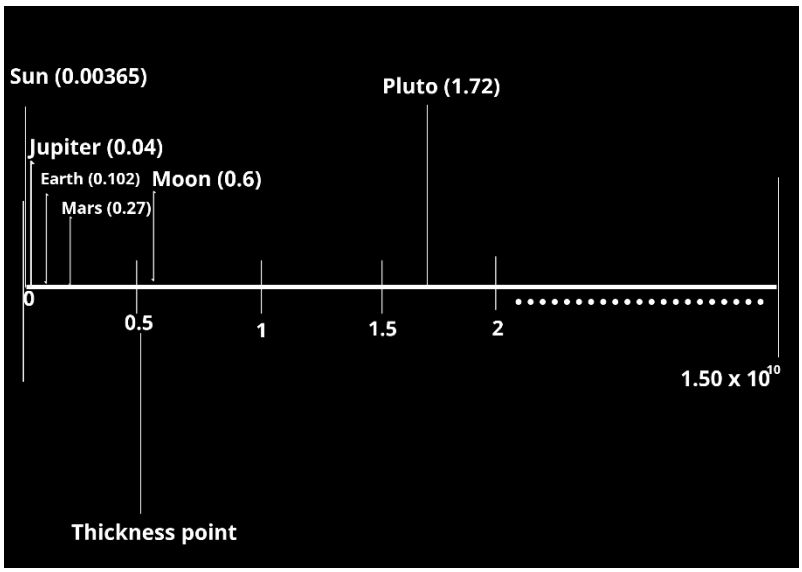


*Figure 8*

The mass of a planet will determine the pressure that'll be applied. As shown in Figure 8, the Sun and Jupiter are bigger masses than earth and mars. Also, earth and mars are also bigger masses than the moon and Pluto. Figure 8 shows the difference between the nature of spacetime in different planets. Between the 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 x $10^{10}$. Hence, its value still describes a nature of spacetime thick enough to hold the planets from falling. The values of the nature of spacetime 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. Currently,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 name 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 further. This means, no matter how free the nature of space is, just like in earth, an object particle in free fall can cause a distortion on the slightest little particle of spacetime which will bring about a slight (little) gravitational effect (Quantum Gravity). The gravity sequence continues. Generally, the concept of stretching of the default nature of spacetime which is very thick, exist mainly because of the presence of humans and creatures which will be inside these planets. Humans will not be able to interact properly in an environment of a thick spacetime. Therefore, once a planet exerts pressure, the effect of gravity automatically stretches the default spacetime inside that planet, to reduce its thickness so as to accommodate humans and to enable smooth interaction.

*d) Time (Special Relativity)*

The concept of time as related to space is mainly about the thickness of spacetime. This is the knowledge Albert Einstein was trying to pass to the world with his concept. The reason it wasn't yet understood properly is because the different natures of spacetime were not identified then. Now that I've presented the different natures, time can now be explained as per Albert Einstein's description. An alternative approach on time as related to space was introduced in [17]. Time is basically the comparison between different natures of spacetime in different areas. With the help of Albert Einstein's time dilation, I introduced a real concept of time in [17] with this new approach to GR.

As we know, time is not rotation and revolution of the earth around the sun. There is nothing like "The time in United States is ahead of the time in Cuba".

The nature of spacetime on earth is the same in all areas resulting into all areas having the same time. It is due to the rotation and revolution of the earth around the sun that enables some areas to experience morning (light) and some areas to experience night (darkness). However, in a situation like in another planet, we can't say that time is the same because actually it takes a longer time for objects in free fall to reach the ground on other planets than on earth. With the values of $s_{stretched}$ for different planets, I introduce a real concept of time.

*Table 1*

| Body | $S_{stretched}$ for planets | $P_E = S_{stretched}$(planet)/ $S_{stretched}$ (Earth) |
|---|---|---|
| Sun | 0.00365 | 0.035805 |
| Mercury | 0.27855 | 2.732489 |
| Venus | 0.11274 | 1.105944 |
| Earth | 0.10194 | 1 |
| Moon | 0.61728 | 6.055327 |
| Mars | 0.26525 | 2.602021 |
| Jupiter | 0.03854 | 0.378066 |
| Saturn | 0.09025 | 0.885325 |
| Uranus | 0.09372 | 0.919364 |
| Neptune | 0.07107 | 0.697175 |

*Table 2*

| Body | $P_E$ | Time(t) [$t/_{PE}$] |
|---|---|---|
| Sun | 0.035805 | t/0.035805 |
| Mercury | 2.732489 | t/2.732489 |
| Venus | 1.105944 | t/1.105944 |
| Earth | 1 | t/1 |
| Moon | 6.055327 | t/6.055327 |
| Mars | 2.602021 | t/ 2.602021 |
| Jupiter | 0.378066 | t/0.378066 |
| Saturn | 0.885325 | t/0.885325 |
| Uranus | 0.919364 | t/0.919364 |
| Neptune | 0.697175 | t/0.697175 |

The tables (1 & 2) show the values of the nature of spacetime in different planets alongside the time constant ($P_E$). To solve a problem on time in another planet, t in the related formulae will be replaced with $t/P_E$ as table 2 shows.

*e) Mathematical test (Time)*

Solving a simple problem which involves motion, for example;

An object moves with a speed of 20m/s through a distance of 3000m. How long will it take the object to reach its destination from a starting point, if the event was recorded in each of the following planets: Earth, Mars and Venus.

Solution;

We use equation; $v=d/t$

v – velocity

d – distance

t - time

From the example above, $d$=3000m, $v$=20m/s, t =?

For Earth, we have $t_{/1}= d/v$, 3000/20 =150sec

For Mars, we have $t_{/2.602021} =d/v$, 3000/20= 150sec x 2.602021 = 390.30sec

For Venus, we have $t_{/1.105944}=d/v$, 3000/20 = 150sec

150sec x 1.105944=165sec.

From the test, it is seen that the same situation on planets with lower gravity than earth like Mars and Venus, takes a longer time than the same situation on earth which has a higher gravitational effect than the other two.

This is the result of the statement "Gravity affects Time"

The idea of the Experiment of putting twin babies on different planets (from A. Einstein) resulting into the baby on the planet with gravity to some extent, aging faster than its twin in a planet with little or no gravity is from this simple calculation.

To know the differences in time between planets, since we only know the situation on earth, it can be used to determine for other planets. We simply relate to the situation of seconds to minutes to hours, on Earth.

Similarly, for time, to calculate the exact time on another planet, we simply take the value of a minute for earth,

Therefore, one minute is equivalent to 60sec.

To find the time in Venus, we have $t/P_E$ which is 60/1.105944, we have 54sec. therefore, regardless of how we mark the rotation and revolution of a planet to determine time, we can say that time in Venus in (minutes) is 6secs slower or behind earth's time. As we say 60sec makes 1minute on Earth, we then say 54sec makes 1minute in Venus. Days is actually a concept from the rotation of earth around the sun but we can use 54sec per minute and use it to relate with the total number of earth days it takes Venus to rotate around the sun as compared to earth, this will then be the time on Venus as per its rotation and revolution around the sun. However, related to time in space, seconds might not be the exact unit for this but the bottom line is that; if seconds is used as the unit of time as per the difference in the natures of spacetime (the time in Venus moving in (seconds) as related to space is 6sec slower that earth's time moving in seconds.

However, I know that seconds emerges from rotation and revolution but real time (space) should not be in seconds. Whatever unit that will be decided in future, after calculating just as i calculated for Venus, the approved unit should be inserted i.e. time (space) in Venus is 6(unit) behind earth's time. Time in other planets can be determined through this concept of differences in the nature of gravity and spacetime between planets. This time theory will be relevant when humans start migrating to other planets.

To calculate $g$ for another planet, we can simply take g for earth which is 9.8 and divide it by $P_E$ of the particular planet. E.g. for Venus we have 9.8/1.105944, we have 8.86m/s. This is how we truly know that gravity is related to Space and Time.

Time must always be defined with space (spacetime).

*f) 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].

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

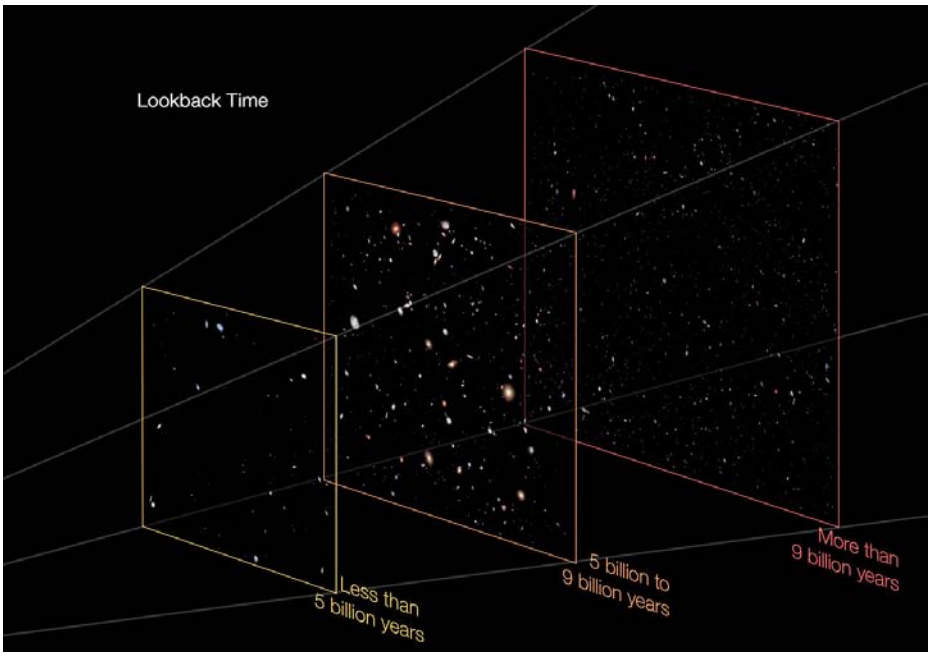


*Figure 9:* Hubble eXtreme Deep Field, the photo was assembled by combining NASA/ESA Hubble Space Telescope observations taken of a patch of sky within the original Hubble Ultra Deep Field

One of the major evidences of the expansion of the universe is the galaxy clusters decrease in density[25]. Figure 9 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 only 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, the presence of the other cause (dark energy) of the stretching of spacetime has been revealed. I now proceed to reveal the nature of dark energy.

*h) 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 than 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];

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

Earlier in this paper, we discovered mathematically the value of the default nature of spacetime (the thickest form).

This concept provides a mathematical prove of the relationship between spacetime and dark energy with the illustration shown in figure 10

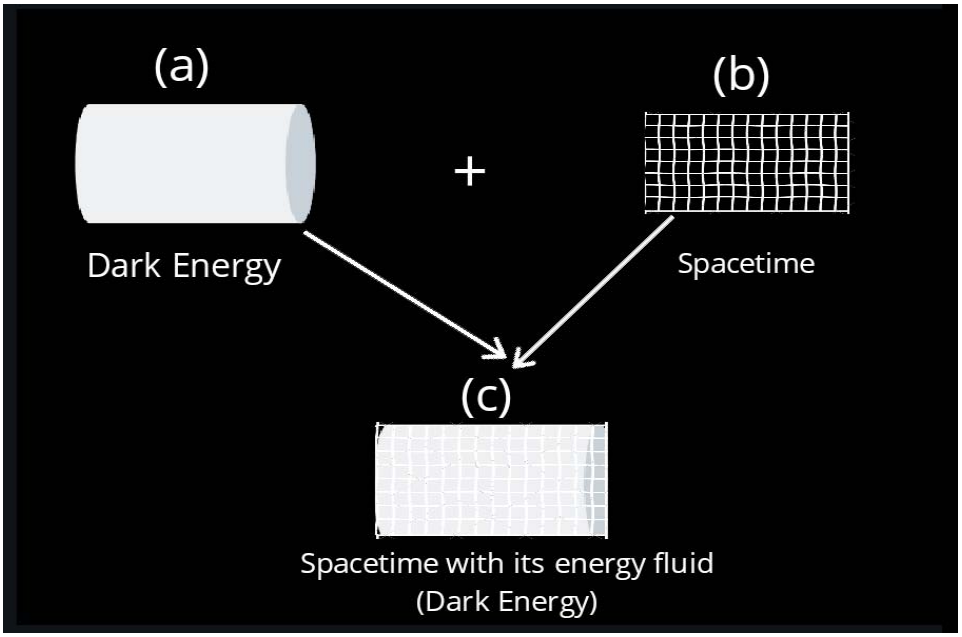


*Figure 10*

In figure 10, if (a) is the energy fluid of spacetime (dark energy) and (b) is spacetime itself, a combination of both is shown as (c); this is how spacetime exists. Dark energy exists with spacetime. If there is a default spacetime which existed before cosmic inflation, this means there is a default amount of dark energy that existed with the default spacetime.

If dark energy is presented as $E_d$ and the value of the default nature of spacetime is $S_{default} = 1.50 \times 10^{10}$. Thus, one thing is certain, dark energy must move with the speed of light (c). I formed an equation; $E_d = S \times c$, relating dark energy with spacetime. Inserting the related parameters, the value of dark energy as related to the default spacetime before cosmic inflation is $4.5 \times 10^{18}$ as a constant. However, this is the default value of dark energy associated with a default spacetime. The nature of spacetime at the outer space has been stretched/expanded. Therefore, the value($4.5 \times 10^{18}$) as dark energy of a huge amount is now spread smoothly around the universe due to the expansion/stretching of spacetime at the outer space. The unit associated with that value describes a huge amount of dark energy that was very dense. Expansion of spacetime will then enable dark energy to spread smoothly around the universe. Dark energy at a particular area could be high and low in another area. Values could differ but the default value at cosmic inflation is presented as ($4.5 \times 10^{18}$) of a high energy unit.

## IV. Quantum Mechanics – Electromagnetism

Quantum Mechanics (QM) is a fundamental theory that describes the properties of nature on an atomic scale. While QM describes in atomic scale, classical physics which is now explained with GR, describes properties of nature on a macroscopic (bigger) scale. This results in QM and GR being the twin major pillars of physics. Quantum Mechanics has a root i.e. it started from somewhere. All microscopic and submicroscopic particles originated from somewhere which I'll display in this section. Although the smallest

particle of an object can still be split further, there's an approved scale for QM as related to the TOE.

*NB:* It doesn't mean that the approved state cannot be split further.

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.

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, 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 11 shows

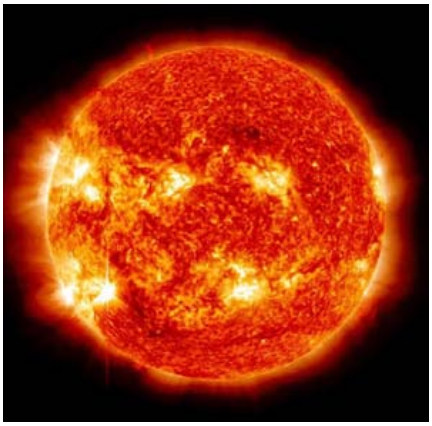

*Figure 11*

Planets in different solar systems rotate around their star. These stars are the source of light to the planets in their related solar system. 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 12

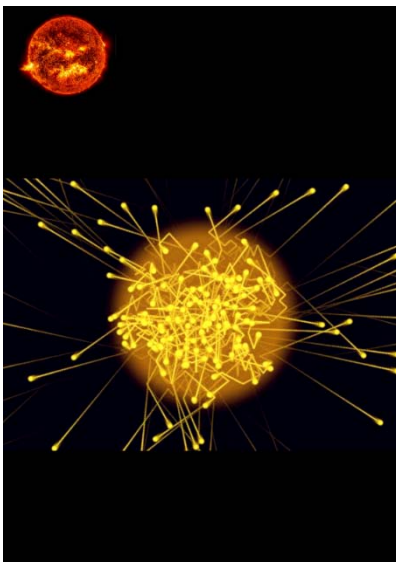

*Figure 12*

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 very large view. This implies that; although the sun can emit different types of photon of the EM spectrum, all these different emitted photons all came from a source.

*a) Pack Photons (p-rays)*

In this concept, as related to the stars, a term called "Pack Photons" is introduced.

A pack photon represents the whole energy picture of a star in quantum state. Stars consist of a mixture of all EM rays and can emit photons of different rays but all these photons have an origin. The sun can't emit a separate photon as a UV photon and then emit another as an X-ray photon. No, it doesn't happen that way. This is what happens; A pack photon represents the whole energy picture from a star as photon. Therefore, a pack photon is the highest energy photon from the spectrum. A pack photon (p-rays) which is a mixture of all particles of the spectrum is the default nature of these photons, it can be reduced to a gamma ray photon, from gamma ray to an x-ray photon, and so on. It is the peak of the Electromagnetic spectrum. The stars are the only bodies that possess electromagnetic radiation in full scale with all mixtures of the spectrum. Thus, the stars produce pack photons.

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 observational prove of this new theoretical concept of EMR will be done mathematically.

The default energy of a photon from the Inferior Light 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) = $3 \times 10^8$m/s

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

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

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

$E_{packphoton} = 4.5 \times 10^{16}$ with no unit for the mean time.

Thus, the energy of a pack photon is given as $4.5 \times 10^{16}$. 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 ($1.60 \times 10^{-19}$C) gives the exact or approximate value of the measurement of the fine structure constant i.e. $4.5 \times 10^{16} \times 1.60 \times 10^{-19} = 0.0072$.

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 $2.0 \times 10^{-10}$ 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 inferior light (Electromagnetic Radiation) consists of photons with an energy of $4.5 \times 10^{16}$ as a pack-photon i.e. each photons of the inferior light has an energy of $4.5 \times 10^{16}$. The stars (matter) at the point of creation, absorbed the same inferior light that solidified to form it, the stars now possess the inferior light. The stars in its matter form, absorbed the inferior light (Electromagnetic Radiation) to give the picture we now see as the stars as shown in figure 13

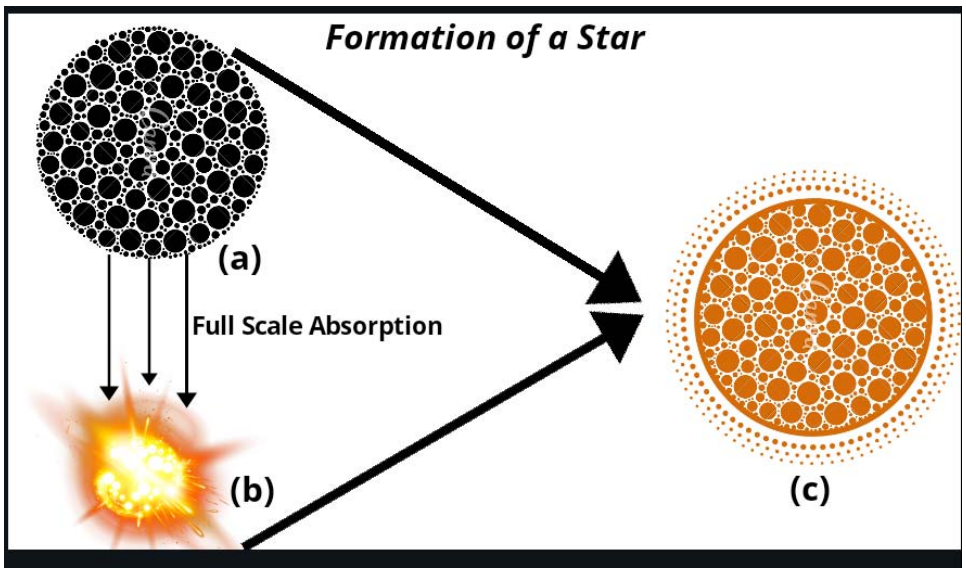


Figure 13

In figure 13, (a) is just like any other planet that was formed, (b) is the inferior light itself. Although stars were formed by the inferior light, instead of cooling to form a normal planet; they proceeded to absorb the same inferior light that formed it to give to picture (c) which is a star.

Each electron absorbed a corresponding photon from the inferior light. Thus, the energy value from each photon from the stars will be 0.0072 ($7.2 \times 10^{-3}$). This will now be the new energy value of a pack photon (Figure 14)

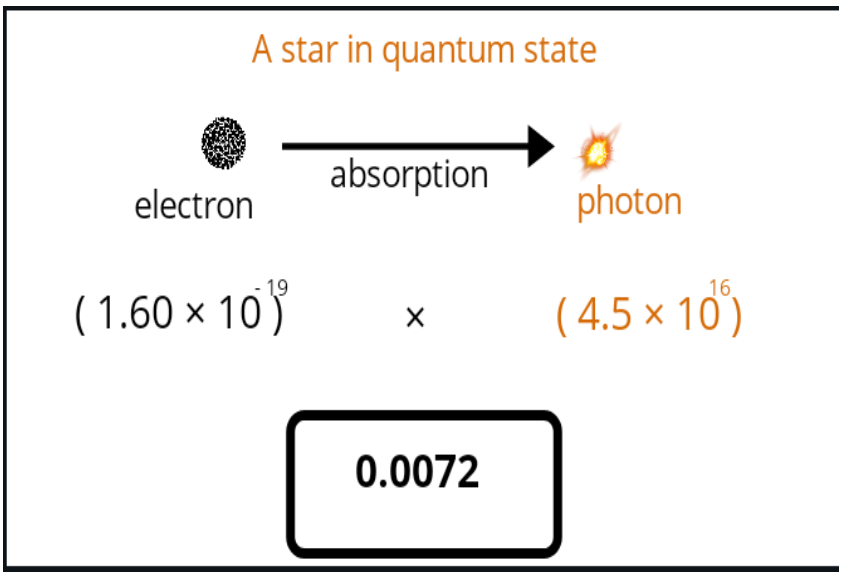


Figure 14

Just after the point of absorption during creation, the energy value of a photon from the stars will be measured as 0.0072 but as time passes, a shuffle happens.

The stars produce their energy from nuclear fusion. Using our closest star (Sun), the energy produced by the sun is from nuclear fusion done at its heart (core). The journey of a photon from the sun's core away from its surface to any planet passes through a complicated process. After the creation of stars, all absorbed photons of the inferior light by the electrons are drawn at the core of a star and re-emitted still with an energy value of 0.0072. However, a shuffle happens just outside the core, these photons with an energy of 0.0072 are shuffled by other parts of the sun and re-emitted in lower frequencies. This is what led to the characterization of the rays of the spectrum according to their frequency and wavelength. This concept of shuffle will lead to the term "Reduction of Pack-Photons".

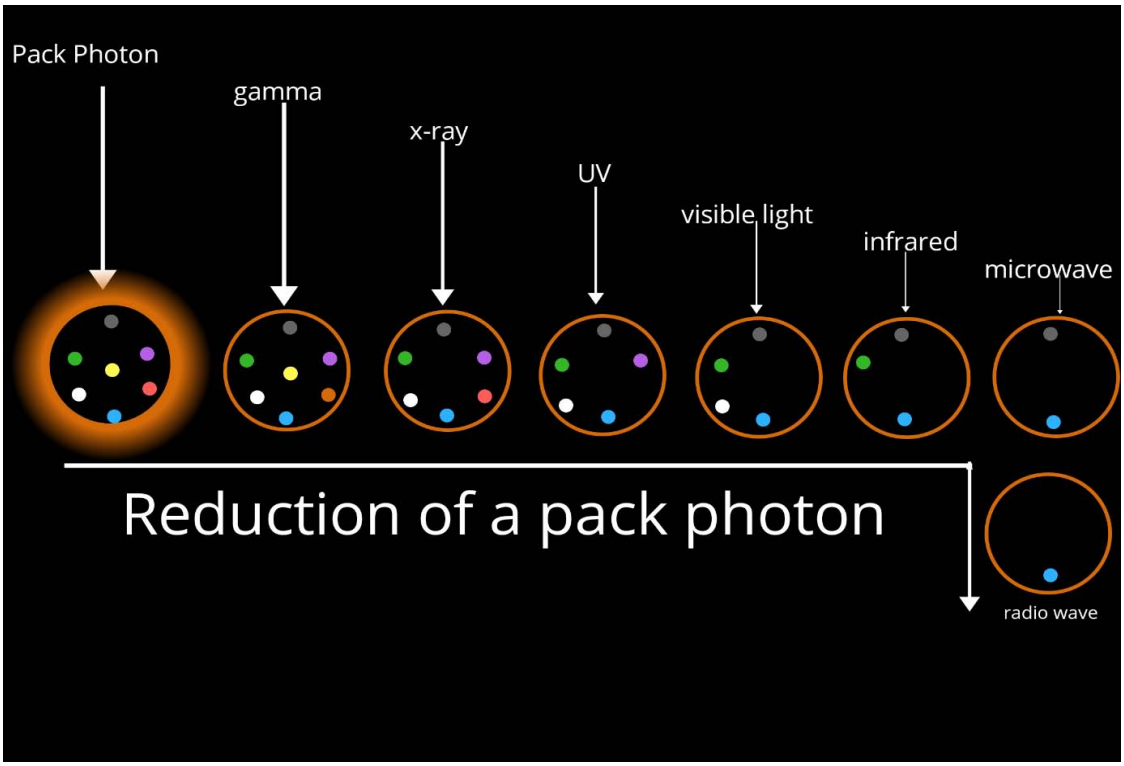


*Figure 15*

Gamma ray, X-ray, UV photons etc., are all reduced version of a Pack- Photon. A Pack-Photon is the peak of the spectrum with highest frequency and the lowest wavelength. Figure 15 shows the reduction of a pack photon. UV piece (purple), Infrared piece (green), X-ray piece (red), Gamma ray piece (yellow), radio wave piece (blue) microwave piece (black) and visible light piece (white). A Pack -Photon is the default. It can be reduced to gamma, from gamma to x-ray, from x-ray to UV and so on. The sequence continues. From figure 15, an x-ray photon does not have the gamma piece (yellow) on it. Also, in a UV light photon, the x-ray piece (red) is absent, and so on. The sequence continues up to radio wave. Instead of the idea that other photons (rays) of the spectrum are emitted on their own from the sun, rather all photons are emitted from the core of the sun as pack photons but can be absorbed by other parts of the sun and re-emitted in lower frequencies that can find their way to anywhere outside. However, pack-photons are only emitted at the core of a star which we can't see but these pack-photons are only being able to escape shuffling by other parts of the sun to the surface in its complete form, once in a long period (occasionally). Any photon we see today from the sun was once a pack-photon.

The Electromagnetic spectrum was discovered long ago, the concept of pack photon is just being introduced in this paper (2020). This means, there's an EM radiation form higher than the normal gamma rays, if it has been observed, observers might just categorize it as a form of gamma ray. A pack-photon might have been seen/observed but described as a gamma ray photon just because gamma rays are the highest currently in the spectrum. Thus, calculations will help differentiate.

*b) Mathematical Test*

In some of my previous papers, I included the unit for the value 4.5 x $10^{16}$ as joule (J), in some, I didn't include a unit. The Physics community will be responsible for the decision of the unit once it is discovered. I'll just do my calculations without a unit to avoid complications. The value 4.5 x $10^{16}$ as the energy of a Pack-Photon from the inferior light may not be in joules, it could be in eV or a unit that doesn't exist, and we can never prove or measure that value because the inferior light itself was been absorbed by the stars which are classical forms of matter. The value of a Pack-Photon changes to 0.0072. This value (0.0072) is preferred to be in joules but I proceed to get the frequency and wavelength of a pack-photon.

*Frequency*

The Equation (E=hf) is the relationship between the energy of a photon(E) with its frequency (f). h is the planck constant.

If the value (0.0072) is assumed to be in joules. The reduced planck constant in joules/sec (1.054 x $10^{-34}$) is used. The frequency of a pack photon is

$$f = E/h. \quad f = 0.0072/(1.054 \times 10^{-34})$$

$$f = 6.83 \times 10^{31} (Hz)$$

*Wavelength*

The wavelength (λ) of a photon is given as (λ) = c/f, where c is the speed of light (3 x $10^8$) and f is the frequency.

Therefore, the wavelength of a pack photon is (3 x $10^8$)/(6.83 x $10^{31}$).

$$\lambda = 4.39 \times 10^{-24}(m)$$

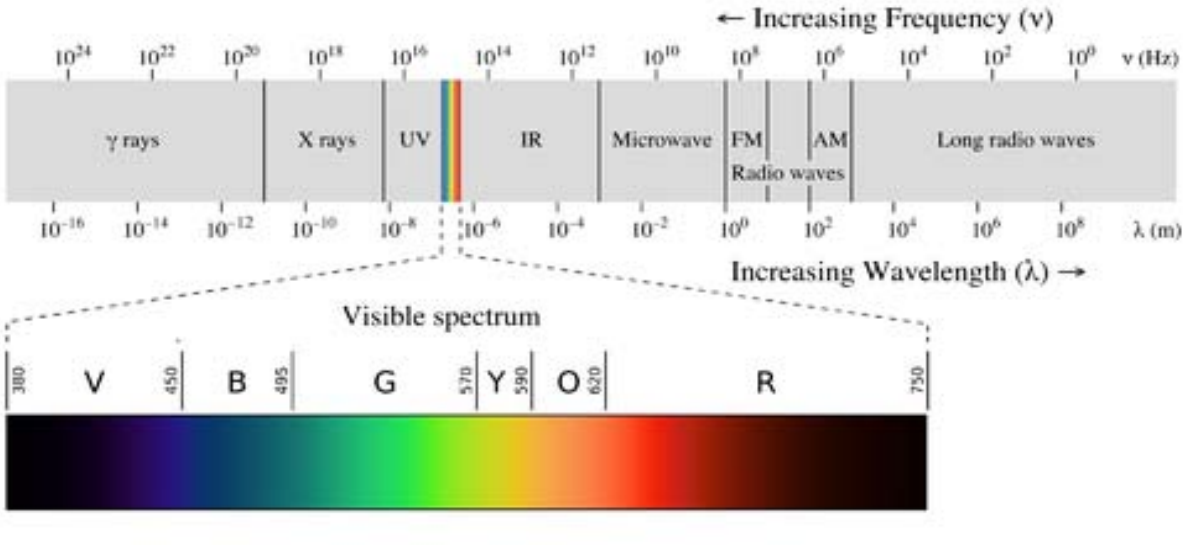


*Figure 16*

If we compare the details of the highest energy (gamma ray) of the spectrum from figure 16 with the details for a pack – photon, it is seen that a pack - photon is higher than a gamma ray.

Figure 16 shows the electromagnetic spectrum; gamma ray has a frequency (Hz) of $10^{20}$ - $10^{24}$ and a wavelength (m) of $10^{-16}$- $10^{-12}$. A photon higher than a gamma ray photon will have a frequency of $>10^{24}$ and a wavelength of $<10^{-16}$. However, from the mathematical test, the frequency of a pack photon is of $10^{31}$ which is $>10^{24}$ and the wavelength is of $10^{-24}$ which is $< 10^{-16}$. Thus, the mathematical test/prove is complete and the details for a pack-photon should be the peak of the spectrum. Hence, the spectrum needs an update after an observational prove.

I hereby present an updated version of the Electromagnetic Spectrum to the Science Community, shown in Figure 17.

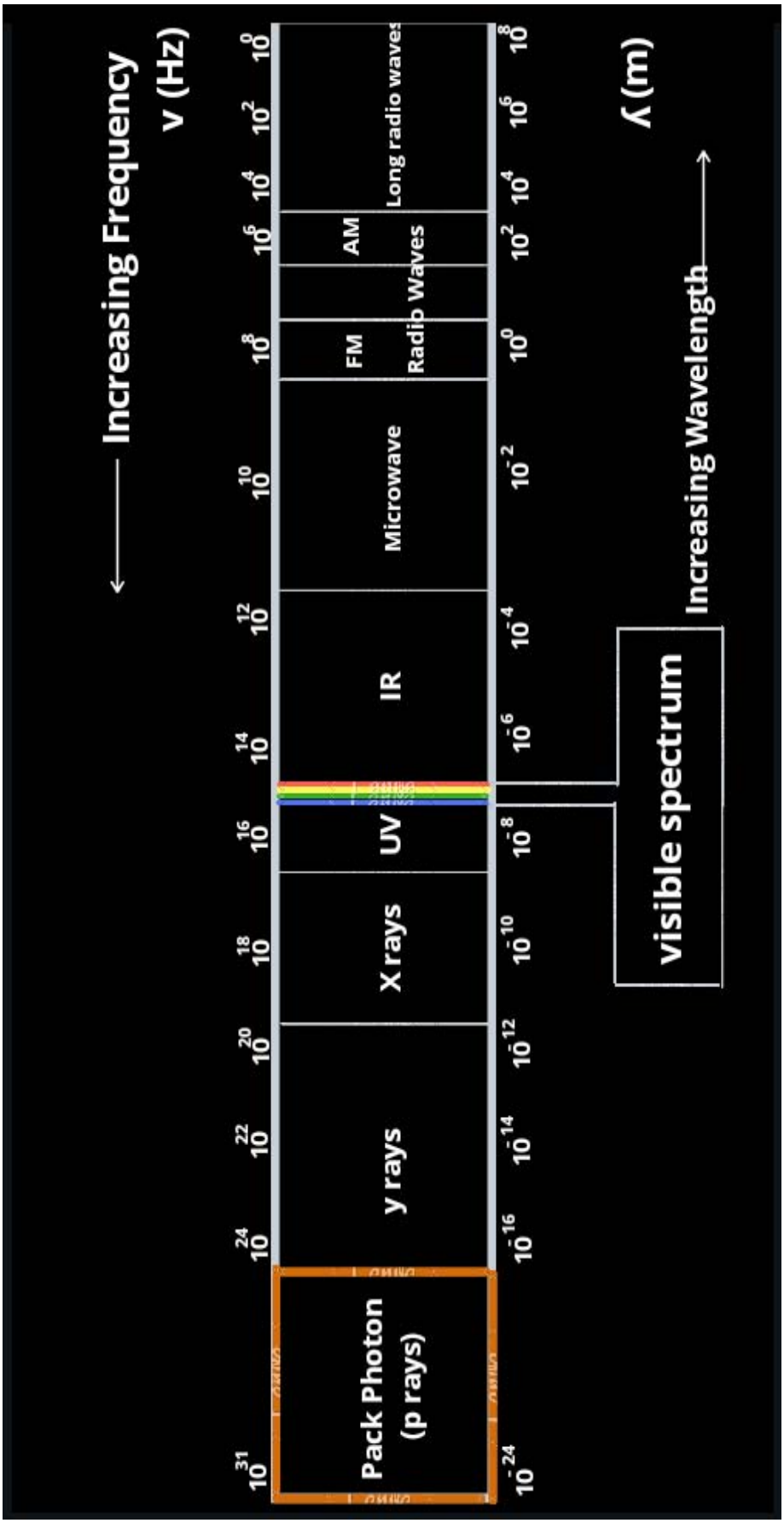


Figure 17

*c) A Clue on Observational prove*

Due to the shuffling that occurs as explained, a pack photon in its complete state or close to its complete state is observed at the surface of a star once in a while (occasionally). I can't say the exact period it can be emitted but I know all things/process are not perfect, there are days/periods that a pack-photon will escape shuffling and be emitted to the surface of the sun in its complete form. However, it's almost impossible for a pack-photon to find its way to earth as its complete nature rather its reduced version is seen on earth which are other forms of the spectrum. The pack photons are emitted right from the core of the sun. Figure 18 is an illustration.

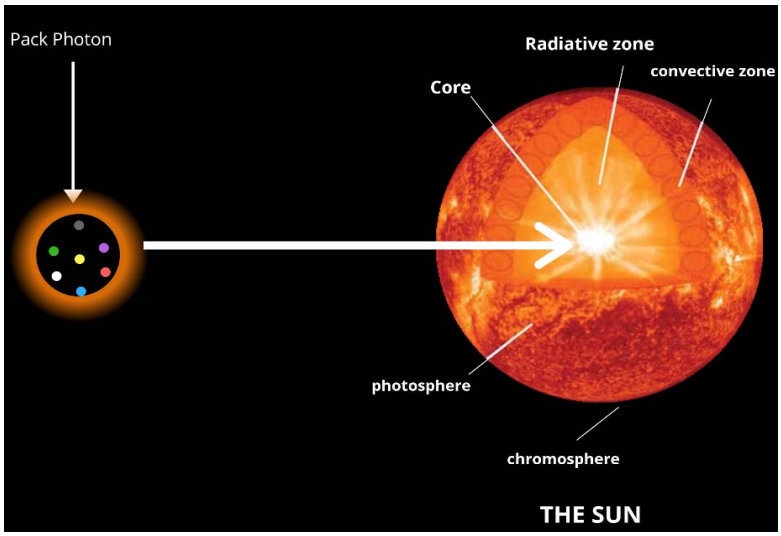


*Figure 18*

If a pack-photon manages to escape shuffling, the closest position to be observed and noticed would be from the position of the sun's equator. This observation can be done by the help of telescopes, satellites or a photon detector at the outer space. The pack-photon maybe difficult to detect, but its discovery and confirmation of values will lead to the concluding acceptance of the "Theory of Everything".

All these years, we wouldn't know that there is something like p-rays because they are emitted at the core of a star which we can't observe and they are shuffled to lower frequency just outside the core. Therefore, we can't observe them. However, it is possible that some must have escaped shuffling over the years and appeared at the surface and we wouldn't know.

A pack photon might have been seen/observed and described as a gamma ray photon. Any form of photon/ray with a frequency (Hz) higher than $10^{24}$ should be regarded as a pack-photon (p-rays) i.e. a pack photon will have a frequency (Hz) of $10^{24}$- $10^{31}$. The help of the organizations with telescopes and satellites or photon detectors at the outer space are needed to prove this concept, especially the solar parker probe which was launched recently to study our closest star (sun). The detection can only be done at the outer space.

There's not a complete pack photon on earth except one manages to escape through the ozone layer.

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

## V. Unification

This section is the official unification of QM and GR.

The Universe is about two lights which are Energy and Dark Energy. The solidification of these lights is what we know as matter and dark-matter.

These two lights are supposed to be merged together i.e. everything made from energy is supposed to be merged with dark energy. If they are merged, we should see the things around us as dark energy or a form of dark energy.

Its straight, the original form of the universe is with both lights merged, but presently both lights are not merged but rather they exist as two separate entities, resulting into the observation of only energy while dark energy remains invisible.

However, the above fact will bring about a twin equation which will unite QM and GR.

To get the equation of the universe and unite both QM and GR, the unification of both lights will be displayed.

I present the related constants for Unification

Speed of light (c) = $3 \times 10^{8}$m/s

Planck constant (h) = $6.6 \times 10^{-16}$eV.s

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

$S_{default} = 1.50 \times 10^{10}$ represented as S

$P_c$ will represent the current value of the universe and $P_o$ will represent the original value of the universe. The original value of the universe signifies that both dimensions (Superior and Inferior) are merged. The current value signifies the current state of the universe as both dimensions are not merged.

To understand this unification, all that I've explained from Section III has to be understood properly. What we refer to as dark energy was described (S × c) and what we refer to as energy originates from p-rays (pack-photon [k/hc]). They are the default dark energy and default energy.

*a) Equation Derivation for Unification*

First Equation Derivation;

$$(\text{Superior Light})/(\text{Inferior Light}) = P_c \ldots\ldots\ldots (1)$$

$$(\text{Dark Energy})/(\text{Energy}) = P_c \ldots\ldots\ldots\ldots (2)$$

$$(S \times c)/(k/hc) = P_c \ldots\ldots\ldots\ldots\ldots (3)$$

$$(S \times c^2 \times h)/(k) = P_c \quad \ldots\ldots\ldots\ldots (4)$$

$$Sc^2h/k = P_c \ldots\ldots\ldots\ldots\ldots (5)$$

The above equation (5) will have a duplicate which will represent when both lights are merged. Merging means that energy will become the form and value of dark energy.

Second Equation Derivation (Energy becomes Dark Energy);

$$(\text{Superior Light})/(\text{Inferior Light} \times 100) = P_o \ldots\ldots\ldots (6)$$

$$(\text{Dark Energy})/(\text{Energy} \times 100) = P_o \ldots\ldots\ldots\ldots (7)$$

$$(S \times c)/(k/hc \times 100) = P_o \quad \ldots\ldots\ldots (8)$$

$$(S \times c^2 \times h)/(k \times 100) = P_o \quad \ldots\ldots\ldots (9)$$

$$Sc^2h/k \times 100 = P_o \ldots\ldots\ldots\ldots\ldots (10)$$

*b) Mathematical Test*

We have two equations;

1.) $Sc^2h/k = P_c$

2.) $Sc^2h/(k \times 100) = P_o$

Test with the first equation;

$$Sc^2h/k = P_c$$

Inserting Parameters

$$[(1.50 \times 10^{10}) \times (3 \times 10^8)^2 \times (6.6 \times 10^{-16})]/(8.9 \times 10^9) = P_c$$

$$P_c = 100.$$

Test with the second equation;

$$Sc^2h/(k \times 100) = P_o$$

Inserting Parameters

$$[1.50 \times 10^{10} \times (3 \times 10^8)^2 \times (6.6 \times 10^{-16})]/[(8.9 \times 10^9) \times (100)] = P_o$$

$$P_o = 1.$$

From the test, it is seen that $P_o$ and $P_c$ are constants as 1 and 100 respectively. When both light dimensions merge, they become one as the value (1) - $P_o$ which is the original value of the universe signifying unity, but presently, both light dimensions are not merged and differ by 100 as $P_c$.

The value $P_o$ as 1 can also be given as $Sc^2h/(kP_c) = P_o$

However, both twin equations are the unification of GR and QM illustrated with figure 19

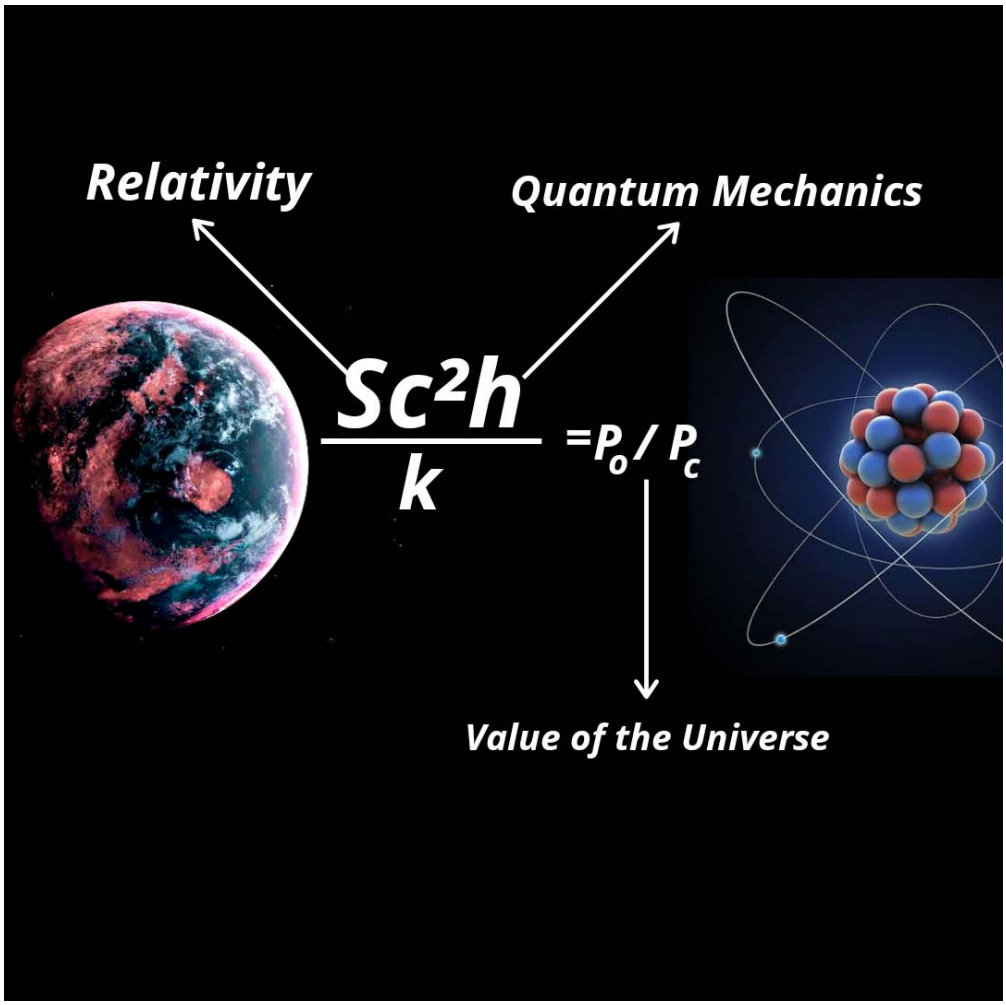


*Figure 19*

The meaning of the Unification/Equation is; In the Universe, objects can be macroscopic or microscopic (big or small) and they can move in space with different speeds but a peak speed of the (speed of light) at certain positions. The break-down of the equation will unleash the nature of the objects as either a nature of one light (matter) or the other light (dark-matter) alongside spacetime. The last stage reveals the both lights as their self. If the lights are unified, the value of the universe is 1, if the lights separate, the value of the universe changes to 100.

This equation can be derived in many ways, I only presented the major derivation.

From the new approach in section 3, S which is $S_{default}$ is the constant that represents relativity. h (planck constant) is the major constant in quantum mechanics. Thus, both twin pillars of physics are hereby unified with the above equation shown in figure 19.

The major fact is that both lights can be merged, bringing back the original form of the universe. When both lights are merged, there will be nothing like energy rather only dark energy will exist(energy will become the form of dark energy).

## VI. Next Phase

This section introduces the physics of the dark dimension. The properties of nature in this visible dimension is similar to the dark dimension. They are both twin dimensions. Therefore, the way we calculate for an entity or the way we represent an entity, has a similar representation in the dark dimension.

The Universe

| Dark Dimension | 100 | Visible Dimension |
|---|---|---|

1) The Superior Light($E_d$)=S x c = [1.50 x $10^{10}$ x 3 x $10^8$]

$E_d$ = 4.5 x $10^{18}$(Dark Energy)

*(Higher; Quantum state)*

The Inferior Light(E) = k/hc = 9 x$10^9$/[6.63 x $10^{-16}$ x3 x$10^8$]

E = 4.5 x $10^{16}$ (Energy)

*(Quantum state)*

2.) The superior light ($E_d$) = $M_d$ x $c^2$

$E_d$ = 50 x (3 x $10^8$)$^2$……$E_d$ = 4.5 x $10^{18}$

*(Higher State)*

The Inferior Light (E) = M x $c^2$

NB; The energy and mass of matter should be inserted into this equation, they are not constant *(Higher State)*

3.) The Solidified form of the Superior Light (dark Matter)

$M_d$(50) = S/c = 1.50 x $10^{10}$/3x $10^8$.....

*(Higher; Quantum State)*

The Solidified form of Inferior Light (Matter)

Electron(e)= 1.60 x $10^{-19}$…… *(Quantum State)*

4.) The Solidified form of the Superior Light

$M_d$(50) = $E_d/c^2$…… *(Higher State)*

The Solidified form of the Inferior Light

M = $E/c^2$……*(Higher State)*

5.) Visibility value of the Superior Light dimension

$K_s$ = (1.388)

100 Visibility value of the Inferior Light dimension

$K_p$ = 138.8

6.) Absorption of the superior light by its solidified form

$M_d$ x $E_d$ = 50 x (4.5 x $10^{18}$) = 2.25 x $10^{20}$(Light Mode S)

*(Quantum State)*

100 The tendency of the solidified form of the superior light to absorb the inferior light $M_d$ x E=(50 x 4.5 x $10^{16}$) = 2.25 x $10^{18}$……*(Quantum State)*

7.) Absorption of the superior light by its solidified form

[$M_d$ x c]$^2$ = [50 x 3 x $10^8$]$^2$ =2.25 x $10^{20}$ (Light mode S)

*(Higher State)*

Absorption of the inferior light by its solidified form

[M x c]$^2$. … This is how to calculate the energy of a star by its mass…..(Light Mode P) *(Higher State)*

8.) The tendency of the solidified form of the inferior light to light to absorb the superior light….

e x $E_d$ = 1.60 x $10^{-19}$ x 4.5 x $10^{18}$ = 0.72

*(Quantum State)*

100 Absorption of inferior light by its solidified form

e x E = 1.60 x $10^{-19}$ x4.5 x$10^{16}$= 0.0072 (Light Mode P)

*(Quantum state)*

9.) To solve the tendency issue; we use its fellow as an attachment.

$e \longrightarrow M_d \quad E_d$

1.60 x $10^{19}$ x 50 x 4.5 x $10^{18}$ = 36 *(Quantum State)*

$M_d \quad e \longrightarrow E$

100 50 x 1.60 x $10^{-19}$ x 4.5 x $10^{16}$ = 0.36*(Quantum State)*

Absorption of the superior light by the solidified form of the Inferior light.

Absorption of the inferior light by the solidified form of the superior light

10.) The (Higher state) of the previous will be M x [$M_d$ x c]$^2$

i.e M x [2.25 x $10^{20}$]

The (Higher state) will be $M_d$ x [M x c]$^2$

i.e 50 x [M x (3x $10^8$)]$^2$

In the above illustration, the value of dark energy is for both quantum and higher. The reason is; A photon from dark energy will have the same value as the default dark energy itself but in a smaller unit similar to a pack-photon of the Inferior Light.

The fact that the default dark energy value is gotten as $4.5 \times 10^{18}$, a pack-photon (quantum) from the inferior light with value ($4.5 \times 10^{16}$) implies that merging is possible and was done at creation as per (quantum to higher). However, a photon to photon (quantum to quantum) merging is the main point; Although the default dark energy value is $4.5 \times 10^{18}$ as a big energy unit, a photon from dark energy will also have the value $4.5 \times 10^{18}$ which will have the same unit as a pack-photon representing energy.

Matter can become negative (Anti-matter) from a positive state but its default state is positive. That shouldn't be forgotten.

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 1. 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) divides the current value of the universe (100), signifies that there are two major dimensions in the universe presently, a dimension of dark matter and dark energy and a dimension of matter and energy (radiation).

The Physics of the dark dimension should have emerged a long time ago. However, this arrival of the TOE will result into the introduction of dark physics. From the above illustration, it is seen that similar calculations between both dimensions differ by 100 ($P_c$). Until both dimensions merge into one, we can have just one description ($P_o$).

## VII. A Major Prove of the Theory of Everything

Energy (Inferior Light) was basically used to form planets/planetary bodies and stars. Planets cooled and solidified to form a combination of land and water, air in some. So, it's basically land and water. From the land with the presence of water, vegetations grew. Animals and humans were made from the dusts of the lands. Natural Resources from the lands is been explored by man to produce more advanced types of matter. In some cases, solidification happened in the presence of air which produced some rocky resources, and water to produce some liquid resources.

Thus, its basically land and water. From the blueprint of the universe, it is said that particles of dark energy (Superior Light) exist in water i.e. water is 99% of Inferior Light (matter) and 1% of the Superior Light (dark matter).

The inferior light that formed the planets can still be seen on the stars. Its color is orange-like and the Superior Light is white-like. If you want to see the inferior light, just look up at the sun. However, lets see if we can get any detail from land and water.

*Figure 20*

*Figure 21*

*Figure 22*

In figure[20,21&22], it is seen that there's a similarity between the light in 20 and the lands in 21 & 22 (red earth sand). This is to prove that the inferior light solidified into planets and the stars absorbed the same light after cooling.

Its only as a result of being present in this time that we see white sands in some places because the sand were actually brought from rivers for certain purposes. At the early days, white sand cannot be seen on normal roads and paths except close to the rivers/oceans and beneath.

*Figure 23*

*Figure 24*

The fact is that white sand is associated with water (figure 23 & 24). Even the water at the atmosphere (clouds) are white in nature. There is only a thing like red-earth sand, white sand was formed after enough particles of the superior light in water has accumulated on the red sand after solidification process (creation). i.e. red sand changes to white sand in the presence of enough water after series of accumulation for a very long time. Thus, creating a whole new sand as white sand with a different nature.

This is just one of the major prove of the Theory of Everything.

Here is a brief explanation on the reality of TOE after all discussions;

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.

Let's face the reality, radiations (EMR) from black holes do not vanish in space just like that unless it is regarded as magical and magic is of the superior dimension. 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 unification, 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; due to merging, 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) becoming the form of dark energy. Dark energy is superior to EM radiation from their values. Thus, if these two are combined, EM radiation becomes 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 (bigger) state of matter i.e. If all matter in this universe are traced to their natural source, it will result to EM radiation. This makes matter 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).

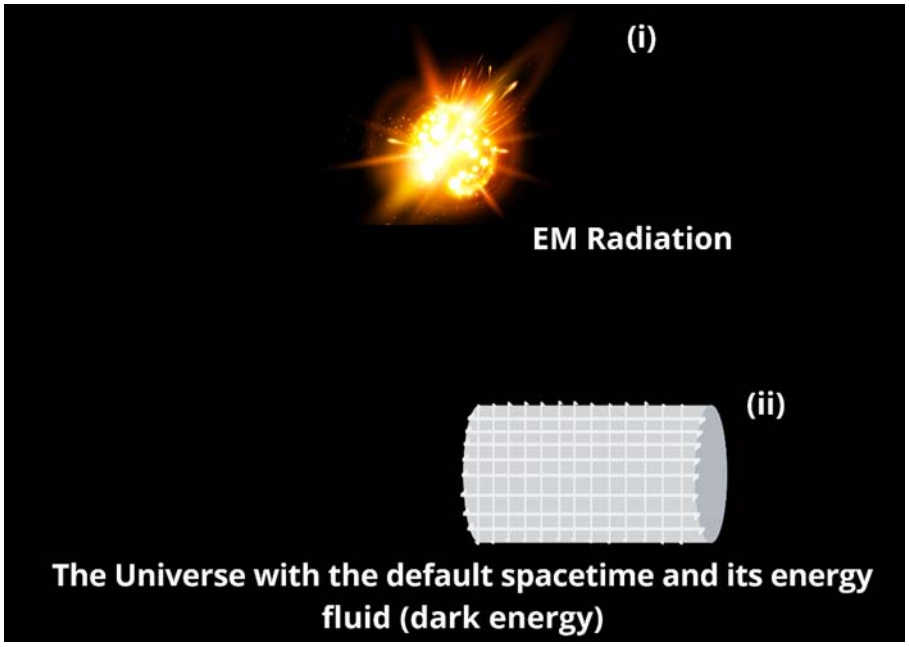


*Figure 25*

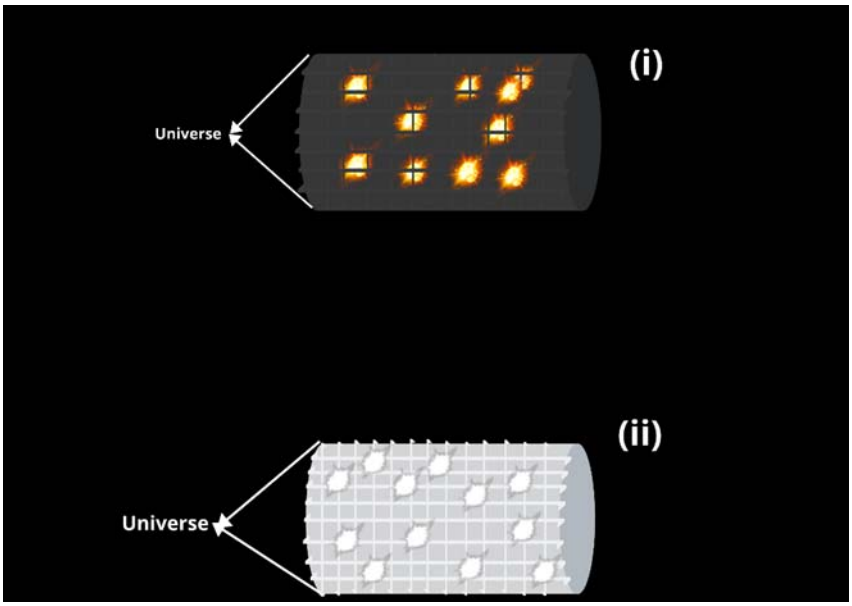


*Figure 26*

During the creation of the universe, spacetime was used everywhere as the entire geometry and structure of the universe i.e. the universe itself is the default spacetime along with its energy fluid just like (ii) in Figure 25, this also implies that dark energy was also everywhere. The solidification of EM radiation formed all planetary bodies 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 25 as EM radiation and (ii) in Figure 25 as the universe with the default spacetime and its energy fluid. In Figure 26, (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 become 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 straight, 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 26. 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 26), 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 26) 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 at the outer space, 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 free 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 radiations i.e. just like the EM radiations exploded long ago, scattering at different places, they'll all come back together this time and proceed to re-unite with dark energy.

However, what caused the splitting of EM radiation from dark energy is biblically revealed to be as a result of a mistake from the first man. The reason for the invisibility of the dark dimension is due to this; After the splitting of both dimensions, there were no forms of dark energy that possessed the same dark energy itself, in full scale. When matter absorbs energy in full scale, it contributes to the visibility of the Inferior Dimension. On the other hand, when dark matter absorbs dark energy in full scale, it contributes to the visibility of the Superior Dimension. The Stars did it for the Inferior dimension, which makes it visible but a similar situation has not been done for the Superior dimension. Figure 27 is an illustration.


*Figure 27*

The absence of dark matter forms that possess dark energy is the reason why the Superior dimension is invisible. This situation is easy to understand with the blueprint of the Universe.

The theoretical concept of merging exists 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 energy i.e. take the form of dark energy but presently both entities differ by 100.
(i) in Figure 26 represents an unstable universe while (ii) in Figure 26 represents a stable universe.

Einstein told the world that energy and matter are two forms of the same thing. It has been understood now. The inferior light which is the original form of energy itself was solidified to form the planets that are matter and also contains other forms of matter. Thus, the same matter can be reversed back to energy. The fine structure constant also proves that; Although a photon can become an electron, when an electron absorbs a photon from the inferior light, it becomes a photon again.

Trace more parts of science to this "Theory of Everything" and more unsolved problems and secrets will be revealed.

## VIII. Conclusion

All theories and equations except Relativity and some known constants in this paper are novel and proposed by Prince Jessii.

This theory is the TOE itself and I'm presenting it to the science environment/community. There is no other TOE outside this. Also, from another angle/view other than physics, to know everything about your universe, simply purchase the blueprint of the Universe from ref [27]. Another major prove of this theory will be the discovery of a pack-photon (p-rays) from the sun which can be done by the help of NASA. The world awaits the discovery.

## Acknowledgement

We have come this far in physics with the TOE and some physicists/scientists have somehow contributed to the TOE with their theories, constants and observations in one way or the other without knowing they contributed. It is thanks to all of them.

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Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 7 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

# Kelvin's Secret Dropper

By F. F. Mende

*Abstract-* The physics of Kelvin's dropper is still not completely understood, since it is unclear how neutral drops of water, even when polarized, can acquire a unitary charge. The article suggests that the process of acquiring a unitary charge by droplets in a Kelvin dropper is similar to acquiring charges by raindrops falling from a thundercloud. Therefore, a thundercloud, judging by the physical processes occurring in it, represents a giant Kelvin dropper.

*Keywords: kelvin dropper, lightnings, water, polarization, charge.*

*GJSFR-A Classification: FOR Code: 249999*


*Strictly as per the compliance and regulations of:*

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## I. Introduction

Drops of rain from a thundercloud bring negative charges to the earth's surface; it still does not have a generally accepted theory of this phenomenon [1]. First of all, it should be noted that thunderstorm clouds consist of several thunderstorm cells closely adjacent to each other, the development of processes in which is identical, but shifted in time. By a thunderstorm cell is meant a region that has a certain horizontal extent in which all the basic physical processes take place.

In Fig. 1 in an idealized form presents a thunderstorm cell at an early stage of development [1].

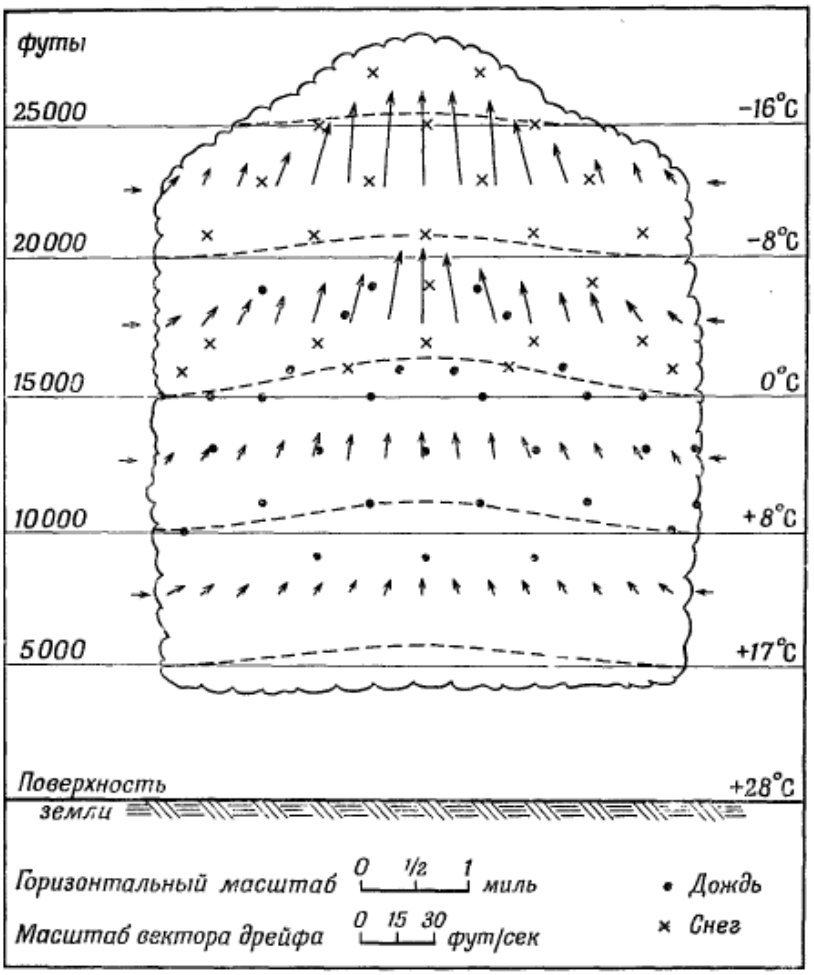


*Fig. 1:* Thunderstorm cell at an early stage of development

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

Streams of warm air rush up and cool down as they rise. If the temperature at the bottom of the cell, located at an altitude of 5,000 feet, is about +17 degrees Celsius, then at an altitude of 25,000 feet it is -16 degrees, and in this area water vapor begins to turn into snow. Further development of the thunderstorm cell is shown in Fig. 2 [1].

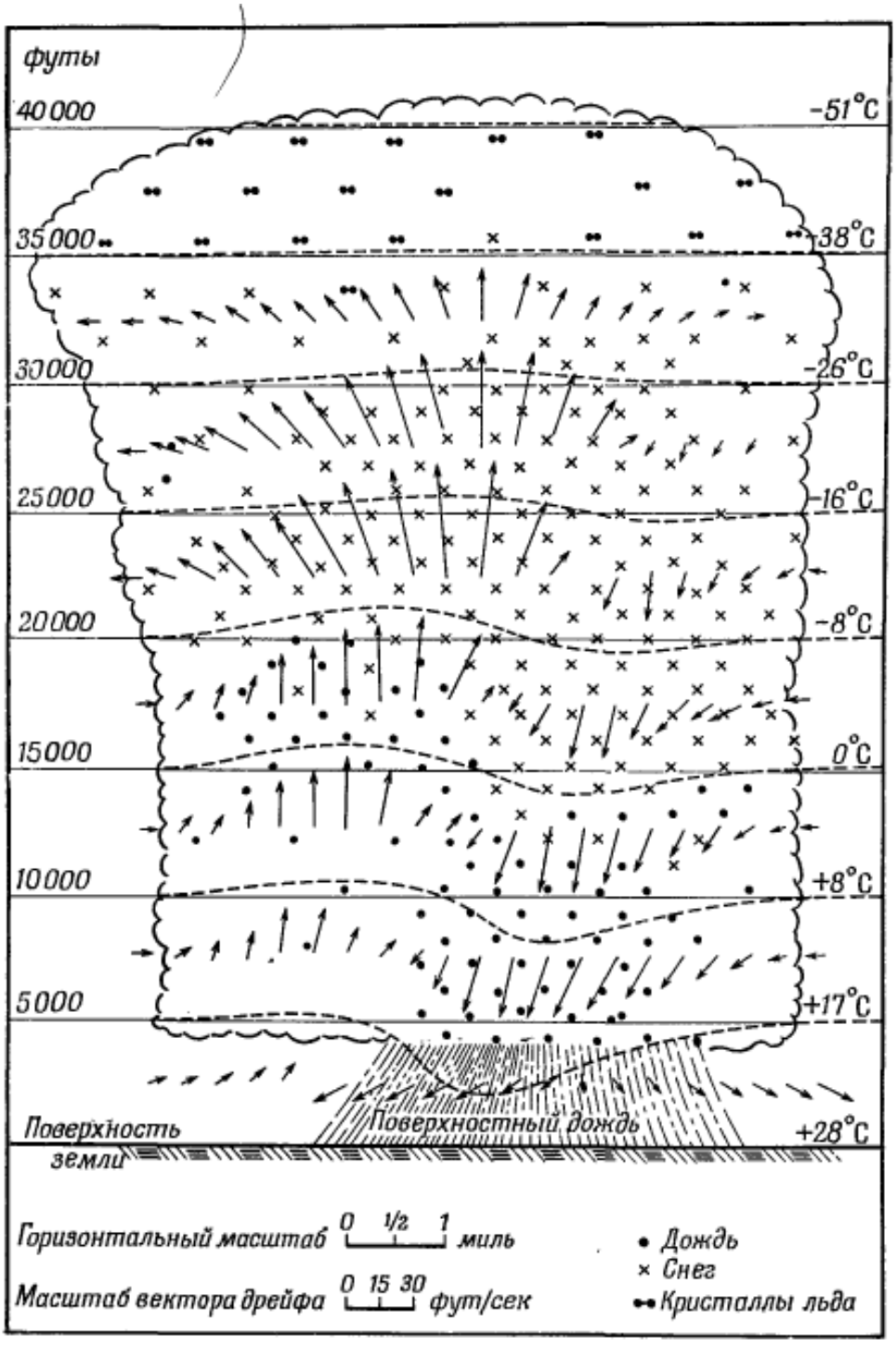


*Fig. 2:* Further development of the thunderstorm cell

In this state, the cell is considered ripe and it begins to rain from its lower part, while ice crystals form in its upper part. Ice crystals formed in the upper part of the cell and snow formed in its middle part, falling down, begin to melt in the streams of warm rising air, turning into drops. It is at this stage that lightnings are formed, indicating that this process is accompanied by charge transfer from the upper part of the cell to its lower part. But the mechanism for such a transfer is not yet clear.

## II. Friction Electrification

It is known that the friction of amber on wool leads to its electrification. This is due to the fact that the dielectric constant of amber (the relative dielectric constant of amber is 2.6 - 2.8) is greater than that of wool, and electrons transfer from a dielectric with a lower dielectric constant to a dielectric with a higher dielectric constant. A similar phenomenon is easily observed during friction of dielectric films (for example, from fluoroplastic), with dielectrics whose dielectric constant is less. For some types of fluoroplastic, the relative permittivity reaches 10. Such films are so electrified that they literally adhere to neutral conductors, or to other dielectrics with a lower dielectric constant.In water and ice, the relative permittivity is also high and for static fields reaches 3.25 and 80 for ice and water, respectively.

Between the upper and lower parts of the thunderstorm cell there is a very large potential difference. Therefore, raindrops falling through a thundercloud are strongly polarized. Water is a polar dielectric, its molecule has an electric moment, and its polarization is associated with the rotation of electric dipoles in an electric field. Polarized drop of water is shown in Fig. 3.

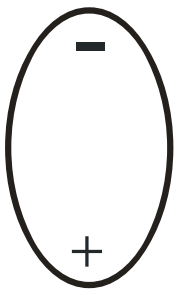


*Fig. 3:* Polarized drop of water

Its lower part is positively charged, and the upper one is negative. Therefore, flying through ionized air containing free electrons, its lower part collects them. When a drop leaves a thunderstorm cell, where there is no large potential gradient, the polarization of the drop disappears, but the electrons, due to the fact that water has a high dielectric constant, cannot leave the drop, and together with it fall on the earth's surface.

## III. Kelvin's Dropper and its Principle of Action

The implified model of Kelvin's dropper is shown in Fig. 4

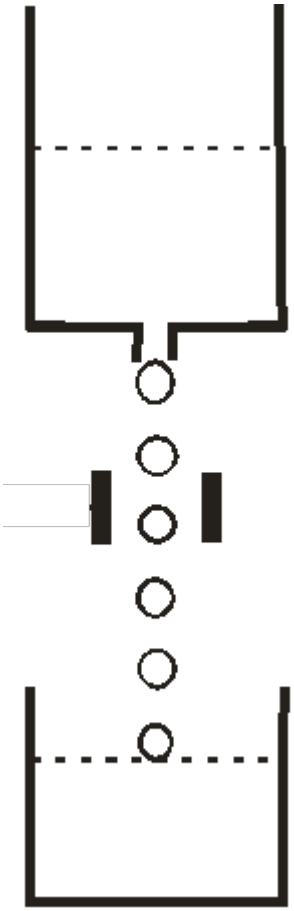

*Fig. 4:* Simplified Kelvin Dropper Model

From the upper vessel, neutral drops of water flying past the middle ring electrode, which is called the inductor, fall into the lower isolated vessel. In this case, the lower vessel acquires a negative or positive charge. Therefore, droplets carry unitary charges that accumulate in the water of the lower vessel. But why they were brought there by drops of water that enter electrically neutral from the upper vessel, it is not clear. A prerequisite for charge transfer by water droplets is a large potential difference between the inductor and the lower vessel, and, consequently, their high polarization, as noted in [2]. In this work, it is also reported that the performance of the Kelvin dropper according to the scheme shown in Fig. 4, was confirmed using a Van de Graaff generator as a high-voltage voltage source. But the processes of polarization of water droplets cannot lead to the appearance of unitary charges in them.

A modified design of such a dropper was proposed by Kelvin, it is presented in Fig. 5 [3].

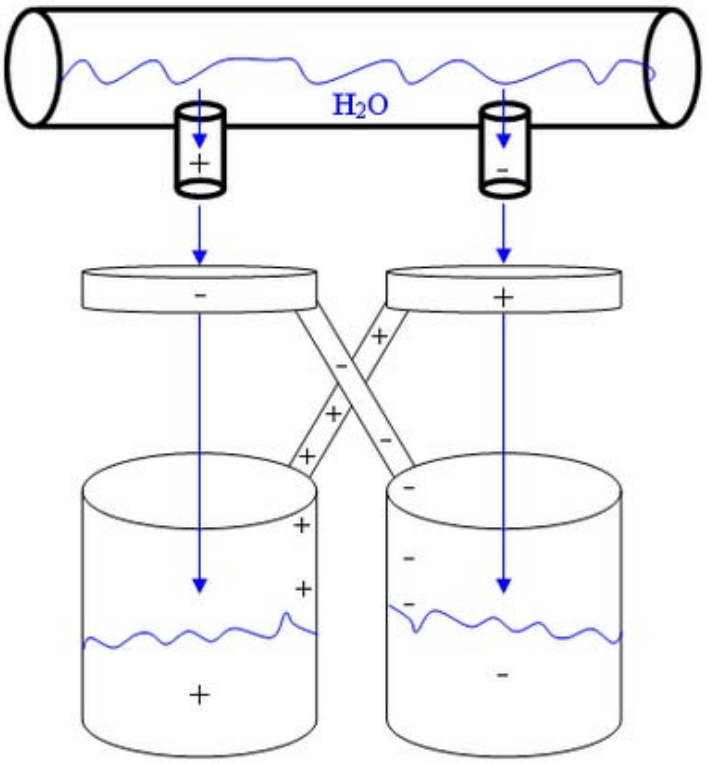


*Fig. 5:* Kelvin's dropper

Some fundamental differences in the principle of operation, compared with the option presented in Fig. 4, this dropper does not. Kelvin's dropper differs only in that there are two simplified droppers and two cross-connected inductors connected to the lower containers. Judging by the picture, it is clear that it is assumed in advance that water droplets come out of the holes in the upper vessel already charged, and the signs of the charges of these drops are opposite. But how can this be if the water in the upper vessel is electrically neutral.

To clarify the principle of operation of Kelvin's dropper, her experimental layout was shown, shown in Fig. 6.

*Fig. 6:* The experimental layout of the Kelvin dropper

Experimental studies conducted on this layout showed the following features that were not noted in well-known publications. It can be seen that above the inductor, the jets are solid. But after the water jets, flying through the inductors, fall into the area between the inductors and the lower vessels, they are split into small droplets scattering in different directions. This process is clearly visible in Fig. 7.

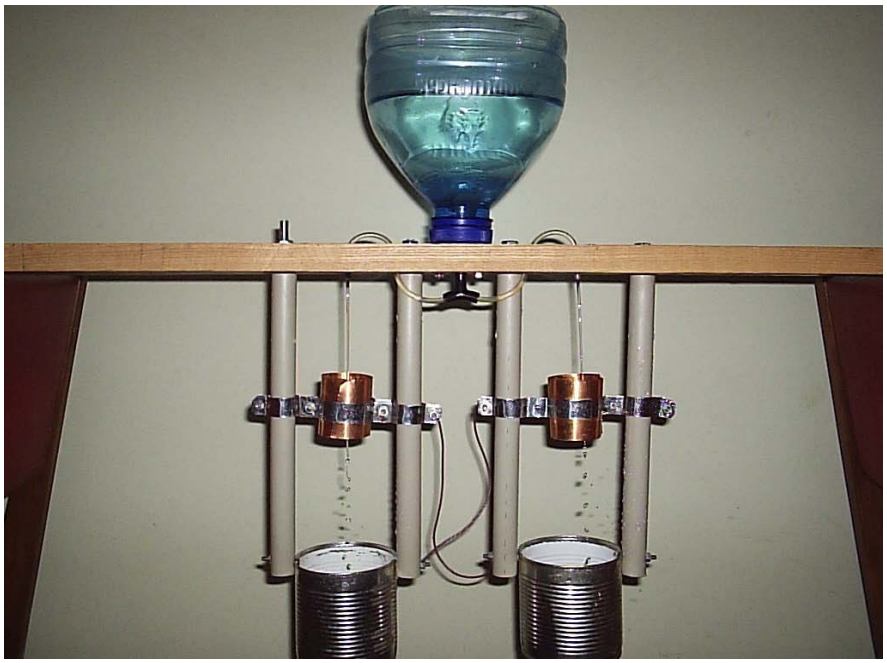

*Fig. 7:* The process of crushing solid jets into droplets after their passage through inductors

Such fragmentation is due to the fact that unidirectional electric dipoles formed during the polarization process repel each other. The water molecule is polar. In the process of polarization, the electric dipoles of all molecules rotate in the same direction, which leads to their repulsion. This repulsion leads to crushing of the jets into droplets. It should be noted that the lower vessel is negatively charged in the case when the lower part of the polarized drop falling into it is positively charged. With the reverse polarization of the droplet falling in the lower vessel, the vessel acquires a positive charge. With the reverse polarization of the droplet falling in the lower vessel, the vessel acquires a positive charge. Which of these conclusions can be drawn. Drops acquire additional unitary charges during the passage, between the inductors and the lower vessel, in the case when there is a large potential difference between the inductors and the lower vessel. This may be due to the following circumstance. In the space surrounding us, there is always a radiation background caused by both natural and artificial processes. This background leads, although weak, to ionization of the atmosphere, in which free electrons and ions are present in it. They are then collected by the lower part of the polarized droplet when flying through an albeit weakly but still ionized atmosphere. In the case when the lower part of the polarized drop is positively charged, it collects electrons on this part, and when the lower part is negatively charged, it collects positively charged ions. This explains the fact that the lower vessels of the dropper have different potentials.

Similar processes, as already mentioned, occur during the transfer of charges by raindrops. The polarization of these drops is such that their lower part is positively charged, and this is an additional factor in the collection of such a drop of electrons. Therefore, the processes of charge transfer by raindrops are similar to the processes in Kelvin's dropper. Significant drawback of the Kelvin dropper as a high-voltage generator is that such a generator cannot operate continuously, since the discharge of water from the lower tank during continuous operation of the generator has not yet been resolved. Such a generator so far can only work in cyclic mode, when after the discharge of water from the lower tanks, the next start of the generator occurs.

## IV. Conclusion

The physics of Kelvin's dropper is still not completely understood, since it is unclear how neutral drops of water, even when polarized, can acquire a unitary charge. The article made the assumption that the process of acquiring a charge by droplets in a Kelvin dropper is due to the fact that the surrounding atmosphere is ionized due to the existing radiation background.

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Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 7 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

# Mechanism of Film Boiling Elimination when Intensively Quenching Steel Parts in Water Polymer Solutions of Low Concentration

By Nikolai I. Kobasko
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*Abstract-* The paper considers a mechanism of the elimination of the film boiling process during intensive quenching (IQ) of steel parts in water polymer solutions of low concentration. The use of the IQ process results in improvement of material mechanical properties and steel part performance characteristics. Evaluation of ways of eliminating of the film boiling process using a modern physics point of view allows significant improvement of the IQ equipment making it less costly and more efficient. All of this cardinally simplifies the implementation of the IQ technology in heat treat practice. The paper shows how creation of a thin insulating surface layer during quenching of steel parts in low concentration of inverse solubility polymers results in eliminating of film boiling processes that makes the quench process intensive. Historically in heat treating industry, an effective heat transfer coefficient was widely used for evaluating of the nucleate boiling process. And quenching during the nucleate boiling mode of heat transfer was considered as slow cooling.

*Keywords: IQ process; mass production; new approach; insulating layer; film boiling elimination; service life; low cost.*

*GJSFR-A Classification: FOR Code: 020304*


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# Mechanism of Film Boiling Elimination when Intensively Quenching Steel Parts in Water Polymer Solutions of Low Concentration

Nikolai I. Kobasko

*Abstract-* The paper considers a mechanism of the elimination of the film boiling process during intensive quenching (IQ) of steel parts in water polymer solutions of low concentration. The use of the IQ process results in improvement of material mechanical properties and steel part performance characteristics. Evaluation of ways of eliminating of the film boiling process using a modern physics point of view allows significant improvement of the IQ equipment making it less costly and more efficient. All of this cardinally simplifies the implementation of the IQ technology in heat treat practice. The paper shows how creation of a thin insulating surface layer during quenching of steel parts in low concentration of inverse solubility polymers results in eliminating of film boiling processes that makes the quench process intensive. Historically in heat treating industry, an effective heat transfer coefficient was widely used for evaluating of the nucleate boiling process. And quenching during the nucleate boiling mode of heat transfer was considered as slow cooling. That is why powerful quenching systems were recommended for performing IQ processes. It is shown that the absence of the film boiling process makes quenching intensive. Quenching parts made of optimal hardenability steel under such condition results in the development of high surface compressive residual stresses and in material super-strengthening that, in turn, increases a quality and service life of steel parts. The paper can be useful for engineers, scientists and college students.

*Keywords: IQ process; mass production; new approach; insulating layer; film boiling elimination; service life; low cost.*

## I. Introduction

Conventional quenching of steel parts and tools in heat treating industry is performed in oils, water polymer solutions of high concentration and water. As a rule, parts made of alloy steels are quenched in oils or water polymer solutions of high concentration while parts made of plain carbon steels are quenched in water. To control quenching process, cooling curves and cooling rate curves are widely used in practice. In contrast to conventional quenching methods, intensive quenching (IQ) processes are conducted in plain water or water polymer solutions of low concentration and are applicable to all types of steel. Implementing of the IQ methods requires interruption of the cooling process at a proper time based on consideration of the quench process physics. As known [1], five possible scenarios of the heat transfer process are considered during quenching parts in liquid media:

a) Full film boiling and nucleate boiling processes are present at the same time on the part surface. The area of nucleate boiling moves up along the part surface replacing film boiling. A wetting process of a cylindrical Cr-Ni steel sample of Ø15mm by 45mm long quenched in still water of 60°C is discussed in the book [1].

b) A film boiling process takes place throughout the entire part surface area at the beginning of the quench. At a certain point in time, a nucleate boiling process followed by a convection mode of heat transfer replaces film boiling (this is a well known classical consideration [1, 2]).

c) Some local areas of the part surface are covered by the vapor blanket, while at the same time, other areas experience nucleate boiling. These local areas do not move and their presence is one of the major reasons for significant distortion of steel parts during quenching in liquid media[1,3].

d) The boiling process takes place on some local areas of the part surface. Film boiling and nucleate boiling processes appear periodically in these areas, replacing each other (see Fig. 2) [1, 4].

e) The film boiling process is completely absent from the very beginning of quenching and only a transient nucleate boiling process followed by convection take place [5].

When the IQ process is designed correctly, the film boiling process is completely absent during quenching. For developing quenching processes in liquid media, engineers used to use a parabolic heat conductivity equation considering the following three classical modes of heat transfer: film boiling, nucleate boiling and convection. Later modified law of Fourier was taken into account and a hyperbolic heat conductivity equation was used for calculating an initial heat flux density which, in this case, is a final value and, in many cases, is below the critical value $q_{cr1}$ [6]. It means that any film boiling is completely absent. In this

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paper, it is shown that the absence of the film boiling results in establishing of the intensive quenching process. The use of the IQ processes for steel parts has been explored extensively during the last several decades by IQ Technologies, Inc. of Cleveland, Ohio (established in 1999) and Intensive Technologies Ltd. of Kyiv, Ukraine (founded in 2000) [7, 8].

This paper discusses the physics of accelerated cooling in water polymer solutions of low concentration when thin insulating surface layer is formed during quenching of steel.

## II. Intense Quenching when Film Boiling is Completely Absent

As known, the real heat transfer coefficient (HTC) during a transient nucleate boiling process is calculated as a ratio of the heat flux density produced by bubbles to the overheat of the boundary layer [3, 5], *i.e.*

$$\alpha_{nb} = \frac{q}{T_{sf} - T_s}. \qquad (1)$$

In heat treating industry, historically, the HTC during transient a nucleate boiling process is calculated as:

$$\alpha_{ef} = \frac{q}{T_{sf} - T_m},\ T_m << T_s. \qquad (2)$$

Here $\alpha_{nb}$ is a real HTC during the transient nucleate boiling process; $\alpha_{ef}$ is an effective HTC; q is a heat flux density; $T_{sf}$ is a part surface temperature; $T_s$ is a quenchant saturation temperature; $T_m$ is a bath temperature.

The effective HTC cannot be used for calculating of the temperature gradient throughout the part thickness during transient nucleate boiling process. Fig. 1 presents a qualitatively difference between temperature gradients calculated using the real and affective HTC ($TG_{effc}$ and $TG_{real}$ accordingly). As seen, the temperature gradient calculated using the real HTC is much greater compared to that calculated using the effective HTC. Note that the part surface temperature is below the martensite start temperature $M_S$ when using the real HTC.

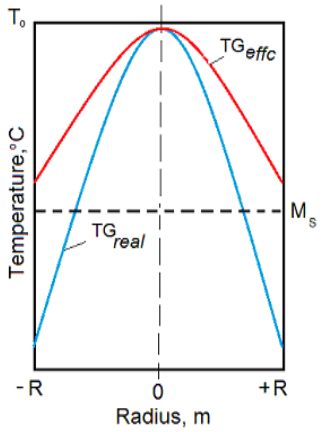


*Fig. 1:* Temperature gradients calculated using real and effective HTC.

As seen from Table 1 and Fig. 2, values of the real HTCs are very large as compared with that of the effective HTC [3, 9].

*Table 1:* Real HTCs in W/m²K during nucleate boiling process depending on the temperature of water solution when heat flux density is 15 MW/m² [9].

| Temperature of water solution | Tolubinsky | Shekriladze | Average |
|---|---|---|---|
| 10 | 152248 | 176546 | 164397 |
| 20 | 193929 | 243641 | 218785 |
| 40 | 224989 | 241615 | 233302 |
| 60 | 271273 | 271323 | 271298 |

The real HTCs were calculated using well known dimensionless equations of authors [10 - 12] who considered HTC as a ratio of heat flux to overheat $T_{sf} - T_s$ (see Eq. (1).

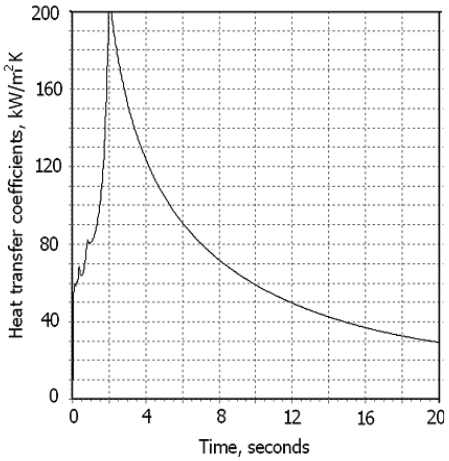


*Fig. 2:* Shock and nucleate boiling heat transfer coefficients versus time for a sphere of Ø38.1mm quenched from 875°C in a 5 % aqueous NaOH solution at 20°C [3].

As one can see from Table 1 and Fig. 2, nucleate boiling is an intensively forced process which lasts for a relatively long time (see Table 2).

*Table 2:* Conventional $Bi$ and generalized $Bi_V$ Biot numbers vs time during quenching spherical probe Ø 38.1mm from 875°C in a 5 % aqueous NaOH solution at 20°C.

| Time, s | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
|---|---|---|---|---|---|---|---|---|---|
| $HTC$, $kW/m^2K$ | 200 | 120 | 90 | 70 | 60 | 50 | 43 | 37 | 33 |
| $Bi$ | 405 | 240 | 180 | 140 | 120 | 100 | 86 | 74 | 66 |
| $Bi_V$ | 123 | 73 | 55 | 43 | 36 | 30 | 26 | 22 | 20 |

Using Eq. (3), it is possible to see what temperature gradients appear during quenching versus time (see Table 3).

$$\psi = \frac{\overline{T}_{sf} - T_s}{\overline{T}_V - T_s} = \frac{1}{\left(Bi_V{}^2 + 1.437 Bi_V + 1\right)^{0.5}} \tag{3}$$

*Table 3:* Smoothness criterion $\psi$ and generalized Biot number $Bi_V$ vs time during quenching spherical probe Ø 38.1mm from 875°C in a 5 % aqueous NaOH solution at 20°C

| Time, s | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
|---|---|---|---|---|---|---|---|---|---|
| $Bi_V$ | 123 | 73 | 55 | 43 | 36 | 30 | 26 | 22 | 20 |
| $\psi$ | 0.008 | 0.013 | 0.018 | 0.020 | 0.027 | 0.033 | 0.037 | 0.044 | 0.048 |

The following conclusion can be made. If any film boiling during quenching in liquid media (water and water solutions) is completely absent, the cooling process is very intensive and uniform in the interval of temperatures $T_o$ and $T_s$ without powerful agitation of the liquid (see Fig. 2 and Table 3).

A value of the HTC during nucleate boiling is evaluated as a ratio (1) because the nucleation depends on $\Delta T = T_{sf} - T_S$ and doesn't visibly depends on the bath temperature in the quench tank (see Eq. (4)) [10].

$$R_{cr} = \frac{2\sigma T_S}{r^* \rho'' \Delta T} \tag{4}$$

$$\Delta T = T_{sf} - T_S$$

According to Tolubinsky [10], during an established nucleate boiling process, the heat flux density is proportional to the cube of the wall overheating (Eq. (5)) while the HTC is proportional to the squared overheat $\Delta T = T_{sf} - T_S$ (see Eq. (6)).

$$q \propto (\Delta T)^3 \tag{5}$$

$$\alpha_{nb} \propto (\Delta T)^2 \tag{6}$$

Due to this fact, after the probe immersion into cold liquid, its surface temperature drops immediately

close to the saturation temperature $T_S$ of the liquid (see Eq. (7)) and maintains at this level for a relatively long time [3].

$$T_{sf} \approx T_S + \Delta\bar{\xi} \approx Const \qquad (7)$$

Duration of the transient nucleate boiling process $\tau_{nb}$ is proportional to the squared thickness D of the probe, inversely proportional to the material thermal diffusivity and depends on the probe shape $k_F$ and liquid physical characteristics (included into $\bar{\Omega}$) if the initial temperature $T_o$ and the bath temperature $T_m$ are fixed (see Eq. (8)) [14]:

$$\tau_{nb} = \bar{\Omega} k_F \frac{D^2}{a} \qquad (8)$$

During this period of time, the cooling process is very intensive even in the still cold water or water solution if any film boiling is completely absent. When a pure nucleate boiling process is realized, there is no need in the use of powerful pumps or powerful motors with propellers for providing heat transfer conditions required by the IQ process. According to Kutateladze [12], a liquid agitation process affects insignificantly the HTC during nucleate boiling. In many cases, powerful pumps and propellers are used for destroying of film boiling processes, especially during batch quenching where film boiling appears inside the load.

Often, investigators use effective HTC (see Eq. (2)) which is almost ten times lesser as compared with the real HTC. In this case, the part cooling rate during the nucleate boiling mode of heat transfer appears to slow. Even in the scientific literature, a method for testing quenchants was developed where effective HTC was used to check condition $Bi \leq 0.2$. As a result, incorrectness appears in many practical situations. This problem was widely discussed in Ref [9].

In Ref. [15] effective HTC was calculated using silver spherical probe 20 mm in diameter (see Fig. 3).

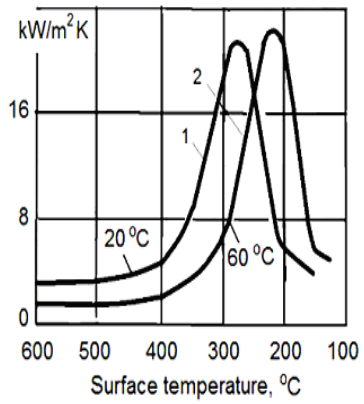


*Fig. 3:* Effective heat transfer coefficients versus surface temperature of silver spherical probe 20 mm in diameter during quenching in water at different temperatures: first curve 1 is true for water at 20°C; the second curve 2 is true for water at 60°C [15]

Fig. 4 shows incorrect surface temperature calculation in cylindrical probe when using HTC from Fig. 3.

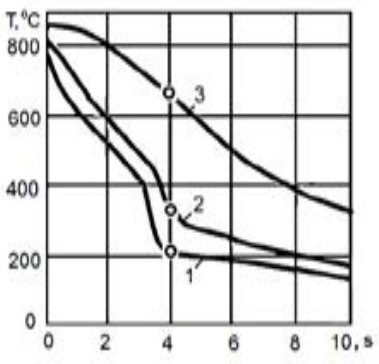


*Fig. 4:* Calculated temperature cooling curves for 20 mm cylindrical probe made of AISI 304 steel versus time when HTC was taken from Fig. 1 [16]: 1 is surface temperature; 2 is average volumer temperature; 3 is temperature at the center of cylindrical probe; o is transition time from film to nucleate boiling process.

It looks like saturation temperature of water is 200°C instead of 100°C that creates 100% error (see Fig. 4). Moreover, duration of film boiling is too long. In fact, surface temperature of probe during quenching in cold water and water solutions drops immediately close to 100°C as shown in Table 4.

## III. Consequences Linked with Consideration of Effective HTCs

According to French [13], the time for establishing of the self-regulating thermal process (SRTP) is almost the same for different sizes and forms of steel components (see Table 4) and its duration is 1 – 2 seconds if any film boiling is completely absent. This phenomenon can be explained by an extremely fast cooling during the immersion of hot steel parts into cold liquid. At the very beginning of intense cooling, independently on form and size of the part the part surface is considered as a semi – infinite because only a very thin surface layer of the material is firstly activated. Further, when a transient nucleate boiling process is established, the cooling time depends on the form and dimensions of steel parts.

*Table 4:* Time required for the surface of steel spheres of different sizes to cool to different temperatures when quenched from 875 °C in 5 % water solution of NaOH at 20 °C agitated with 0.914 m/s (French, 1930) [13].

| Size, Inches, (mm) | Time, sec | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 700°C | 600°C | 500°C | 400°C | 300°C | 250°C | 200°C | 150°C |
| 0.25" (6.35 ) | 0.027 | 0.037 | 0.043 | 0.051 | 0.09 | 0.15 | 0.29 | 0.69 |
| 0.5" (12.7) | 0.028 | 0.042 | 0.058 | 0.071 | 0.11 | 0.15 | 0.26 | 0.60 |
| 4.75" (120.6) | 0.043 | 0.066 | 0.09 | 0.12 | 0.17 | 0.21 | 0.29 | 0.95 |
| 7.15" (181.6) | 0.040 | 0.070 | 0.100 | 0.140 | 0.240 | 0.310 | 0.42 | 1.15 |
| 11.25" (285.8) | 0.043 | 0.120 | 0.190 | 0.330 | 0.570 | 0.960 | 1.26 | 2.18 |

Since $\alpha_{ef} << \alpha_{real}$, incorrect temperature gradient appears during computer calculation as is shown on Fig. 1 above. Such incorrectness can generate other problems which are listed below:

- Large errors when calculating temperature gradients under condition of $Bi = \frac{\alpha_{ef}}{\lambda} R \le 0.2$.
- Incorrect calculation of the quenchant agitation rate in IQ tanks required for implementing of the IQ process.
- Some error appears when calculating of residual stresses when using effective HTCs.
- Delaying of the implementation of the IQ technology due to the high cost and complexity of IQ equipment.

It follows from the above considerations that the transient nucleate boiling process taking place during quenching of steel parts in water and water solutions provides uniform and intensive cooling if any film boiling is completely absent. In heat treating practice, powerful pumps and propellers are usually used for eliminating an undesirable film boiling process. More effective and less costly ways for eliminating the film boiling process are discussed in the paper [17].

## IV. Elimination of Any Film Boiling Process by Creation of a Thin Polymeric Surface Layer

A possibility of providing of the intensive quenching process during hardening of steel parts in 1% water PAG polymer solution was discussed in Ref. [18]. For the first time, a mechanism of the elimination of the film boiling process during quenching of a cylindrical probe in a low concentration of water polymer solution was explained by the creation of a thin insulating surface layer in Ref. [9]. Further this idea was supported by results of many experiments including quenching of standard probes in mineral oils [19, 20]. An absence of any film boiling process during quenching of probes in low concentration of water polymer solutions is explained by the decrease of the initial heat flux density $q_o$ which is calculated by Eq. (9) [9]:

$$q_{in} = \frac{q_o}{\left(1 + 2\frac{\delta}{R}\frac{\lambda}{\lambda_{coat}}\right)} \quad (9)$$

$$\Delta l = \left(1 + 2\frac{\delta}{R}\frac{\lambda}{\lambda_{coat}}\right) \quad (9a)$$

Where $\lambda_{coat} = 0.2W/mK$ and $\lambda_{sl} = 20W/mK$ then $\frac{\lambda_{sl}}{\lambda_{coat}} = 100$. When thickness of insulating layer is 100 $\mu m$

and 2R = 0.020 m then $\frac{\delta}{R}=\frac{100\times10^{-6}m}{10\times10^{-3}m}=0.01$. In this case $\Delta l=\left(1+2\times0.01\times100\right)=3$. It means that the initial heat flux density during quenching of a given sample can be reduced by 3 times that eliminates completely any film boiling process since $q_{in}<q_{cr1}$. More data on the value of $\Delta l$ are provided in Table 5.

*Table 5:* Possible values $\Delta l$ during quenching in low concentration of water PAG polymer solutions

| No. | $\frac{\delta}{R}$ | $\frac{\lambda_{sl}}{\lambda_{coat}}$ | $\Delta l$ |
|---|---|---|---|
| 1 | 0.001 | 100 | 1.2 |
| 2 | 0.005 | 100 | 2 |
| 3 | 0.01 | 100 | 3 |
| 4 | 0.001 | 200 | 1.4 |
| 5 | 0.005 | 200 | 3 |
| 6 | 0.01 | 200 | 5 |

Poly Alkylene Glycol(PAG) polymers of the optimal concentrations provide an ideal uniform cooling for minimizing distortion and preventing the crack formation during hardening of machine components and tools due to their inverse solubility that is a reason for the polymeric surface layer formation [9, 21]. More information on the use of water PAG solutions as a quenchant is provided in book [22].

Now, let's consider initial heat flux densities during conventional quenching. For this purpose, a set of accurate experimental data of French from Table 4 were used for solving inverse problem with the first type of boundary condition. Results of heat flux densities calculations are shown in Fig. 5 a) and Fig. 5 b). Maximal heat flux densities on graphs are considered as initial heat flux densities. They are 17.7 MW/m$^2$ and 14.7 W/m$^2$ for spherical probes of Ø12.7mm and Ø120.6mm accordingly. According to Table 5, initial heat flux densities can be reduced by three times by creating a surface insulating layer. The initial heat flux densities became 5.9 MW/m$^2$ and 4.9 MW/m$^2$ accordingly For still water without any agitation at 20°C, the first critical heat flux density is 5.9 MW/m$^2$ [10]. For a slow cooling process, the following ratio is true :

$$\frac{q_{cr2}}{q_{cr1}}=0.2$$

According to Tolubinsky [10], this ratio for the extremely fast cooling is the following:

$$\frac{q_{cr2}}{q_{cr1}}=0.05 \qquad (10)$$

It means that the critical heat flux density $q_{cr1}$ during fast cooling can be four times greater. Moreover, a slow agitation of water or even an insignificant resonance effect generated by a hydrodynamic emitter can increase essentially the first critical heat flux density $q_{cr1}$.

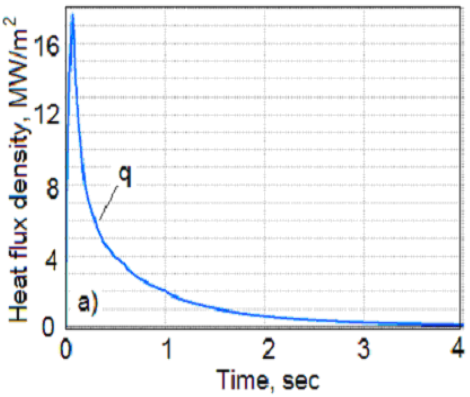


*Fig. 5 a*

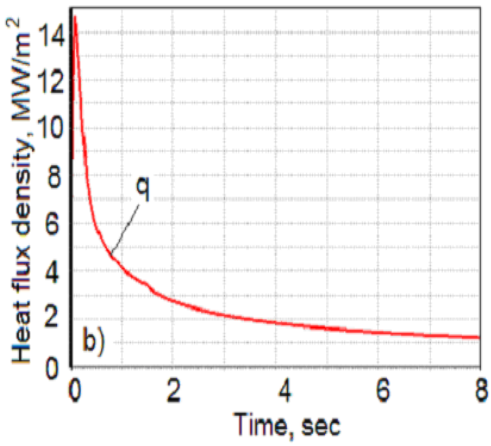


*Fig. 5 b*

*Fig. 5:* Heat flux density versus time when quenching spherical steel samples in 5 % water NaOH solution at 20°C agitated with 0.914 m/s: *a* – 12.7 mm in diameter; *b* – 120.6 mm in diameter.

Thus, combining all together, it is possible to design an intensive and uniform cooling process in water PAG solutions of low concentration. More information one can get from Refs [23, 24].

Similar calculations were performed for mineral oils with and without a polymer addition. As seen from Fig. 6, the addition of polyisobutylene (PIB) to mineral oil decreases or completely eliminates a full film boiling process [20].

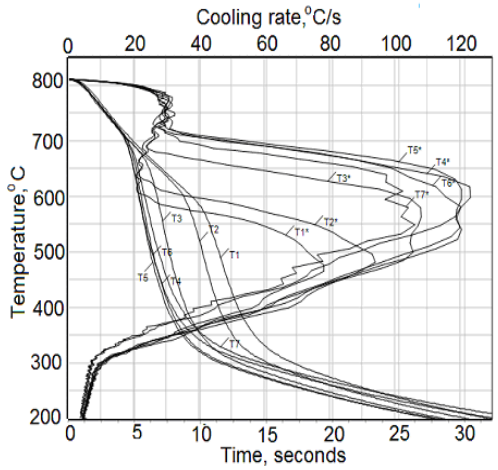


*Fig. 6:* Temperature T and cooling rate $T^*$ versus time at the core of Inconel 600 probe during quenching in solution of PIB-2400 in oil I-8A at 50°oC, % wt: 1 – 0; 2 – 0.5; 3 – 1.0; 4 – 2.0; 5 – 3.5; 6 – 10; 7 – 14

For more information see Refs [19, 20].

## V. Intensively Quenched Optimal Hardenability Steel

*a) The bell – shaped curve*

A bell – shaped curve was discovered by authors [25 - 27] in 1964 (see Fig. 7). It says that distortion and quench crack formation of steel parts is minimal when performing slow cooling or extremely high cooling of steel parts during hardening.

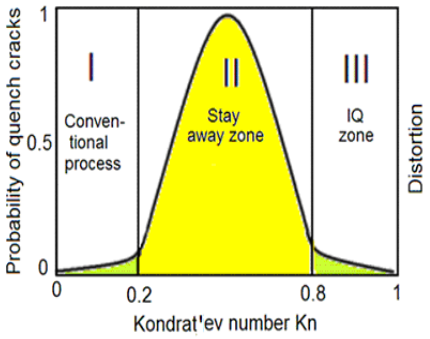


*Fig. 7:* Probability of quench crack formation and distortion versus Kondrat'ev number Kn.

As known, a cooling rate of any steel part is a linear function of the dimensionless number Kn which changes within the range of 0 and 1 [3, 28].

There is a linear correlation between Kondrat'ev number Kn and the core cooling rate of steel parts during quenching (see Eq. (11) and Eq. (12)) [3, 28]:

$$v = \frac{aKn}{K}\left(T - T_m\right) \tag{11}$$

$$v = \frac{aKn\left(T - T_m\right)}{K\left(1 + 2\frac{\delta}{R}\frac{\lambda_l}{\lambda_{coat}}\right)} \tag{12}$$

When the surface of steel parts is covered by an insulating layer having the thickness $\delta$, the part core cooling rate slightly decreases (see Eq. (12)).

As a rule, alloy and high alloy steels are quenched slowly in oils or in the air flow for obtaining minimal distortion and for avoiding the crack formation [22]. However, slow cooling in zone I ($0 < Kn < 0.2$) (see Fig. 7) requires more alloy elements in steel for providing a required hardened layer [3]. Absence of the quench crack formation in zone I is explained by an insignificant temperature gradient throughout the part cross section that results in neutral or low surface tensile stresses. In zone III, distortion is minimal, high surface compressive stresses are formed during intensive quenching preventing the quench crack formation (see Fig. 8) [29].

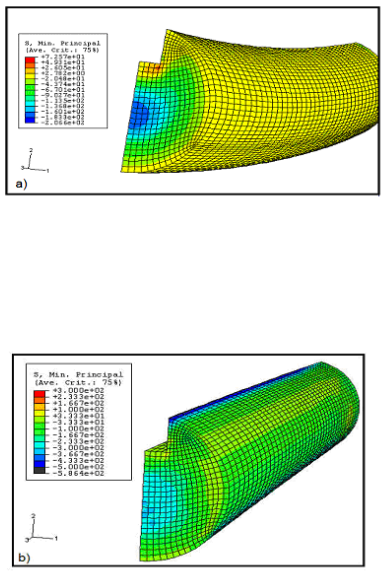


*Fig. 8:* Minimum principal residual stresses in keyway shaft after quenching in oil (a) and after IQ process (b) according to author [29].

As seen from Fig. 8, the IQ process generates high surface compressive residual stresses and minimal distortion, while quenching in oil results in visible distortion and tensile surface residual stresses in keyway shaft [29]. Also, additional strengthening (superstrengthening) of material is observed in condition of intensive quenching that all together increases significantly service life of hardened machine components and tools [3, 30 - 32].

*b) Compressive surface residual stresses and super-strengthened material*

It was discovered in 1983 [33, 34] that there is an optimal depth of the hardened layer which provides a formation of high surface compressive current and residual stresses in quenched specimens after intensive cooling. In 2013 [35, 36], a following correlation between steel chemical composition, part size and shape and optimal hardened layer was obtained based on numerous calculations and results of experiments:

$$\frac{DI \cdot Kn^{0.5}}{D_{opt}} = 0.35 \pm 0.095 \qquad (13)$$

Here DI is a part critical diameter in m which depends on chemical composition of steel and is calculated using well known Grossmann's equation [37]; $D_{opt}$ is thickness of steel part. More information is available in Ukrainian patent [35]. A procedure for using the above correlation is as follows:

- A steel grade with certain chemical composition is chosen.
- The ideal critical size for this steel is determined.
- The ratio $DI/D_{opt}$ for specific steel part is evaluated and alloy elements are reduced two or three times to satisfy ratio (13) which must be in a range of 0.2 – 0.5.
- The part is quenched under a condition of $0.8 \le Kn \le 1$.
- Intensive quenching is interrupted to provide self – tempering.
- The part is tempered at the temperature of Ms or higher.

If ratio (13) is satisfied, a residual hoop stress distribution in the steel component is optimal which is shown in Fig. 9. More information related to optimal hardenability steel is available in book [36] issued by Lambert Academic Publishing in 2018.

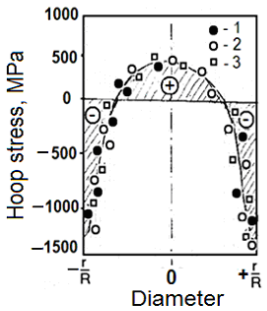


*Fig. 9:* Residual stress distribution in cylindrical specimens when quenching intensively in water flow in condition 0.8 < Kn < 1 [36].

The patented technology allows decrease a content of the alloy elements in steel, increase a service life of machine components and tools, make the environment cleaner and significantly reduce a cost of the technological process.

Optimal hardenability (OH) steel differs from low hardenability (LH) steel [38 – 41] by its application to any size and form of steel parts and it can be an already existing conventional grade if correlation (13) is satisfied by the existing chemical composition of steel. Some differences between LH, OH, and high alloy steel are shown schematically in Fig 10.

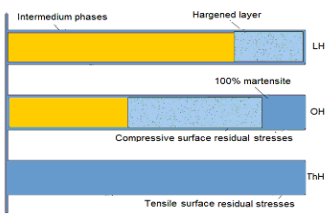


*Fig. 10:* Optimal depth of hardened layer corresponding to the maximum surface compressive residual stresses: LH, low hardenability steel; OH, optimal hardenability; ThH, through hardening [36].

Fig. 11 explains a mechanism of the superstrengthening phenomenon taking place in the part surface hardened layer [3]. The plates of martensite deform the supercooled austenite that is between them, creating a high density of dislocations that are responsible for a high strength of material.

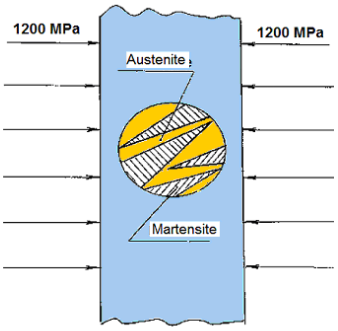


*Fig. 11:* The transformation scheme of austenite into martensite in the compressed layer, illustrating the effect of additional strengthening (super-strengthening) of the material [36].

More information regarding additional strengthening of steel is available in Refs. [30, 36].

*c) Cooling time interruption during IQ process*

The IQ process implemented in low concentration of water polymer solutions should be interrupted at a proper time for the following three main reasons:

1. To provide immediate self – tempering of the part quenched layer.
2. To achieve a fine or nano – bainitic microstructure at the core of steel parts.
3. To prevent dissolving of the surface polymeric layer that can result in a big distortion and crack formation during quenching.

The first two reasons were widely discussed in Refs [3, 26]. The last reason is new one and relates to dissolving of the polymeric layer at the bottom of the load being quenched (see Fig. 12).

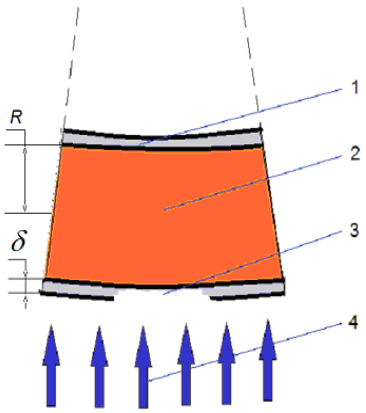


*Fig. 12:* Schematic explaining why a big distortion takes place during quenching in water PAG polymers solutions: 1 – polymer coating; 2 – quenched steel part; 3 – locally dissolved by water flow polymer coating; 4 – water flow [42].

In area 3 in Fig. 12, a non – uniform cooling process takes place that results in big distortion and can be a reason for the quench crack formation. That is why the cooling process should be interrupted before the insulated surface temperature reaches 72°C where dissolving of the polymeric layer starts [42]. The cooling time interruption can be calculated approximately using generalized equation (14), Table 6 and Fig. 13 [26]:

$$\tau = \left[ \frac{kBi_V}{2.095 + 3.87Bi_V} + \ln \frac{T_o - T_m}{T - T_n} \right] \frac{K}{aKn} \qquad (14)$$

*Table 6:* Kondrat'ev coefficients K depending on different shapes and sizes of solid bodies [16]

| Shape | Kondrat'ev coefficient K, m² |
|---|---|
| Slab of thickness L | $\frac{L^2}{\pi^2}$ |
| Infinite cylinder of radius R | $\frac{R^2}{5.784}$ |
| Infinite square bar with sides of L | $\frac{L^2}{2\pi^2}$ |
| Cylinder of radius R and height Z | $\frac{1}{\frac{5.784}{R^2}+\frac{\pi^2}{Z^2}}$ |
| Plate with sides $L_1$, $L_2$, $L_3$ | $\frac{1}{\pi^2\left(\frac{1}{L_1^2}+\frac{1}{L_2^2}+\frac{1}{L_3^2}\right)}$ |
| Sphere | $\frac{R^2}{\pi^2}$ |

*Note: R is radius, L is thickness, Z is height.*

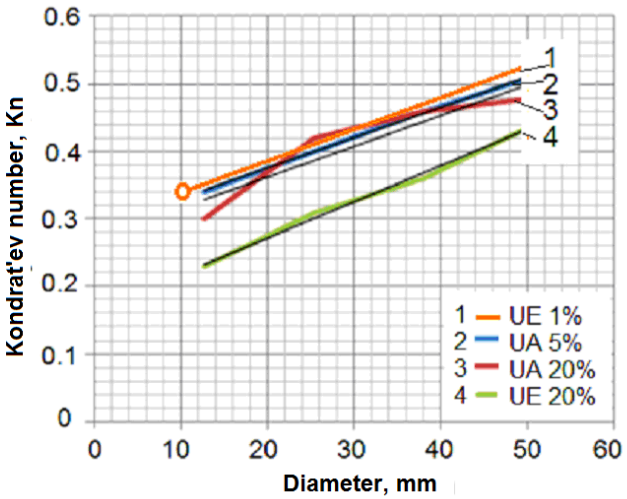


*Fig. 13:* Effective Kondrat'ev numbers Kn for inverse solubility water solutions of polymers depending on their concentrations and size of product: 1 is 1 % of UCON E in water; 2 is 5 % of UCON A in water; 3 is 20 % of UCON A in water; 4 is 20 % of UCON E in water at 20°C [43].

Fig. 13 provides effective Kondrat'ev numbers Kn used for calculating of the cooling time. However, obtained data are true only for calculating of the part core and cannot be used for evaluating of the part temperature field as discussed above [9].

## VI. Benefits and Equipment for Performing of IQ Processes

Benefits of IQ processes and equipment for their implementation are widely discussed in published books [3, 44, 45]. A possibility of combining of the IQ process (that makes a difference in the surface hardened layer) with a possibility of achieving a fine bainitic microstructure at the core of intensively quenched steel parts is underlined below. After interrupting of the IQ process, there is enough room at the core of steel parts to maximize strength and plastic properties of bainite [46]. The first trial was conducted in 1989 that showed amazing results presented in Table 7 [47].

*Table 7:* Mechanical properties at the core of cylindrical probes of Ø50mm made of different steels and quenched in oil and water salt solutions [47]

| Steel grade | Quenchant | $R_m$ (MPa) | $R_{p0.2}$ (MPa) | A (%) | Z (%) | $a_k$ (J/cm$^2$) | HB |
|---|---|---|---|---|---|---|---|
| AISI 4135 (35KhM) | Oil | 950 | 775 | 14 | 53 | 54 | 285 |
| | Water salt solution | 970 | 820 | 17 | 63 | 150 | 285 |
| AISI 4140 (40Kh) | Oil | 770 | 575 | 23 | 64 | 13.8 | 217 |
| | Water salt solution | 860 | 695 | 16.5 | 65 | 168 | 269 |

As known, equipment for performing of IQ processes was firstly designed and manufactured in Former Soviet Union (FSU) for quenching of truck semi – axles in water flow moving with a speed of w > 12 m/s [26, 40, 48]. Further accurate investigations dealing with cooling steel samples in a high speed water flow was made in the USA and Germany [3, 49 – 52]. Also, for performing IQ processes, conventional continuous technological lines were used filled with the water salt solutions of optimal concentration to maximize critical heat flux densities in order to eliminate completely any film boiling process [26]. Quenching in such condition provided a uniform and intensive cooling of steel parts, such as bearing rings, rollers, *etc.* [3, 26]. As mentioned above, two companies were established later in 1999 (IQT) and in 2000 (ITL) dealing with IQ processes with the aim to start implementation of the IQ processes in the heat treating industry for a mass production of steel parts in America, Europe and Asia [3, 7, 8]. In the USA, two types of IQ equipment were designed and manufactured: for batch quenching (an IQ – 2 process) and for single part quencjing (an IQ – 3 process) [3]. In a production IQ – 2 model of a 91 by 91 by 182- cm (36 by 36 by 72-in.) A first integral quench atmosphere 91x91x182cm (36x36x72") furnace equipped with an IQ water quench tank of 41.6 m3 (11,000 gallons) was manufactured by AFC-Holcroft Co. of Wixom, Michigan, USA and was installed at the Euclid Heat Treating Co. (EHT) of Cleveland, Ohio, USA. The furnace is equipped with an intermediate chamber connecting the heating chamber with the IQ tank. One of single-part processing high-velocity systems for implementing of the IQ – 3 process developed and built by IQt is also installed at EHT. The system includes a water tank, powerful pump, stationary upper section of the vertical quench chamber, movable lower loading table of the quench chamber, air cylinders, three-way valve, control valves, flow meters, *etc* [3, 45]. Unique experimental results obtained in both above IQ systems were widely discussed in the literature [3, 26, 45] showing a possibility of the part service life increase by up to 8 times. Despite the results obtained, until now the IQ processes are not in mass production in all continents of our Globe. The reason for restricted use of IQ technology in production is its rather high cost, complicated design, and lack of different kinds of software for controlling and governing of the new technology. This paper discusses how to solve this problem to make IQ processes as a mass production around our Globe. Fig. 14 illustrates one of such possibilities.

Table 8 shows a difference in the cooling temperature curves vs time at the core of cylindrical probes of Ø50mm made of stainless AISI 304 steel and quenched in 14% NaCl water solution at 23°C and in 1% of water polymer solution (PAG) [27]. A more useful information on quenching of steel in water polymer solutions one can find in published literature "[24, 27]. Table 8 supports an idea on the possibility performing intensive quenching in 1% water PAG polymer solution [18, 27].

*Table 8:* Comparison of temperature cooling curves vs time at the core of cylindrical probes of Ø50mm made of stainless AISI 304 steel and quenched in 14% NaCl water solution at 23°C and 1% of water polymer solution (PAG) [27]

| Time, sec | 0 | 10 | 20 | 30 | 40 | 50 | 60 |
|---|---|---|---|---|---|---|---|
| Core temperature during quenching in 14% NaCl water solution at 23°C | 800 | 780 | 650 | 505 | 380 | 250 | 212 |
| Core temperature during quenching in 1% of PAG at 23°C | 800 | 780 | 650 | 500 | 470 | 320 | 210 |

As follows from experiments conducted, intensity of cooling in water salt solution and in 1% of PAG at 23°C are similar (see Table 8) [27].

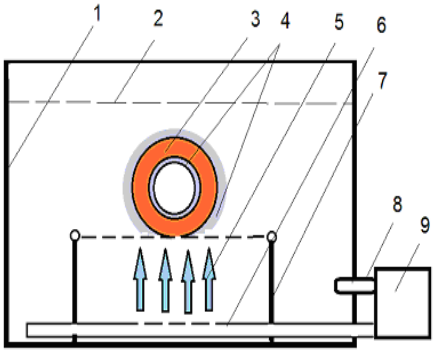


*Fig. 14:* Prinsipal scheme of performing IQ -2 process using of low concentration polymers: 1 is quench tank; 2 is level quenchant in a tank; 3 is steel parft (large gear or large bearing ring); 4 is surface polymeric layer; 5 is liquid stream; 6 is perforated tube or hydrodynamic emitters; 7 is holder; 8 is outlet tube; 9 is pump

If so, no costly intensive and uniform cooling of steel parts can be easily performed by designing and manufacturing a simple quench tank filled with a low concentration of PAG water polymer solution that is shown on Fig. 14. It differs insignificantly from existing conventional tanks used worldwide in the mass production. Quench tanks or continuous technological lines are equipped with hydrodynamic emitters which generate resonance waves with the frequency equal to frequency of vapor film oscillation. Simultaneously, emitters create agitation of a liquid that increases the first critical heat flux density $q_{cr1}$. Listed measures (a thin insulating surface layer formed during quenching in water PAG solutions, resonance effect and slow agitation of the liquid guarantee an absence of any film boiling process that makes cooling intensive. A proposed new approach for designing of the IQ processes for mass production doesn't compete with already existing IQ systems. This is because, based on a current consideration of the transient nucleate boiling, batch quench systems designed for implementing of the IQ -2 process will be suitable for conducting of the IQ- 3 process too. IQ – 3 systems will be used for carburized steel parts where martensite start temperature Ms is below 100°C.

## VII. Discussion

In this short overview, the main early published results of investigations are discussed by author of the paper. A more detail information can be found in the published literature cited below. Based on a careful consideration of the given subject, one can conclude that the physics of the quench process during hardening of steel parts in liquid media is not investigated deep enough due to a very complicated problem that requires essential investment and time. As known, all handbooks consider three classical phases of the quench process that include film boiling, transient nucleate boiling and convection. It was firmly accepted by worldwide community that during quenching from high temperatures in liquid media the film boiling process always takes place which, as a rule, is a slow cooling. Such opinion is based on the conventional heat conductivity law of Fourier (15). During the immersion of probes heated to a high temperature into a cold liquid $\partial x \to 0$, and it means that $q \to \infty$. That is why, even among the thermal scientists an opinion that the film boiling must be present during quenching was accepted. However, at the beginning of the 20th century, very costly and painstaking experiments were performed in the USA by French who published his very accurate investigation in his book [13]. It was shown by French that during quenching of steel spheres of different sizes from 875 °C in 5 % water solution of NaOH at 20 °C agitated with 0.914 m/s any film boiling was completely absent (French, 1930) [13]. A long time, nobody paid any attention to these very costly and important experimental results since they contradicted the theory and investigators could see that the film boiling process was present during quenching.

$$q = -\lambda \frac{\partial T}{\partial x} \tag{15}$$

Scientists and engineers started to explore parabolic heat conductivity equation (16) which is based on the conventional law of Fourier (15) and must include certain boundary conditions related to film boiling, nucleate boiling and convection and initial condition to obtain a specific solution for the considered specific object.

$$c\rho \frac{\partial T}{\partial \tau} = \lambda div\left(gradT\right) \tag{16}$$

Later, the conventional law of Fourier (15) was modified and rewritten as shown by Eq. (17) to make an initial heat flux density the final value during cooling of solid objects in any thermo - dynamical closed system [6]

$$q = -\lambda \frac{\partial T}{\partial x} - \tau_r \frac{\partial q}{\partial \tau} \quad (17)$$

Here $\tau_r$ is relaxation time which is very small value. Eq. (17) generates hyperbolic Eq. (18) which can be used to solve the problem of calculating more accurately initial heat flux densities during quenching.

$$c\rho \frac{\partial T}{\partial \tau} + \frac{1}{w_r^{\,2}} \frac{\partial^2 T}{\partial \tau^2} = \lambda div(gradT) \quad (18)$$

Here $w_r = \sqrt{\frac{a}{\tau_r}}$ is a speed of thermal wave distribution in m/s [6]. The initial heat flux density $q_{in}$ in this case is always a finite value which can be $q_{in} < q_{cr1}$ that provides the absence of the film boiling process. It was shown by author [53] that the thermal diffusivity of steel $a$ and relaxation time $\tau_r$ can be measured experimentally by measuring a speed of the thermal wave distribution.

If the speed of thermal wave distribution is infinity $(w_r \to \infty)$, hyperbolic heat conductivity Eq. (18) become parabolic where the initial heat flux density is infinity and, as a result, the developed film boiling process during quenching from high temperatures in liquid media should be always present. To fix such incorrectness, a contemporary modern physics should consider hyperbolic heat conductivity Eq. (18) with the boundary and initial condition that correctly describe the transient nucleate boiling process that later passes to convection. In the last decade, mathematicians and physicists developed original methods for solving the hyperbolic heat conductivity equation with different kinds of the boundary condition which can be used as a tool for investigating of the IQ processes [54 - 58]. However, solutions are too complicated for engineers working in the heat treating industry. That is why an appropriate software should be designed to simplify developing recipes for IQ processes. Anyway, the most important result of our consideration is a theoretical explanation of the film boiling absence during quenching in liquid media when the initial heat flux density $q_{in}$ is below the first critical heat flux density $q_{cr1}$, *i.e.* $q_{in} < q_{cr1}$. In this case, the cooling process is very intensive from the very beginning of quenching and there is no need to use very powerful propellers and costly pumps to eliminate the undesirable film boiling mode during hardening of steel with the martensite start temperature $M_S > 100^oC$. As discussed above, the initial heat flux density $q_{in}$ can be significantly reduced by creating of the thin surface insulating layer that is automatically formed during quenching in water polymer solutions of low concentration. During a very fast cooling, the critical heat flux density $q_{cr1}$ increases and it means that the insulating layer can eliminate easily the film boiling process. However, another problem arises here . The point is that big companies, which manufacture polymers for quenching processes, are interested in custometers who use 10%, and 20% solutions not a 1% water polymer solution because of the decreased revenue. The problem can be compromised if manufactures and designers of the costly software for governing of quenching technological processes will work together to sell packages to heat treating industry that will increase the cost of polymers due to investments from big companies for physical investigations and software developments. The considered technology can reduce not only water polymer concentration, but also can cardinally reduce a content of the alloy elements in steel, make the IQ processes and equipment less costly, save materials, and make environment green. All of these are very important for the future generation to live safely on our Globe.

## VIII. Conclusions

1. The less costly IQ process can be designed using low concentration of water PAG polymer solution that creates a thin surface polymeric layer during cooling and reduces the initial heat flux density below its critical value $q_{cr1}$.
2. There is a belief that the IQ process can become as a mass production globally when it is introduced in the heat treating practice as a package that includes a low concentration water polymer solution, hydrodynamic emitters for slow quenchant agitation, appropriate software for controlling and governing of the technological process based on already available equipment or equipment to be simply designed and manufactured.
3. The proposed technology can be successfully combined with the patented optimal hardenability steel (if its martensite start temperature $M_S > T_s$) that results in formation of high surface compression residual stresses and provides superstrengthening of material in the part surface layer.
4. Achievements in the field of IQ processes and in the field of bainitic transformations can be put together via interrupting of the cooling process at a proper time.
5. To perform correctly the cooling time interruption, an effective dimensionless Kondrat'ev number Kn for inverse solubility polymers can be used which depends on the polymer solution concentration and thickness of quenched components and is true only for core cooling time calculation.

## Acknowledgements

The author would like to thank his colleagues from IQ Technologies Inc., Ohio, USA who have been pushing enthusiastically the IQ technology into practice since 1999 and colleagues from Ukrainian National Academy of Sciences who investigated and published several papers connected with the effect of polymer additives to mineral oils resulting in eliminating of the film boiling processes. Special thanks to Dr. Michael A. Aronov, CEO of IQ Technologies Inc, for discussion and editing of the paper.

*Nomenclature*

| | |
|---|---|
| $Bi$ | Biot number |
| $Bi_V$ | Generalized Biot number |
| $Kn$ | Kondrat'ev number |
| $\alpha_{nb}$ | Heat transfer coefficient (real) during nucleate boiling in W/m $^2$K |
| $\alpha_{ef}$ | Effective heat transfer coefficient (for restricted use) during nucleate boiling in W/m$^2$K |
| $\Delta$ | Overheat of a boundary layer |
| $\Delta\bar{\xi}$ | Average overheat of a boundary layer within the nucleate boiling process |
| $a$ | Thermal diffusivity of solid material in m $^2$/s |
| $\psi$ | Criterion as a characteristic for temperature gradient through section of sample |
| $c$ | Specific heat capacity |
| $\Omega$ | Parameter depending on convective Biot number, initial and bath temperature |
| $\lambda$ | Thermal conductivity of a solid material in W/mK |
| $\lambda_{coat}$ | Thermal conductivity of an insulating layer in W/mK |
| $\rho$ | Density of solid material in kg/m$^3$ |
| $\rho''$ | Vapor density in kg/m$^3$ |
| $R_{cr}$ | Critical radius of growing vapor bubble |
| $r^{\bullet}$ | Latent heat of evaporation in J/kg |
| $\nu$ | Cooling rate during quenching steel parts in liquid media |
| $\sigma$ | Surface tension in N/m |
| $D$ | Diameter or thickness in m |
| $w_r$ | Speed of thermal wave distribution |
| $R$ | Radius in m |
| $\tau$ | Time in seconds |
| $\tau_r$ | Relaxation time |
| $\delta$ | Thickness of insulating layer in m |
| $K$ | Kondrat'ev size factor in m$^2$ |
| $k_F$ | Form coefficient |
| $q$ | Heat flux density in W/m$^2$ |
| $q_{in}$ | Initial heat flux density W/m$^2$ |
| $q_{cr1}$ | First critical heat flux density in W/m$^2$ |
| $q_{cr2}$ | Second critical heat flux density in W/m$^2$ |
| $T_{sf}$ | Surface temperature in °C |
| $\bar{T}_{sf}$ | Average surface temperature in °C |
| $\bar{T}_V$ | Average volume temperature in °C |
| $R_m$ | Ultimate strength in MPa |
| $R_{p0.2}$ | Yield strength in MPa |
| $A(\%)$ | Elongation in % |
| $Z(\%)$ | Contraction in % |
| $a_k$ | Impact strength in J/cm$^2$ |

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Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 7 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

# How are Lightning Formed?

By F. F. Mende

*Abstract-* Lightning discharges are formed during the development of a thunderstorm cell. First of all, it should be said that thunderclouds consist of several thunderstorm cells closely adjacent to each other, the development of processes in which is identical, but shifted in time. By cell we mean a region with a certain extent in the horizontal direction, in which all the basic processes take place. It is the physical processes that occur in such cells that lead to the occurrence of lightning.

*Keywords: lightning, thunderstorm cell, charge, potential difference.*

*GJSFR-A Classification: FOR Code: 029999p*


*Strictly as per the compliance and regulations of:*

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*Keywords: lightning, thunderstorm cell, charge, potential difference.*

## I. Introduction

Lightning discharges are formed during the development of the so-called thunderstorm cell, the process of formation of which is described in sufficient detail in the monograph [1]. First of all, it should be said that thunderclouds consist of several thunderstorm cells closely adjacent to each other, the development of processes in which is identical, but shifted in time. A cell means a region that has a certain horizontal extent in which all the basic physical processes take place.

In Fig. 1 in an idealized form presents a thunderstorm cell at an early stage of development.

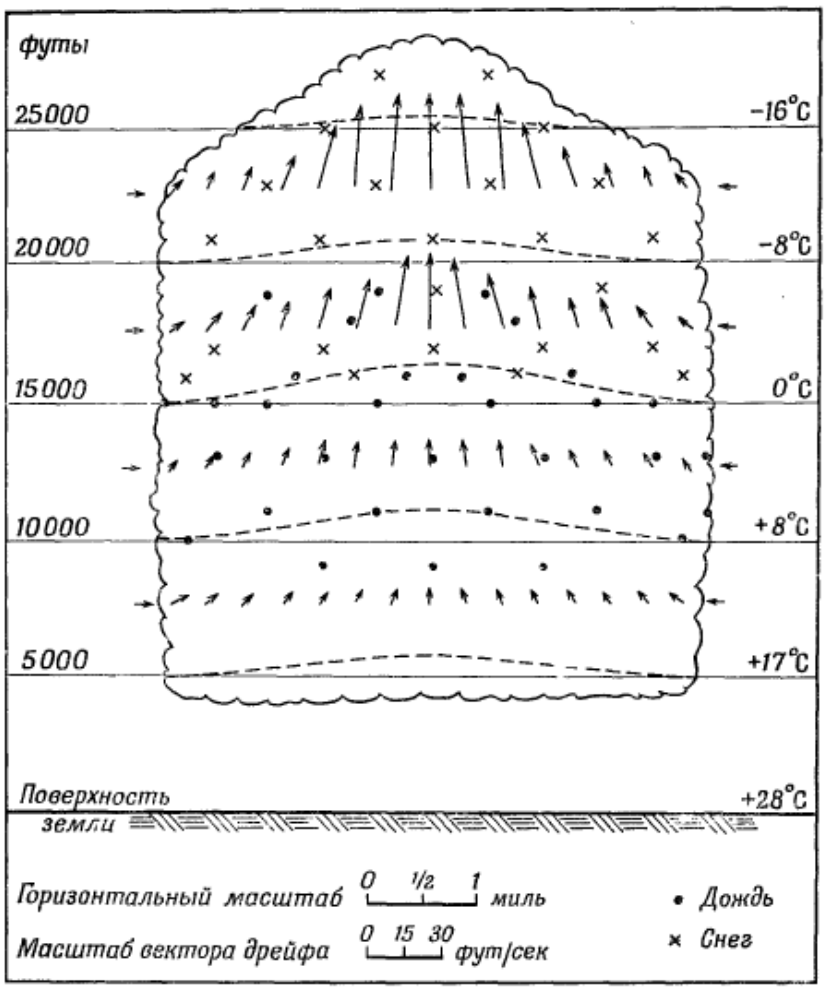


*Fig. 1:* Thunderstorm cell at an early stage of development

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

Streams of warm air rush up and cool down as they rise. If at the bottom of the cell, located at an altitude of 5,000 feet, the temperature is about +17 degrees Celsius, then already at an altitude of 25,000 feet it is -16 degrees, and in this area water vapor begins to turn into snow. Further development of the thunderstorm cell is shown in Fig. 2.

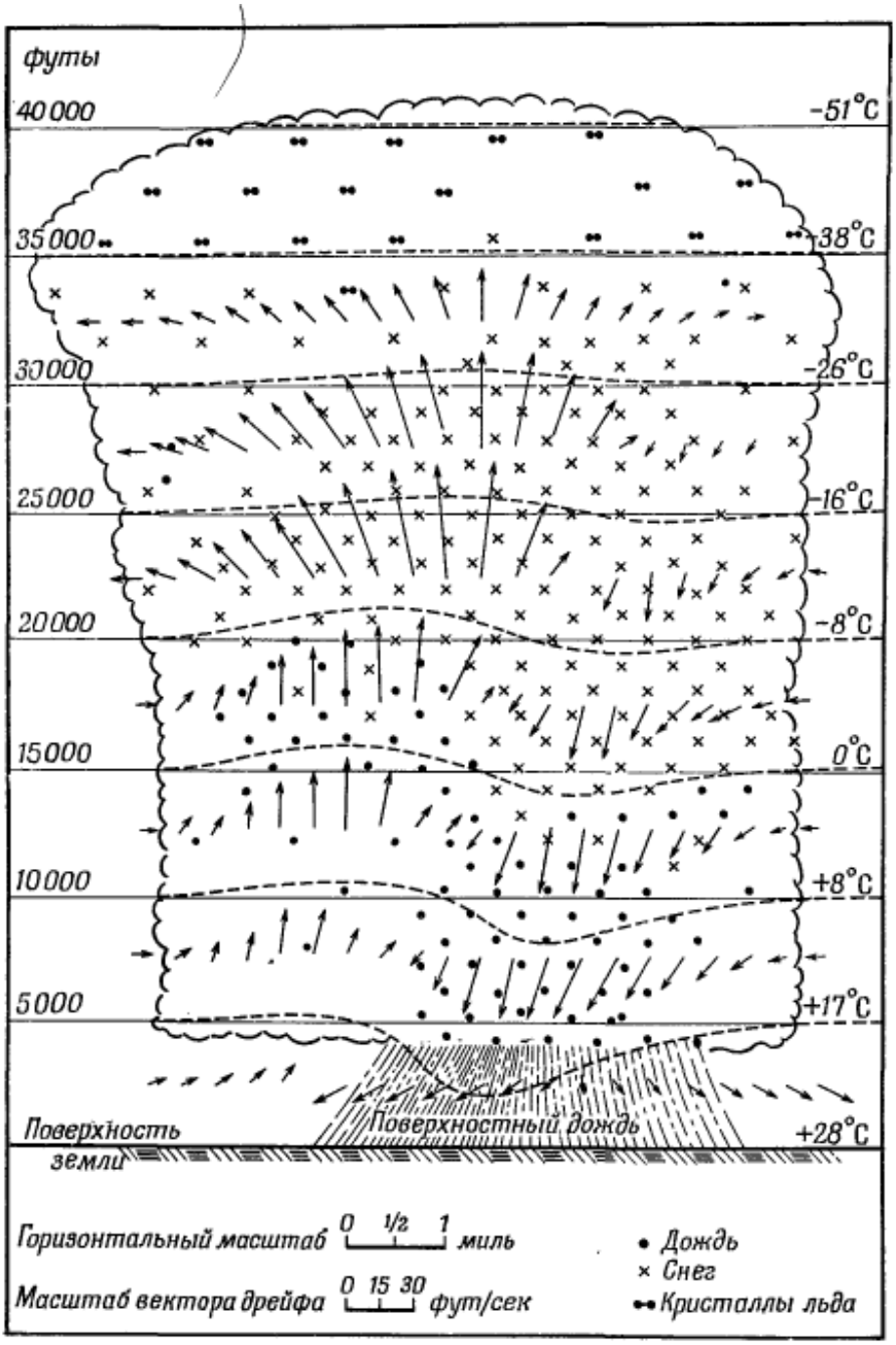


*Fig. 2:* Further development of the thunderstorm

In this state, the cell is considered ripe and it begins to rain from its lower part, while ice crystals form in its upper part. Ice crystals formed in the upper part of the cell and snow formed in its middle part, falling down, begin to melt in warm air, turning into raindrops. It is at this stage that lightnings are formed, indicating that this process is accompanied by charge transfer from the upper part of the cell to its lower part. But the mechanism for such a transfer is not yet clear.

## II. Electrification by Friction

It is known that the friction of amber on wool leads to its electrification. This is due to the fact that the

dielectric constant of amber (the relative dielectric constant of amber is 2.6 - 2.8) is greater than that of wool, and electrons transfer from a dielectric with a lower dielectric constant to a dielectric with a higher dielectric constant. A similar phenomenon is easily observed during friction of dielectric films (for example, from fluoroplastic), with dielectrics whose dielectric constant is less. For some types of fluoroplastic, the relative permittivity reaches 10. Such films are so electrified that they literally adhere to neutral conductors, or to other dielectrics with a lower dielectric constant.

In water and ice, the relative permittivity is also high and for static fields reaches 3.25 and 80 for ice and water, respectively. Therefore, if water droplets, or ice crystals, fall into an environment where there are free electrons, such electrons will adhere to them.

## III. The Process of Lightning

In a mature thunderstorm cell, ice crystals form at heights of the order of 40,000 feet (about 12 km). This, of course, is not yet the ionosphere, which begins with altitudes of about 60 km, but there is already some kind of air ionization at this altitude. And to the crystals of ice formed at this height, the electrons in the air stick. Falling down together with electrons, these crystals carry their charges down. During the fall, falling into the warm air, ice crystals melt, turning into raindrops, but since the dielectric constant of water is much higher than that of ice, the electrons remain on these drops. A raindrop collects electrons on itself for the reason that the electric field of a thundercloud is polarized, as shown in Fig. 1.

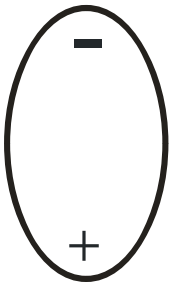


*Fig. 1:* Polarization of the raindrop

The lower part of the polarized droplet is positively charged and when falling down, this part also captures the electrons encountered in its path. This process leads to the fact that when raindrops fall on the ground, the thunderstorm cell acquires an additional charge and a potential difference is formed between the cell and the earth's surface. This leads to lightning.

## IV. Conclusion

The article describes the physical processes leading to the formation of lightning. Previously, this point of view on the formation of lightning was not presented in the scientific literature. Lightning discharges are formed during the development of a thunderstorm cell. First of all, it should be said that thunderclouds consist of several thunderstorm cells closely adjacent to each other, the development of processes in which is identical, but shifted in time. By cell we mean a region with a certain extent in the horizontal direction in which all the basic processes take place. It is the physical processes that occur in such cells that lead to lightning.

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Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 7 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
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# A PNF Intervention Strategy with ICF Tool Applied for Improvement of Dressing in a Patient with Rotator Cuff Syndrome: A Case Report

By Jin-Cheol Kim & Jeong-A Lee

*Abstract-* *Purpose:* This study was conducted to investigate the intervention effect obtained by applying an ICF tool to improve the dressing in a patient with rotator cuff syndrome to schematize the problems and approaching with PNF to solve the problems.

*Methods:* The subject of this study was a 44-year-old patient who underwent surgery after complete right rotator cuff tear. To treat his symptoms, the processes of clinical practice were implemented in the order of examination, assessment, diagnosis, prognosis, intervention, and outcome. During examination, patient information was collected using the ICF core set. In the assessment, the problems were schematized, and an ICF assessment sheet was used to identify the interaction of the problems. The diagnosis was made by clearly describing the causal relationship derived from the assessment in ICF terms. To solve the problems, the intervention was given in the order of indirect, direct, and task based on the philosophy of PNF. To evaluate the outcome, the differences before and after the intervention were compared. Additionally, the comparison for the ICF qualifier is presented with the ICF evaluation display.

*Keywords:* *dressing, intenational classification of functioning disability and health, prioproceptive neuromuscular facilitation, rotator cuff syndrome exercise.*

*GJSFR-A Classification:* *FOR Code: 029999*

*Strictly as per the compliance and regulations of:*

# A PNF Intervention Strategy with ICF Tool Applied for Improvement of Dressing in a Patient with Rotator Cuff Syndrome: A Case Report

## 회전근개 파열 환자의 옷입고 벗기 향상을 위해 ICF Tool을 적용한 PNF 중재전략: 증례보고

Jin-Cheol Kim [α] & Jeong-A Lee [σ]

*Abstract-* ***Purpose:*** This study was conducted to investigate the intervention effect obtained by applying an ICF tool to improve the dressing in a patient with rotator cuff syndrome to schematize the problems and approaching with PNF to solve the problems.

***Methods:*** The subject of this study was a 44-year-old patient who underwent surgery after complete right rotator cuff tear. To treat his symptoms, the processes of clinical practice were implemented in the order of examination, assessment, diagnosis, prognosis, intervention, and outcome. During examination, patient information was collected using the ICF core set. In the assessment, the problems were schematized, and an ICF assessment sheet was used to identify the interaction of the problems. The diagnosis was made by clearly describing the causal relationship derived from the assessment in ICF terms. To solve the problems, the intervention was given in the order of indirect, direct, and task based on the philosophy of PNF. To evaluate the outcome, the differences before and after the intervention were compared. Additionally, the comparison for the ICF qualifier is presented with the ICF evaluation display.

***Results:*** The results of the study showed clinical advantages in shoulder strength, eccentric control, range of motion, scapular stability, and shoulder pain. Overall, our patient with rotator cuff syndrome showed improvement in dressing and undressing activity in response to the PNF strategy.

***Conclusion:*** Application of the PNF intervention strategy after complete rotator cuff tear would have a positive effect on patient upper extremity function.

*Keywords: dressing, intenational classification of functioning disability and health, prioproceptive neuromuscular facilitation, rotator cuff syndrome exercise.*

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## I. 서 론

어깨 관절 통증은 흔한 근골격계 질환으로 사회적인 참여에 제약을 일으키는 주요 원인이다. 성인 인구의 20% 이상이 일상생활에서 어깨 관절 질환을 경험한다 (Kuijpers 등, 2004). 어깨 관절에서 주로 나타나는 손상 은 충돌 증후군, 유착성 어깨관절낭염, 근막통증증후 군, 골관절염, 회전근개파열 등이 있다. 이로 인해, 불편 을 겪는 개인은 수면 장애, 먹기, 씻기, 옷 입고 벗기와 같은 자기관리 활동에 제한을 보인다(Linsell 등, 2006).

특히, 회전근개 파열은 최근 레저 활동에 참여하는 사람들이 늘어남으로써 발생 빈도율이 증가하고 있다. 골프, 테니스, 탁구, 야구, 배드민턴과 같은 동적인 스포 츠 활동에서 두드러지게 나타난다(Boissonnault 등, 2007). 또한, 노화와 자가면역 이상에 따른 어깨 관절 손상, 일상생활에서 팔을 자주 사용하는 과사용증후군 에서도 미세한 파열과 통증을 동반한다. 이러한 내. 외적 요인으로 회전근개가 파열되면 어깨는 점진적으 로 퇴행성 변화를 보인다(Boes 등, 2006). 회전근개 봉합 술 후 초기 보조기 착용은 부동자세를 만들고, 어깨에 석회화를 진행시켜 관절가동범위가 현저하게 감소된다. 퇴원 후 환자는 통증 감소, 관절가동범위 증진, 관절의 안정성 유지, 근력 및 근지구력 향상에 대한 관리가 필요하다(Franceschi 등, 2007).

최근 회전근개 봉합술 후 다각적 관점에서 접근할 수 있는 재활 프로그램을 강조하고 있다. 개인의 직업 복귀와 사회참여를 고려할 수 있는 포괄적인 재활

프로 그램의 인식과 필요성이 제기되었다(De Carli 등, 2017). 그러나 대부분 근골격계 재활 환경은 신체 기능 수준만 을 고려한 어깨 관절 근력 강화와 관절가동범위 증진에 초점을 둔 운동방법 이었다. 하지만 고유수용성 신경근 촉진법 (Proprioceptive Neuromuscular Facilitation; PNF) 은 신체 기능과 구조(body function & structure), 활동과 참여(activiity & participation), 환경(environmental) 요인 에서 문제를 파악하는 기능적인 접근을 한다(Guiu-Tula 등, 2017). 또한, 긍정적인 접근(positive approach), 잠재 력 동원(mobilizer reserve), 운동조절과 운동학습(motor control & motor learning)의 원리, 전인적 관점(consider whole person)에 입각하여 문제를 해결하려고 한다. 이러한 개념적 틀을 PNF는 철학(philosophy)이라고 한다. 그외 기본절차와 패턴, 테크닉은 PNF를 이루고 있는 구성요소이다.

PNF는 가능한 한 가장 높은 기능 수준을 성취하기 위해 4가지 구성요소(철학, 기본 절차, 패턴, 테크닉)를 바탕으로 문제를 해결한다. 첫 번째, 환자의 정보를 수 집한다. 두 번째, 활동 수준의 제한과 어려움을 평가한 다. 세 번째, 활동 제한의 우선순위를 결정한다. 이에 영향을 주는 손상 수준 정보를 파악하고 가설을 설정한 다. 네 번째, 활동 제한과 손상 수준에 대해 객관적이고 표준화된 도구로 검사하여 측정한다. 다섯 번째, 평가 를 통해 파악한 문제 목록을 해결하기 위해 중재를 적용 한다. 여섯 번째, 활동 제한과 손상 수준에 대해 재측정 하고 전. 후 비교를 통해 가설을 재검정한다(Adler 등, 2007).

세계보건기구는 국제기능.장애.건강분류(International Classification of Functioning, Disability and health)체계를 제시하였다. ICF는 건강과 관련된 구성요소를 신체 기 능과 구조, 활동 및 참여, 환경 요인, 개인 요인으로 분류하였다. 각 구성요소는 상호작용하여 인과관계를 설명한다. ICF는 건강과 관련된 광범위한 상태를 파악 할 수 있도록 과학적인 방법으로 제공하였다(Stucki 등, 2002). ICF 이점은 재활 주기(rehab cycle) 단계에서 ICF Tool (ICF core set, ICF assessment sheet, ICF categorical profile, ICF intervention table, ICF evaluation display)을 적용할 수 있다는 것이다(Steiner 등, 2002). ICF Tool은 ICF 모델과 통합하여 재활 주기의 사정(Assessment)단 계에서 ICF Core set, ICF Assessment sheet을 사용할 수 있다. 배정(assignment) 단계는 ICF Categorical profile을 사용한다. 중재(Intervention) 단계는 ICF Intervention tool을 사용하고, 평가(Evaluation) 단계는 ICF Evaluation display 도구를 사용할 수 있다(Rauch 등, 2008).

그래서 본 연구의 첫 번째 목적은 임상 실기 과정 동안 ICF Tool을 적용하여 문제 해결에 대한 상호작용 을 알아보고, 두 번째 목적은 회전근개 파열 환자에게 PNF 중재를 적용하여 옷 입고 벗기 활동에 미치는 영향 을 알아보기 위함이다.

## II. 연구 방법

*a) 검진(ICF core set)*

i. *환자 정보*

a. *개인 정보*

44세 여성 환자로 키 165㎝, 체중 65㎏이다. 환자는 시내에서 작은 옷 가게(shop)을 운영하였다. 취미 활동 으로 배드민턴 동호회에서 주 5회, 하루 2시간씩 배드 민턴 치는 것을 즐겼다.

b. *진단명과 과거력*

2018년 2월 6일 오른쪽 어깨 관절 회전근개 완전 파열 손상을 진단받고 정형외과적 수술을 받았다. 담당 의사는 수술 후 수술 부위의 안정성을 위해 어깨 보조기 (sling)를 처방하였다. 환자는 어깨 보조기를 착용한 상 태로 한 달 동안 일상생활을 수행하였다. 그 외 특별한 과거력은 없었다.

c. *환경과 사회적 정보*

환자는 본인이 운영하는 옷 가게에서 상품을 홍보하 기 위해 컴퓨터 업무를 하였다. 또한 옷 가게에 상품을 진열하고 마네킹에 코디하는 일을 주로 하였다. 배드민 턴 동호회 모임을 정기적으로 참여하였고, 모임에 총무 를 맡고 있었다.

d. *환자의 요구사항*

Brief ICF Core set for musculoskeletal for post-acute을 이용하여 환자의 신체 기능과 구조, 활동과 참여, 환경 적 요인에 대한 정보를 수집하였다. ICF Core set으로 얻은 활동의 항목을 바탕으로 인터뷰를

진행하였다. 자기관리에 어려움이 있는 일상생활에서 가장 불편한 활동이 무엇인지에 대해 물었다. 환자는 "배드민턴 동 호회에 나가서 다시 배드민턴을 치고 싶다", "샤워하는 데 불편함이 없었으면 좋겠다", "옷 입고 벗기가 어렵고 특히 벗을 때 매우 힘들다"라고 하였다.

e. *가족 지원과 개인적 태도*

환자의 경제적인 수준은 재활 비용을 지불하기에 무 리가 없어 재활 과정에 긍정적인 영향을 주었다. 치료실 내에서 주변 사람들과 자주 통화를 하였고, 지인과의 인맥 관계를 좋게 형성하는 것으로 보였다. 동호회에서 도 구성원들의 모임을 주도한다고 하였다. 이러한 부분 은 긍정적인 요인으로 작용할 것으로 판단하였다.

f. *기능적 활동 수준*

환자는 현재 어깨 관절의 근력저하, 안정성 저하, 가동범위 제한, 통증으로 인해 옷 입고 벗기, 식사하기, 팔을 들어 올려 수행하는 자기관리 활동과 배드민턴 동호회에 참여하는데 제약이 있다.

ii. *검사 및 측정*

a. *일차 활동 제한*

옷 입고 벗기의 활동 제한을 측정하기 위해 수행력 시간과 어깨 장애지수(Disability of Arm Shoulder Hand Score; DASH) 점수를 기록하였다. DASH는 팔에 손상 을 가진 환자가 팔을 사용하여 일상생활을 수행하는 활동과 신체 기능의 능력을 알아보는 자가 설문 보고서 다(Beaton 등, 2001a). 이 설문지는 1~5점 척도로 구성되 었고, 1점은 어려움 없음, 2점은 약간 어려움, 3점은 중간 정도 어려움, 4점은 아주 어려움, 5점은 전혀 할 수 없음이다. DASH는 임상에서 팔 기능을 평가하는데 신뢰도 r= .70, 높은 타당도 ICC= .96 를 보인다(Beaton 등, 2001b). 병원 환의 복 상의를 각각 오른쪽과 왼쪽 팔에 끼워 입고 벗는 시간을 측정하였다. 옷 입기는 오른쪽 팔을 끼워 입을 때와 왼쪽 팔을 끼워 입을 때 걸리는 시간을 측정하였다. 옷 벗기는 오른팔 소매를 빼서 벗을 때와 왼쪽 팔 소매를 빼서 벗을 때 걸리는 시간을 측정하였다.

b. *신체 기능과 구조 손상*

① 어깨 근력 및 관절가동범위

손상 측 팔의 근력을 측정하기 위해 도수근력검사 (Manual Muscle Test; MMT)를 실시하였다. 각 관절의 움직임은 실제 옷 입고 벗기 자세인 앉은 자세에서 검사 52 | J Korean Soc Phys Med Vol. 13, No. 3 하였다. 치료사는 어깨 관절의 굽힘, 폄, 벌림, 가쪽돌 림, 안쪽돌림 근력을 측정하였다.

관절가동범위를 측정하기 위하여 각도계(Goniometer) 를 사용하였다. 어깨 관절의 굽힘, 폄, 벌림 가동범위는 대상자가 바로 누운 자세에서 위팔뼈 머리 외측부와 주 두돌기를 기준으로 측정하였다. 가쪽돌림과 안쪽돌림 가동범위는 대상자가 바로 누운 자세에서 주두돌기와 자뼈의 붓돌기를 기준으로 어깨 관절의 90도 벌림과 팔 꿉 관절을 90도 굽힘한 상태에서 측정하였다. 각도계는 임상에서 어깨 관절의 가동범위를 측정하는데 적합한 타당도를 가지며 높은 신뢰도를 보인다(Tyler 등, 1999).

② 어깨뼈 안정성 검사

어깨뼈 안정성을 측정하기 위하여 어깨뼈 측방주행 검사(Lateral Scapula Side Test; LSST))를 실시하였다. 앉은 자세에서 어깨 관절을 각각 0도, 45도, 90도 벌림시 키고, 등뼈 7번의 극돌기에서 어깨뼈 하각의 내측연 거리를 측정하였다. 환자마다 차이가 있기 때문에 양측 을 측정하여 왼쪽과 오른쪽을 비교하였다. 손상이 없는 어깨뼈와 손상이 있는 어깨뼈의 거리 차이가 1.5㎝ 이 상 차이가 나타나게 될 경우 비대칭이 있는 것으로 판단 한다. 어깨뼈 측방주행 검사는 어깨뼈의 위치와 대칭성 을 평가하는데 높은 타당도(ICC=.75)를 보인다(Curtis 과 Roush, 2006).

③ 통증 검사

대상자가 지각한 통증을 측정하기 위하여 시각 사상 척도(Visual Anlalogue Scale; VAS)를 사용하였다. 대상 자에게 자신의 통증 정도를 1~10점까지 제시하였다. 0점은 통증이 없음, 5점은 중간 정도의 통증이 있음, 10점은 참을 수 없음으로 설명하고, 통증 정도에 대한 점수를 요구하였다. VAS의 검사자 내

신뢰도는 r=.97으 로 높은 신뢰도를 보인다(Boonstra 등, 2008).

*b) 평가(ICF Assessment sheet)*

i. *기능적인 문제 파악*

환자의 기능적인 문제를 파악하기 위하여 Brief ICF Core set for musculoskeletal for post-acute을 사용하였다. 활동과 참여 영역에서 능력치와 수행치, 신체 기능과 구조에 대한 평가치를 작성하였다. 이에 영향을 미치는 환경요소의 촉진 요인과 억제 요인을 파악하였다.

a. *활동 제한과 참여 제약*

활동과 참여 영역에서 '들어 올리기(d4300.12)', '내 려놓기(d4305.12)', '손이나 팔로 돌리거나 뒤틀기(d4453.12)', '전신 씻기(d5101.22)', '옷 입기(d5400.23)', '옷 벗기(d5401.23)', '스포츠(d9401.33)' 항목에 제한이 있었다. 이와 같은 활동 제한은 배드민턴 동호회에 참여하는데 제약을 가지고 있었다. 들어 올리기(d4300.12), 내려놓기(d4305.12), 손이나 팔로 돌리거나 뒤틀기 (d4453.12)는 보조를 통한 수행에서 경도(5~24%)의 어 려움이 있었고, 보조 없이 순수한 개인 능력은 중도 (25~45%)의 어려움이 있었다. 전신 씻기(d5101.22)는 보조를 통한 수행에서 중도(25~45%)의 어려움이 있었 고, 보조 없이 순수한 개인 능력은 중도(25~45%)의 어 려움이 있었다. 옷 입기와 옷 벗기는 보조를 통한 수행 에서 중도(25~45%)의 어려움이 있었고, 보조 없이 순수 한 개인 능력은 고도(50~95%)의 어려움이 있었다. 스포츠(d9401.33)는 보조를 통한 수행에서 고도(45~95%)의 어려움이 있었고, 보조 없이 순수한 개인 능력은 완전(95~100%) 어려움이 있었다.

b. *신체 기능과 구조 손상*

신체 기능 및 구조 영역에서 '수면기능(b134.1)', '분 리된 근육의 지구력(b7400.1)', '단순 수의적 운동의 조 절(b7600.1)'은 경도(5~24%)의 손상이 있었다. '상지 통 증(b28014.2)', '한 관절의 안정성(b7150.2)', '한지 근육 의 힘(b7301.2)'은 중도(25~45%)의 손상이 있었다. '어 깨뼈의 가동성(b7200.3)'은 고도(50~95%)의 손상이 있 었다.

c. *환경적 및 개인적 요소*

환경적 요소는 '직계가족의 태도(e310.+1)', '보건 전 문가의 개인적 태도(e450.+1)'가 경도(5~24%)의 촉진요 인으로 작용하였다. 가족들의 적극적인 지지와 격려는

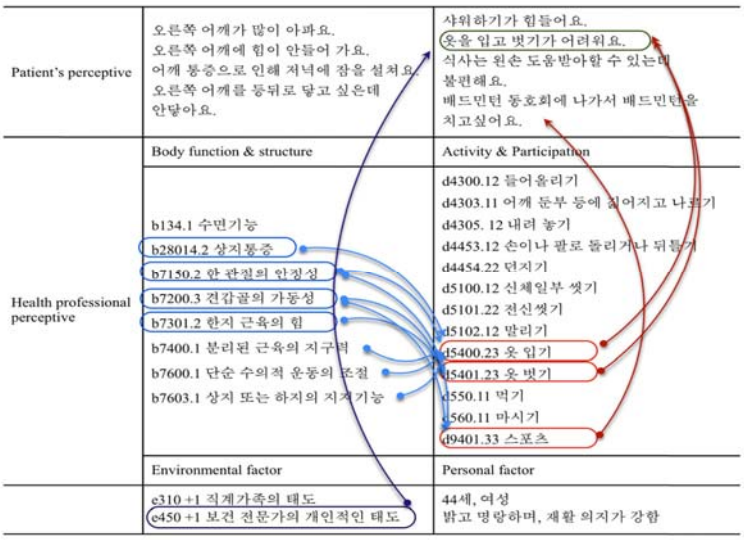


*Fig. 1:* ICF assessment sheet

경도(5~24%)의 촉진 요인이었다. 치료사가 제공하는 재활 서비스는 경도(5~24%)의 촉진요인으로 작용하였 다. 환자분의 강한 재활 의지와 적극적인 운동 참여는 다양한 활동을 수행하는데 긍정적인 영향을 줄것으로 판단하였다.

d. *ICF의 각 항목간 상호작용 분석*

환자의 요구 사항을 토대로 협의된 목표를 설정하였 다. ICF assessment sheet을 사용하여 목표의 연관성과 신체 기능 및 구조, 활동과 참여, 환경 요인으로 상호작 용을 분석하였다(Fig. 1).

ii. *의사결정 과정*

a. *환자의 요구사항과 해결과제 우선순위 선정*

환자는 "배드민턴 동호회에 나가서 다시 배드민턴 을 치고 싶다", "옷 입고 벗기를 어려움 없이 하고싶다", "샤워하는데 불편함이 없었으면 좋겠다"라고 하였다. 환자의 요구 사항에 대해 치료사와 협의한 결과 일상생 활에서 옷 입고 벗기를 어려움 없이 하는 것으로 정하였 다. 옷 입고 벗기 활동을 해결하기 위해 ICF d5. 자기관 리에 '옷 입기(d5400.23)', '옷 벗기(d5401.23)' 항목을 우선순위로 합의하였다.

b. *가설 설정*

환자와 협의하여 우선적으로 해결해야 할 과제는 옷 입고 벗기였다. 옷 입고 벗기 움직임을 분석하기 위해 치료실 환경에서 병원 환의복 상의를 입고 벗는 움직임에 대해 동영상 촬영하였다. 움직임 분석을 통해 관찰한 내용을 사실 그대로 기술하였다. 각각 기술한 내용에 대해 가설을 설정하고 이를 검증하였다.

① 팔을 들어 올릴 때 힘이 약해서 일까?

회전근개 파열은 외상성 파열, 노화로 인한 병리적 변화, 해부학적 구조물이 변형을 일으켜 가시위근 쪽이 좁아진다. 이때 가시위근에 약증이 먼저 보이고, 작은 원근, 어깨밑근 순서로 근 약화가 나타난다(Başkurt 등, 2011). 이러한 근거를 바탕으로 어깨 관절 굽힘, 폄, 벌림, 가쪽돌림, 안쪽돌림에 대해 MMT를 시행하였다. 그 결과, 왼쪽 어깨 근력은 모든 자세에서 중력과 치료 사의 최대 저항을 이길 수 있는 Normal 등급이었다. 하지만 오른쪽 어깨 근력의 굽힘, 폄, 가쪽돌림, 안쪽돌 림은 중력에 대항해 전체 관절가동범위가 나타난 Fair+ 등급이었고, 폄근은 Good 등급이었다. 왼쪽 어깨 근력 과 오른쪽 어깨 근력을 비교하였을 때 오른쪽 어깨 근력 이 상대적으로 저하되어 있는 것을 확인할 수 있었다.

② 팔을 내리는 원심성 근수축이 약해서 일까?

등장성 수축의 결합은 주동근의 구심성 수축과 원심 성 수축을 일으키는 것이다. 원심성 수축은 역치가 높 은 운동단위에서부터 먼저 발화되므로 운동단위 동원 명령이 선택적으로 추가되는 양상을 보인다(Nardone 등, 1989). 수축성 구조뿐만 아니라 인대, 비수축성 결합 조직에도 장력이 작용하게 되어 원심성에 관여한다. 예를 들면, 물을 마시고 물병을 탁자에 내려놓는 일상 생활 활동에서 등장성 수축의 결합을 볼 수 있다. 이러 한 근거를 바탕으로 오른쪽 팔의 굽힘-벌림-가쪽돌림 패턴에 combination of isotonic 테크닉을 적용하여 시도 횟수를 오른쪽과 왼쪽을 비교하였다. 그 결과, 오른쪽 팔은 한 번도 시도를 하지 못하였고, 왼쪽 팔은 5회를 성공하였다. 이를 통해 왼쪽 팔을 내릴 때 원심성 조절 의 저하를 확인할 수 있었다.

③ 어깨 관절의 가동범위 제한일까?

회전근개가 파열되면 수동 운동 시에 어깨 관절 상부 에서 구조적으로 제한이 나타난다. 또한, 능동적으로 팔을 들어 올릴 때 정상적인 팔 들기 각도가 최대 15도 까지 차이가 나며, 팔 들기 속도는 8%까지 감소된다 (Malmström 등, 2015). 이때, 등세모근(상부,하부) 및 앞 톱니근의 과도한 근 활성이 증가하여 몸통을 가쪽굽힘 시켜 팔을 들어 올리는 동작에 보상작용을 한다. 어깨 관절의 능동적 운동 범위가 감소되면서 팔 사용을 기피 하기 때문에 일상생활 활동에 어려움을 겪는다(Smith 과 Smith, 2010). 이러한 근거를 바탕으로 어깨관절 굽 힘, 폄, 벌림, 가쪽돌림, 안쪽돌림의 수동 및 능동 관절가동범위를 측정하였다. 그 결과, 오른쪽 어깨 수동관절 가동범위는 굽힘 143°, 폄 180°, 벌림 93°, 안쪽돌림 127°, 가쪽돌림 113°이었다. 능동관절가동범위는 굽힘 138°, 폄 180°, 벌림 89°, 안쪽돌림 125°, 가쪽돌림 105° 이었다. 정상 관절가동범위와 비교하였을 때 관절가동범위에 제한이 있음을 확인할 수 있었다.

④ 어깨 관절의 불안정성 때문일까?

어깨 관절의 불안정성은 어깨뼈 안정 시 위치와 비정 상적인 관절의 움직임과 관련이 있다(Hébert 등, 2002). 어깨뼈의 불안정성은 어깨가슴관절의 동작이

과하거 나 저하된 움직임을 보인다. 이는 관절와위팔관절 주변 에 스트레스를 유발하는 요인이다(Cools 등, 2002). 어 깨 관절 주위의 기능과 안정성은 매우 중요하다. 어깨 뼈는 몸통과 팔 사이에 위치하여 해부학적 및 운동학적 으로 중간 연결고리와 안정성 역할을 하기 때문이다. 이러한 근거를 바탕으로 어깨뼈 측방주행검사를 실시 하였다. 그 결과 오른쪽 어깨는 0°에서 5.7 cm, 45°에서 6.8 cm, 90°에서 7.9 cm이고, 왼쪽 어깨는 0°에서 4 cm, 45°에서 5 cm, 90°에서 6 cm이었다. 왼쪽과 비교하였을 때 어깨뼈의 비대칭성을 확인할 수 있었다.

⑤ 통증 때문일까?

회전근개 파열은 회전근개에 섬유화가 진행되고 주 변 근육들의 위축과 약증을 동반한다(Gerber 등, 2004). 이로 인해, 해당 근육이나 건의 불연속이 지속되어 누 워있을 때나 야간에 통증이 심하다(Williams Jr 등, 2004). 이러한 근거를 바탕으로 VAS를 측정하였다. 그 결과 휴식시 4점, 팔을 사용하는 활동 시 7점을 호소하였 다. VAS 점수로 어깨 관절의 통증을 확인할 수 있었다.

## III. 진단

ICF Core set을 활용하여 환자의 요구 사항과 기능적 문제를 확인하였다. 가장 우선적으로 해결해야 할 과제 는 옷 입기(d4500.23), 옷 벗기(d4501.23)가 중도의 어려 움이 있었다. 이에 영향을 주는 신체 구조와 기능의 팔 통증(b2801.2)은 중도 손상, 한 관절의 안정성 (b7200.3)의 고도 손상, 어깨뼈의 가동성(b7200.3)의 고 도 손상, 한지 근육의 힘(b7301.2)의 중도 손상을 파악하 였다.

## IV. 예후

장기 목표는 6주 후 옷 입기와 옷 벗기에 어려움 없이 수행하는 것으로 정하였다. 환자의 능동적인 참여를 유도하기 위해 구체적인 세부 목표를 제시하였다. 통증이 발생하지 않는 범위에서 어깨 관절의 관절가동범위를 증진시켜 옷 입기와 옷 벗기에 어려움이 없도록 단기 목표를 설정하였다. 세부목표는 관절가동범위를 회전근개 파열 환자의 옷입고 벗기 향상을 위해 ICF Tool을 적용한 PNF 중재전략 : 증례보고 | 55 굽힘 180°, 벌림 160°, 안쪽돌림 160°, 가쪽돌림 160° 범위로 증진시킨다. MMT의 Fair+를 Good 등급으로 향상시킨다. 등장성 혼합 수축 횟수를 0에서 3회로 증진시킨다. LSST 길이를 1.3 cm로 줄인다. VAS 점수를 7점에서 4점으로 감소시킨다.

## V. 중재

중재는 총 6주간 주 3회, 1일 30분씩 시행하였다. 모든 운동은 30회를 1세트로 하여, 3세트를 실시하였 다. FITT (frequncy, intencity, time, type; FITT) 원리에 입각하여 환자의 기능 수준에 맞게 적절한 강도와 난이 도를 고려하였다. 세트 사이에 중간 휴식시간 1분을 가지며 적용하였다. 문제 목록을 해결하기 위해 적절한 PNF 상지 패턴을 적용할 때, 간접적(indirect), 직접적인 (direct) 방법으로 접근하였다(Goo, 2012).

### a) *관절가동범위 증진*

오른쪽 팔의 관절가동범위를 증진시키기 위한 간접 적인 접근 방법은 옆으로 돌아누운 자세에서 왼쪽 어깨 뼈 앞쪽 내림 패턴과 왼쪽 골반 앞쪽 올림 패턴에 replication 테크닉을 적용하였다. 또 따른, 간접적인 방법은 앉은 자세에서 리프팅(lifting) 패턴을 이용하여 combination of isotonic 테크닉을 적용하였다. 직접적인 방법으로 오른쪽 팔의 굽힘-벌림-가쪽돌림-팔꿉관절 굽힘 패턴에 replication 테크닉을 적용하였다. 또 다른, 직접적인 접근은 앉은 자세에서 팔의 굽힘-모음-가쪽돌림-팔꿉관절 폄 패턴에 replication 테크닉을 적용하였다.

### b) *근력 및 원심성 근 수축 증진*

오른쪽 팔을 들어 올리는 근력에 대한 간접적인 방법 은 오른쪽 팔을 벽에 대고 바로 누운 자세에서 왼쪽 다리의 굽힘-벌림-안쪽돌림-무릎 관절 굽힘 패턴에 repetead stretch 테크닉을 적용하였다. 직접적인 방법은 오른쪽 팔의 굽힘-벌림-가쪽돌림 패턴에 combination of isotonic 테크닉을 적용하였다. 팔을 내릴 때 원심성 근수축에 대한 간접적인 방법은 벽에 발을 댄 교각 자세 에서 리프팅(chopping) 패턴을

오른쪽 방향으로 올리게 하면서 combination of isotonic 테크닉을 적용하였다. 직접적인 방법은 오른쪽 팔의 굽힘-모음-가쪽돌림 패 턴에 combination of isotonic 테크닉을 적용하였다.

c) *어깨뼈의 안정성 증진*

어깨뼈의 안정성을 증진 시키기 위해 간접적인 접근 은 팔꿉 관절을 구부리고 엎드린 자세에서 우측 어깨팔 은 지면을 지지하고 왼쪽 어깨의 폄-벌림-안쪽돌림-팔 꿉 관절 굽힘 패턴에 dynamic reversal 테크닉을 적용하 였다. 직접적인 접근은 팔꿉 관절을 구부리고 엎드린 자세에서 오른쪽 어깨뼈 앞쪽 올림, 뒤쪽 내림 패턴과 왼쪽 어깨뼈 앞쪽 올림, 뒤쪽 내림 패턴에 stabilizing reversal 기법을 적용하였다.

d) *통증 감소*

팔을 내릴 때 통증을 감소시키기 위해 간접적인 접근 은 팔의 폄-모음-가쪽돌림 패턴에 hold relax 기법을 적 용하였다. 직접적인 접근은 팔의 굽힘-벌림-안쪽돌림 패턴에 hold-relax 기법을 적용하였다.

## VI. 연구 결과

a) *일차 활동 제한 변화*

옷 입고 벗기 수행력 시간과 DASH 설문조사를 Table 1에 제시하였다. DASH의 활동 점수는 중재 전 49점에서 중재 후 42점으로 7점 감소하였다. 신체 기능 점수는 중재 전 16점에서 중재 후 12점으로 4점 감소하였다. 수행력 시간은 오른쪽 소매를 끼울 때 12.96초 감소하였고, 왼쪽 소매는 6.34초 감소하였다. 옷 벗기는 오른쪽 소매를 벗을 때 27.43초 감소하였고, 왼쪽 소매는 17.33초가 감소하였다.

b) *근력과 관절가동범위 변화*

근력과 관절가동범위 변화는 Table 2에 제시하였다. 근력은 중재 전 굽힘 Fair+, 폄 Good, 벌림 Fair+, 안쪽돌 림 Fair, 가쪽돌림 Fair에서 중재 후 good 등급으로 향상 되었다.

PROM은 굽힘 27°, 벌림 57°, 안쪽돌림 35°, 가쪽돌림

*Table 1:* Change of Activity Limitation (score, second)

| Item | | Pre | | Post | | Difference | |
|---|---|---|---|---|---|---|---|
| DASH | Activity | 49score | | 42score | | 7score | |
| | Body function | 16score | | 12score | | 4sscore | |
| Putting on clothes | | Rt.36.93s | Lt.39.57s | Rt.23.27s | Lt.33.23s | Rt.12.96s | Lt.6.34s |
| Taking off clothes | | Rt.47.53s | Lt.38.63s | Rt.20.10s | Lt.21.30s | Rt.27.43s | Lt.17.33s |

*Table 2:* Change of MMT and ROM (grade, degree)

| Shoulder motion | MMT | | | | ROM | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pre | | Post | | Pre | | Post | | Difference | |
| | Rt | Lt | Rt | Lt | PROM(Rt) | AROM(Rt) | PROM(Rt) | AROM(Rt) | PROM(Rt) | AROM(Rt) |
| Flexion | Fair+ | N | G | N | 143° | 138° | 170° | 166° | 27° | 28° |
| Extension | Good | N | G | N | 180° | 180° | 180° | 180° | 0° | 0° |
| Abduction | Fair+ | N | G | N | 93° | 89° | 160° | 155° | 67° | 66° |
| Internal rotation | Fair | N | G | N | 127° | 125° | 162° | 160° | 35° | 35° |
| External | Fair | N | G | N | 113° | 105° | 158° | 155° | 45° | 50° |

*Table 3:* Change of Scapula Stability (cm)

| Shoulder motion | Pre | | Post | | Difference |
|---|---|---|---|---|---|
| | Rt | Lt | Rt | Lt | Rt |
| Abduction 0° | 5.7 cm | 4 cm | 5.5 cm | 4 cm | .2 cm |
| Abduction 45° | 6.8 cm | 5 cm | 6.1 cm | 5 cm | .7 cm |
| Abduction 90° | 7.9 cm | 6 cm | 7.2 cm | 6 cm | .7 cm |

45°, AROM은 굽힘 28°, 벌림 46°, 안쪽돌림 35°, 가쪽돌림 50°가 각각 향상되었다.

*c) 어깨뼈 안정성 변화*

어깨뼈 안정성 변화는 Table 3에 제시하였다. 오른쪽 어깨뼈 안정성은 중재 전 0°에서 5.7 cm, 45°에서 6.8 cm, 90°에서 7.9 cm이었다. 중재 후 0°에서 5.5 cm, 45°에 서 6.5 cm, 90°에서 7.7 cm로, 각각의 동작에서 .2 cm, .7 cm, .7 cm가 감소하였다.

*d) 통증 변화*

통증 지수 변화는 VAS를 이용하였다. VAS 점수는 중재 전 7점에서 3점으로 감소하였다.

*e) ICF Qualifier에 대한 변화*

ICF Qualifier에 대한 중재 전. 후 비교는 기능적 프로 파일을 요약한 ICF tool에 마지막 단계인 ICF evaluation display로 나타내었다(Table 4).

## VII. 고 찰

재활의 궁극적인 목표는 환자가 잘할 수 있는 부분과 잘할 수 없는 부분을 파악하여 목표로 한 기능적 활동을 개선하는 것이다. 협의가 이뤄진 일차 활동 제한을 해 결하기 위해 신체 기능의 잠재력을 극대화하고 운동조 절을 학습시켜야 한다. 본 연구는 회전근개 파열 환자 를 대상으로 ICF Tool를 적용하여 환자의 기능적 상태 를 파악하였다. 환자와 협의한 활동 수준을 개선하기 회전근개 파열 환자의 옷입고 벗기

*Table 4:* ICF evaluation display

| ICF categories | | Pre-test | | | | Post-test | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ICF qualifier | | | | ICF qualifier | | | |
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| b134 | Sleep function | | | | | | | | |
| b28014 | Pain in upper limb | | | | | | | | |
| b7150 | Stability of a single joint | | | | | | | | |
| b7200 | Mobility of scapula | | | | | | | | |
| b7301 | Power of muscle of one limb | | | | | | | | |
| b7400 | Endurance of isolated muscle | | | | | | | | |
| b7600 | Control of simple voluntary movement | | | | | | | | |
| b7603 | Supportive functions of arm or leg | | | | | | | | |
| d4300 | Lifting | | | | | | | | |
| d4303 | Carrying on shoulders, hip and back | | | | | | | | |
| d4305 | Carrying on head | | | | | | | | |
| d4453 | Putting down objects | | | | | | | | |
| d4454 | Throwing | | | | | | | | |
| d5100 | Washing body parts | | | | | | | | |
| d5101 | Whashing whole parts | | | | | | | | |
| d5400 | Putting on clothes | | | | | | | | |
| d5401 | Taking off clothes | | | | | | | | |
| d550 | Eating | | | | | | | | |
| d560 | Drinking | | | | | | | | |
| d9401 | Sports | | | | | | | | |

| | | Facilitator | | | | Barrier | | | | Facilitator | | | | Barrier | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4+ | 3+ | 2+ | 1+ | 1 | 2 | 3 | 4 | 4+ | 3+ | 2+ | 1+ | 1 | 2 | 3 | 4 |
| e310 | Immediate family | | | | | | | | | | | | | | | | |
| e450 | Individual attiudes of health professionals | | | | | | | | | | | | | | | | |

위해 PNF 구성요소에 입각하여 접근하였다. 그 결과, 회전근개 파열 환자의 옷 입고 벗기 활동에 긍정적인 영향을 미쳤다.

임상실기는 문제 해결 과정에서 가설 지향적 접근, ICF 접근, 시스템 모델을 고려해야 한다. 이러한 다각적 접근에 기반한 문제 해결을 임상 추론이라고 할 수 있으 며, 치료사의 사고 과정에 필요한 개념적 틀이라고 한 다(Shumway-Cook과 Woollacott, 2007). 본 연구는 환자 의 문제 해결을 위해 임상실기과정 절차를 1. 정보 수집, 2. 정보 분석, 3. 기능적인 문제 파악, 4. 문제의 우선순위 설정, 5. 가설 설정, 6. 가설 검증, 7. 목표와 목적 설정, 8. 중재 전략 작성, 9. 중재 실행, 10. 결과 측정 순으로 진행하였다. 임상실기과정에서 환자의 정보 수집과 협의된 목표 를 설정하기 위해 ICF Core set을 사용하였다. 환자의 기능적인 문제를 파악하고 신체 기능 및 구조, 활동과 참여, 환경요인의 상호작용을 ICF Assessment sheet으로 나타내었다. 문제 목록을 해결하기 위해 PNF를 적용하 였고, 중재 전. 후의 결과측정은 ICF Evaluation display 로 비교하였다(Kirschneck 등, 2011). ICF Tool은 임상 실기 과정에 적용했을 때 문제 목록을 확인하는데 유용 하며, 측정 도구의 적절한 선택과 중재 과정에 긍정적 인 영향을 줄 수 있다(Kang과 Kim, 2017).

팔의 관절 가동범위 제한은 보조근들의 사용과 어깨 뼈의 회전을 이용한 보상작용으로 어깨위팔리듬이 나 타난다(Rizk 등, 1983). 이로인해 어깨 관절의 끼임 증상 도 함께 나타나며 통증을 동반한다. Godges 등(2003)의 연구는 유착성 관절낭염이 있는 환자 20명을 대상으로 실험군은 PNF 중재를 적용하고, 대조군은 연부조직 가 동술을 적용하였다. 그 결과, 두군 모두 관절 가동범위가 유의하게 증가하였다. Ravichandran과 Balamurugan (2015)의 연구는 유착성 관절낭염 환자 60명을 대상으 로 실험군은 PNF 중재를 적용하고, 대조군은 근 에너지 기법을 적용하였다. 그 결과, 실험군에서 관절가동범 위, 통증 완화, 어깨 기능 회복에 유의한 차이를 보고하 였다. 이러한 결과는 선행 연구 결과와 일치하였다. 이 는 PNF 굽힘-벌림-가쪽돌림과 폄-모음-안쪽돌림 패턴 에 율동적 개시 테크닉의 적용이 어깨 관절의 좁아진 관절 공간을 확보하였고, 어깨뼈와 몸통의 보상작용이 감소된 결과라 생각된다.

회전근개 봉합술 후 어깨 관절의 근력을 강화시키는 것은 매우 중요하다(Cohen 등, 2002). 관절낭 단축으로 어깨 관절의 수동움직임 제한과 근력 약화는 능동 움직 임에 제한이 있다(Namdari과 Green, 2010). Ellenbecker 등(2006)은 봉합술 후 12주 경과 환자를 대상으로 근력 강화 훈련을 적용한 결과 관절가동범위와 근력에서 유 의한 향상을 보고하였다. 이러한 결과는 선행 연구 결 과와 일치하였다. 이는 PNF 굽힘-벌림-가쪽돌림 패턴 과 등장성 혼합 테크닉의 적용이 어깨 관절의 근력과 근지구력의 향상을 가져온 것으로 판단된다.

어깨 관절 안정성을 위해 어깨 관절 안정근들 사이의 균형적인 조절 능력 회복에 초점을 두어야 한다 (Ludewig과 Cook, 2000). Song과 Kim (2014)은 회선근개 환자 40명을 대상으로 닫힌 사슬 운동과 열린 사슬 운동 효과를 비교하였다. 그 결과 닫힌 사슬 운동이 어깨 관절 안정성에 유의한 효과가 있다고 보고하였다. 이러 한 결과는 선행연구 결과와 일치하였다. 본 연구는 닫 힌 사슬 운동이 가능한 팔꿉 관절을 구부리고 엎드려 누운 자세에서 상지 패턴과 안정적 반전 테크닉을 적용 하여 어깨의 안정성을 제공하였다. 안정적 반전은 근력 을 강화하고 안정성을 증진시키는데 효과적으로 작용 하였을 거라고 판단된다. 이는 관절 주위의 구심성 수 용기가 더 많은 고유감각을 동원시켜 관절의 동적 안정 성과 자세 유지에 영향을 준 것으로 사료된다.

본 연구는 몇 가지 제한점이 있다. 첫째, 환자가 최종 적으로 요구한 배드민턴 동호회 모임을 참여하여 역할 을 수행하는 지에 대한 추가적인 조사가

이루어지지 않았다. 둘째, 대상자 1명으로 한 사례 연구이기 때문에 결과를 일반화하는데 어려움이 있다. 그러나 현재까지 회전근개 고객에 대한 ICF Tool과 PNF를 적용한 연구 가 미비한 실정이므로 임상적으로 의의가 있다. 향후 연구는 표본 크기를 구하여 인과관계를 알아볼 수 있는 실험 연구가 진행될 필요가 있다.

## VIII. 결 론

본 연구는 회전근개파열 환자를 대상으로 하여 임상 실기과정 모형을 통해 추론하였다. 추론 과정에서 ICF tool은 현명한 의사결정을 내릴 수 있는 도구로 사용하였 다. 검진은 ICF core set을 사용하여 정보를 수집하였다. 평가는 ICF assessment sheet으로 문제를 도식화하고 상 호작용을 밝혔다. 결과는 ICF evaluation display를 사용하 여 전. 후를 비교하였다. 이는 ICF Tool이 환자의 기능적 인 활동과 신체 기능 수준의 문제점을 파악하는데 용이 하였다. 환자의 옷 입고 벗기 활동에 대한 신체 기능의 문제점은 오른쪽 어깨의 근력과 원심성 근수축, 관절가 동범위, 어깨뼈 안정성, 통증이었다. 이 문제를 해결하기 PNF 철학에 입각하여 간접적인(indirect) 접근과 직접적 인(direct) 방법 순으로 접근하였다. 그 결과, 활동과 손상 수준에 향상을 보였다. 따라서, 실제 임상 실기에서 PNF 중재 방법이 회전근개 파열 환자의 옷 입고 벗기 활동에 긍정적인 효과를 얻을 수 있을 것으로 판단된다.

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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:**

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- 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 |

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# Global Journal of Science Frontier Research

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ISSN 9755896