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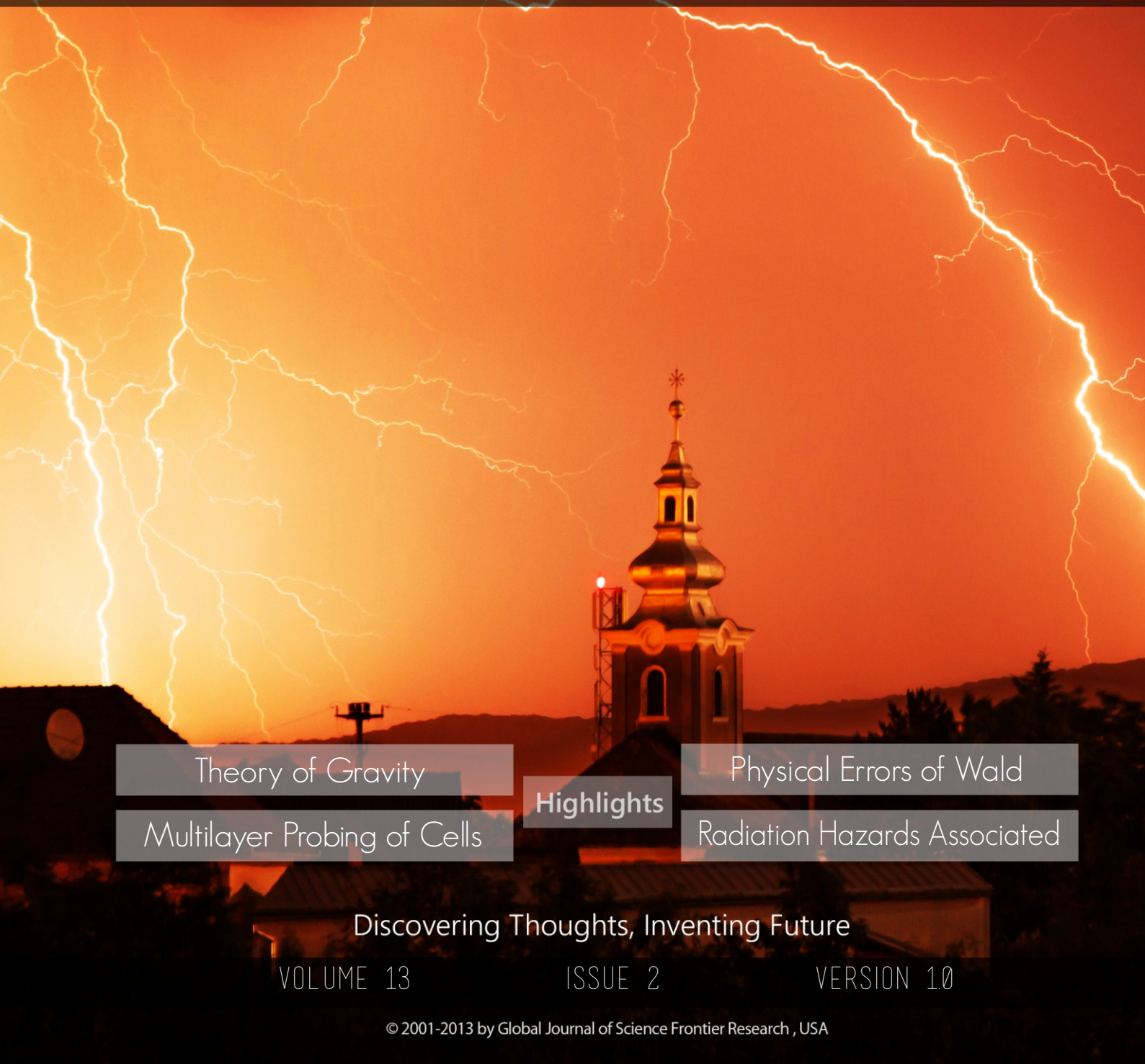

Theory of Gravity

Multilayer Probing of Cells

Highlights

Physical Errors of Wald

Radiation Hazards Associated

Discovering Thoughts, Inventing Future

VOLUME 13 ISSUE 2 VERSION 1.0

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Some Mathematical and Physical Errors of Wald on General Relativity

By C. Y. Lo
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Abstract - In spite of including crucial errors, Wald's book has become a standard reference, in part, because the 1993 No- bel Prize Committee for physics made the same mist- akes. He also has circumvented some errors of Misner, Thorne and Wheeler, but he still fails to understand Einstein's equivalence principle. Moreover, he maintains the major common errors, the existence of dynamic and wave solutions for the Einstein equation, and thus also the claimed validity of linearization for weak gravity and the perturbation approach. Another problem is that he failed to see the invalidity of Einstein's covariance principle in physics. This is due to that in spite of his being additionally cautious, Wald was often not able to tell the difference between mathematics and physics. Although his main errors have been shown in the literature, some theorists may not have the mathematical background or the time to go though these. In this paper, his errors are illustrated and explained in mathematics at the undergraduate level.

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SOME MATHEMATICAL AND PHYSICAL ERRORS OF WALD ON GENERAL RELATIVITY

Strictly as per the compliance and regulations of :

Some Mathematical and Physical Errors of Wald on General Relativity

C. Y. Lo

Abstract - In spite of including crucial errors, Wald's book has become a standard reference, in part, because the 1993 Nobel Prize Committee for physics made the same mistakes. He also has circumvented some errors of Misner, Thorne and Wheeler, but he still fails to understand Einstein's equivalence principle. Moreover, he maintains the major common errors, the existence of dynamic and wave solutions for the Einstein equation, and thus also the claimed validity of linearization for weak gravity and the perturbation approach. Another problem is that he failed to see the invalidity of Einstein's covariance principle in physics. This is due to that in spite of his being additionally cautious, Wald was often not able to tell the difference between mathematics and physics. Although his main errors have been shown in the literature, some theorists may not have the mathematical background or the time to go though these. In this paper, his errors are illustrated and explained in mathematics at the undergraduate level.

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"Science sets itself apart from other paths to truth by recognizing that even its greatest practitioners sometimes err"

-- S. Weinberg, Physics Today, November 2005.

I. Introduction

In celebrating a wonderful tradition, the installation of a new MIT president, I had a chance to talk to MIT President, Dr. L. Rafael Reif. Since he asked the community, including MIT Alumni to help him to do a better job, I ventured again to tell that in my 20 years of research on fundamental problems in physics, I discovered that there are many problems in current theories of general relativity. He asked me to give him a report with details on these.

I examined the MIT open course Phy. 8.962 (instructed by Prof. Bertschinger[1)]) with the textbook [1] by Sean Carroll.[2)] As expected, there still are major errors that started from the beginning of general relativity. For instance, as Gullstrand [2, 3] pointed out in 1921, there is actually no dynamic solution for the non-linear Einstein equation,

$$G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = -\kappa T_{\mu\nu}, \kappa = 8\pi K/c^2 = 1.86\times 10^{-27} \quad (1)$$

Author : Applied and Pure Research Institute 7 Taggart Drive, Unit E, Nashua, NH 03060 January, 2013.

Where $g_{\mu\nu}$ is the space-time metric, $R_{\mu\nu}$ is Ricci tensor, and $T_{\mu\nu}$ is the source, energy momentum tensor of matter [4]. Also K is the gravitational constant in Newtonian theory, and c is the velocity of light in vacuum.

Carroll stated that he has often leaned heavily on the book of Wald [5] as a primary source since it has become a standard reference in the field. Thus, I decided to publish another paper on general relativity to illustrate and explain errors of Wald because this spreading of errors should be stopped as soon as possible. Previously, I have reported problems on MIT open course, Phy. 8.033 to former MIT President Susan Hockfield, but that involved mainly the errors of the Wheeler School [6].

The issue of whether the Einstein equation has far reaching consequences leads to answering issues such as whether $E = mc^2$ is only conditionally valid, (Appendix A),whether all the coupling constants have the same sign, and whether general relativity is not applicable to microscopic phenomena as Penrose and Hawking claimed, etc. In fact, the mistakes on the question of dynamic solutions are responsible for many subsequent absurd claims [7].

II. Equivalence of the Inert & the Gravitational Mass, and Einstein's Equivalence Principle

Wald [5] circumvented Einstein's equivalence principle, but claimed the equivalence of inert mass and the gravitational mass due to Galileo and Newton as "the equivalence principle", but the 1993 Nobel Prize Committee for Physics adapted this view. In so doing, Wald avoided criticizing the error of Misner, Thorne, and Wheeler [6] because they have misidentified Einstein's equivalence principle of 1916 as the invalid 1911 assumption of equivalence between acceleration and Newtonian gravity. However, this also exposed that Wald does not understand Einstein's equivalence principle-historical errors in mathematics and physics.

Einstein's equivalence principle is based on the then highly accurate experimental fact that the inert mass and the gravitational mass can be considered the same although they are defined very differently. Then, he considered two space coordinate systems: an inertial

system K and a system K' that is uniformly accelerated with respect to K. Then masses that are free from acceleration with respect to K, would have equal and parallel acceleration with respect to K'. They behave just as if a gravitational field were present and K' is unaccelerated. Einstein called the assumption of the complete physical equivalence of the systems of coordinates, K and K' the "principle of equivalence". Einstein considered that this principle is evidently intimately connected with the law of the equality between the inert and the gravitational mass, and signifies an extension of the principle of relativity to co-ordinate systems which are in non-uniform motion relatively to each other.

Nevertheless, Wald claimed "This fact, known as the equivalence principle, is expressed in Newtonian theory of gravitation by the statement that the gravitational force on a body is proportional to its inertial mass." Thus Wald changed Einstein's equivalence principle completely, and reduced it to the level of Galileo and Newton. Then, he omitted the Einstein-Minkowski condition completely that follows Einstein's equivalence principle. Thus, Wald could avoid the obvious conflict between the Einstein-Minkowski condition and Einstein's covariance principle [7] that Wald subsequently heavily leaned on.

Moreover, he derived the bending of a light without going through the Einstein-Minkowski condition [4]. Then he omitted the justifications for the adaptation of Einstein's theory of measurement and thus avoided approving the invalid applications of Einstein with special relativity to justify his theory of measurement [8]. He also avoided the issue of inconsistency with observed light bending from using Einstein's theory of measurement. However, he still failed to achieve the consistency with Einstein's theory of measurement because the interior solution and the exterior solution must be continuous at the surface of a massive ball. For the Schwarzschild gauge, this means as shown in his equation (6.2.10) [5] that the total mass

$$M = m(R) = 4\pi\int_0^R \rho(r)r^2 dr \qquad (2)$$

where $\rho(r)$ is the density of the mass. However, this also means that Einstein's theory of measurement is not valid because as shown in his equation (6.2.11), it would require that.

$$M' = m(R) = 4\pi\int_0^R \rho(r)r^2\left[1-\frac{2m(r)}{r}\right]^{1/2} dr \qquad (2')$$

Wald's interpretation is that M' is total proper mass. However, he failed to explain why the difference (M' – M) does not contribute to gravity.

Apparently, Wald was unaware of that Einstein's equivalence principle plays a crucial role in deriving the Maxwell-Newton Approximation (see Appendix B) which is identical to the linearized equation with massive sources in the harmonic gauge [9]. This derivation is necessary because the non-linear Einstein equation has been found [10, 11] to be invalid for the dynamic case. However, Wald also has mistaken that the Einstein equation had dynamic solutions. He failed to see that a mathematical equation may not necessarily have a valid solution for physics, and thus he often claimed a solution for an equation without a necessary proof.[3)]

III. Weak Gravity, Gravitational Waves, and the Principle of Causality

According to Einstein [4], in general relativity weak sources would produce a weak field, i.e.,

$$g_{\mu\nu} = \eta_{\mu\nu} + \gamma_{\mu\nu}, \text{ where } |\gamma_{\mu\nu}| << 1 \qquad (3)$$

and $\eta_{\mu\nu}$ is the flat metric when there is no source. For the static case, condition (3) is verified. However, for the dynamic case, Gullstrand [2, 3] suspected that condition (3) may not be valid. According to the principle of causality, condition (3) should be valid; but this is true only if the equation is valid in physics. Many theorists failed to see this because they failed to see the difference between physics and mathematics clearly [7]. In other words, condition (3) and whether the principle of causality is applicable need a rigorous proof.

Unfortunately, many believe that condition (3) is always valid for general relativity because Einstein has produced accurate predictions for the static case. When the Einstein equation has a weak solution, an approximate weak solution can be derived through the approach of the field equation being linearized. The linearized Einstein equation with the linearized harmonic gauge $\partial^\mu \bar{\gamma}_{\mu\nu} = 0$ is

$$\frac{1}{2}\partial^\alpha\partial_\alpha\bar{\gamma}_{\mu\nu} = \kappa T_{\mu\nu} \quad \text{where} \quad \bar{\gamma}_{\mu\nu} = \gamma_{\mu\nu} - \frac{1}{2}\eta_{\mu\nu}\gamma \quad \text{and} \quad \gamma = \eta^{\alpha\beta}\gamma_{\alpha\beta} \qquad (4)$$

Note that we have

$$G_{\mu\nu} = G_{\mu\nu}^{(1)} + G_{\mu\nu}^{(2)} \quad \text{and}$$

$$G_{\mu\nu}^{(1)} = \frac{1}{2}\partial^\alpha\partial_\alpha\bar{\gamma}_{\mu\nu} - \partial^\alpha\partial_\mu\bar{\gamma}_{\nu\alpha} - \partial^\alpha\partial_\nu\bar{\gamma}_{\mu\alpha} + \frac{1}{2}\eta_{\mu\nu}\partial^\alpha\partial^\beta\bar{\gamma}_{\alpha\beta} \qquad (5)$$

The linearized vacuum Einstein equation means

$$G_{\mu\nu}^{(1)}[\gamma_{\alpha\beta}^{(1)}] = 0 \qquad (6)$$

Thus, as pointed out by Wald, in order to maintain a solution of the vacuum Einstein equation to second order we must correct $\gamma^{(1)}{}_{\mu\nu}$ by adding to it the term $\gamma^{(2)}{}_{\mu\nu}$, where $\gamma^{(2)}{}_{\mu\nu}$ satisfies

$$G^{(1)}_{\mu\nu}[\gamma^{(2)}{}_{\alpha\beta}]+G^{(2)}_{\mu\nu}\left[\gamma_{\alpha\beta}\right]=0\text{, where } \gamma_{\mu\nu}=\gamma^{(1)}{}_{\mu\nu}+\gamma^{(2)}{}_{\mu\nu} \quad (7)$$

Which is the correct form of eq. (4.4.52) in Wald's book. (In Wald's book, he did not distinguish $\gamma_{\mu\nu}$ from $\gamma^{(1)}{}_{\mu\nu}$) This equation does have a solution for the static case. However, detailed calculation shows that this equation does not have a solution for the dynamic case [10, 11]. The fact that there is no solution for eq. (7) means also that the Einstein equation does not have a bounded dynamic solution.

An independent supplementary convincing evidence for the absence of a bounded dynamic solution is, as shown by Hu, Zhang & Ting [12], that gravitational radiation calculated would depend on the approach used. This is also a manifestation that there is no bounded solution. A similar problem in approximation schemes such as post-Newtonian approximation [2, 3] is that their validity is also only assumed.

IV. Illustrative Examples for the Nonexistence of Wald's Equation

To illustrate Wald's error, one can consider the example provided by Misner et al. [6]. They claimed that a plane-wave solution is of the form as follows:

$$ds^2 = c^2dt^2 - dx^2 - L^2\left(e^{2\beta}dy^2 + e^{-2\beta}dz^2\right) \quad (8)$$

where $L = L(u)$, $\beta = \beta(u)$, $u = ct - x$, and c is the light speed. Then, the Einstein equation $G_{\mu\nu} = 0$ becomes

$$\frac{d^2L}{du^2} + L\left(\frac{d\beta}{du}\right)^2 = 0 \quad (9)$$

Misner et al. [6] claimed that Eq. (9) has a bounded solution, compatible with a linearization of Einstein equation (1). It has been shown that Misner et al. are incorrect and Eq. (9) does not have a physical solution that satisfies Einstein's requirement on weak gravity [13, 14]. In fact, $L(u)$ is unbounded even for a very small $\beta(u)$.

On the other hand, from the linearization of the Einstein equation (the Maxwell-Newton approximation) in vacuum, Einstein [15] obtained a solution as follows:

$$ds^2 = c^2dt^2 - dx^2 - (1+2\phi)dy^2 - (1-2\phi)dz^2 \quad (10)$$

where ϕ is a bounded function of u $(= ct - x)$. Note that metric (10) is the linearization of metric (8) if $\phi = \beta(u)$. Thus, the problem of waves illustrates that the lineari zation may not be valid for the dynamic case when gravitational waves are involved since eq. (9) does not have a weak wave solution.

In conclusion, due to confusion between mathematics and physics, Wald [5] made errors in mathematics at the undergraduate level. The principle of causality requires the existence of a dynamic solution, but Wald did not see that the Einstein equation can fail this requirement.

Another well-known counter example is the metric obtained by Bondi, Pirani, & Robinson [16] as follows:

$$ds^2 = e^{2\varphi}\left(d\tau^2 - d\xi^2\right) - u^2\begin{bmatrix}\cosh 2\beta\left(d\eta^2 + d\varsigma^2\right)\\ +\sinh 2\beta\cos 2\theta\left(d\eta^2 - d\varsigma^2\right)\\ -2\sinh 2\beta\sin 2\theta\, d\eta\, d\varsigma\end{bmatrix} \quad (11a)$$

where ϕ, β and θ are functions of u $(=\tau-\xi)$. It satisfies the differential equation (i.e., their Eq. [2.8]),

$$2\phi' = u\left(\beta'^2 + \theta'^2\sinh^2 2\beta\right) \quad (11b)$$

They claimed this is a wave from a distant source. (11b) implies *ϕ cannot be a periodic function.* The metric is irreducibly unbounded because of the factor u^2. Both eq. (9) and eq. (11b) are special cases of $G_{\mu\nu} = 0$. However, linearization of (11b) does not make sense since variable u is not bounded. Thus, they claim Einstein's notion of weak gravity invalid because they do not understand the principle of causality adequately.

Moreover, when gravity is absent, it is necessary to have $\phi = \sinh 2\beta = \sin 2\theta = 0$. These would reduce (11a) to

$$ds^2 = \left(d\tau^2 - d\xi^2\right) - u^2\left(d\eta^2 - d\zeta^2\right) \quad (11c)$$

However, this metric is not equivalent to the flat metric. Thus, metric (11c) violates the principle of causality. Also it is impossible to adjust metric (11a) to become equivalent to the flat metric.

This challenges the view that both Einstein's notion of weak gravity and his covariance principle are valid. These conflicting views are supported respectively by the editorials of the "Royal Society Proceedings A" and the "Physical Review D"; thus there is no general consensus. As the Royal Society correctly pointed out [17, 18], Einstein's notion of weak gravity is inconsistent with his covariance principle. However, Einstein's covariance principle has been proven invalid since counter examples have been found [19, 20].

There are other theorists who also ignore the principle of causality. For example, another "plane wave", which is intrinsically non-physical, is the metric accepted by Penrose [21] as follows:

$$ds^2 = du\,dv + Hdu^2 - dx_i dx_i\text{, where } H = h_{ij}(u)x_i x_j \quad (12)$$

Where $u = ct - z$, $v = ct + z$. However, there are arbitrary non-physical parameters (the choice of origin) that are

unrelated to any physical causes. Being a mathematician, Penrose [21] over-looked the principle of causality.

The plane wave solution of Liu & Zhou [22], which satisfies the harmonic gauge, is as follows:

$$ds^2 = dt^2 - dx^2 + 2F(dt - dx)^2 - \cosh 2\psi(e^{2\phi} dy^2 + e^{-2\phi}dz^2) - 2\sinh 2\psi\, dy\, dz. \quad (13)$$

where $\phi = \phi(u)$ and $\psi = \psi(u)$. Moreover, $F = F_P + H$, where

$$F_P = \frac{1}{2}(\dot{\psi}^2 + \dot{\phi}^2 \cosh^2 2\psi)\,[\cosh 2\psi\,(e^{2\phi} y^2 + e^{-2\phi} z^2) + 2\sinh 2\phi\, yz], \quad (14)$$

and H satisfies the equation,

$$\cosh 2\psi\,(e^{-2\phi}H_{,22} + e^{2\phi} H_{,33}) - 2\sinh 2\psi\, H_{,23} = 0. \quad (15)$$

For the weak fields one has $1 >> |\phi|$, $1 >> |\psi|$, but there is no weak approximation as claimed to be

$$ds^2 = dt^2 - dx^2 - (1 + 2\phi)\, dy^2 - (1 - 2\phi)dz^2 - 4\psi dydz \quad (16)$$

because F_p is not bounded unless $\dot{\phi}$ and $\dot{\psi}$ are zero (i.e., no wave).

The linearized equation for a dynamic case has been illustrated as incompatible with the non-linear Einstein equation, which has no bounded dynamic solutions. Thus, Eq. (9), Eq. (11b), and Eq. (13) serve as good simple examples that can be shown through explicit calculation that linearization of the Einstein equation is not valid. Also, metric (12) suggests that the cause of having no physical solution would be due to inadequate source terms [10, 12, 23].

V. The So-Called Space-Time Singularity Theorems, Positive Mass Theorem, and $E = mc^2$

A surprising conclusion, from the investigation of the Einstein equation, is that the space-time singularity theorems of Penrose and Hawking are actually irrelevant to physics. This is so because their theorems have a common implicit assumption that all the couplings have the same sign. However, from the investigation of dynamic solutions, such an assumption is necessarily invalid in physics [9, 10]. These theorems were accepted because Penrose won the arguments against a well-known Russian scientist E. M. Lifshitz who claimed, with the same set of assumptions, that there is no space-time singularity [24]. However, the problem is not the mathematics in the theorems, but the earlier historical errors in mathematics and physics.

As Pauli [25] pointed out, in principle general relativity can have different signs for their coupling constants. The fact that nobody questioned the assumption of unique sign for all coupling, is probably due to the unverified speculation of formula $E = mc^2$ being generally true. This formula comes from special relativity, and the conversion of some mass to various combinations of energy is verified by the fission and fusion in nuclear physics. However, the conversion of a single type of energy to mass actually has never been verified [7].

Einstein and theorists have shown that the photons can be converted into mass thorough absorption [26]. This conversion is supported by the fact that the π_0 meson can be decayed into two photons. Thus, it was claimed that the electromagnetic energy can be converted into mass because they failed to see that the photons must have non-electromagnetic energy. When Einstein proposed the notion of photons, he had not conceived general relativity yet. Thus, understandably he neglected the gravitational component of light. However, after general relativity, a light ray consists of a gravitational component is natural because the electron has a mass. Besides, the electromagnetic energy-momentum tensor has a zero trace, but the energy-momentum tensor of massive matter has a non-zero trace. In fact, Einstein failed to show the general validity of $E = mc^2$ in spite of several years effort [27]. Experimentally, in contrast of Einstein's claim, $E = mc^2$ is not always valid because a piece of heated up metal has reduced weight [28].

Although the Einstein equation does not have a dynamic solution, physically the dynamic solution must exist for a rectified equation. A problem of the Einstein equation is that it does not include the gravitational energy-stress tensor of its gravitational waves in the source and thus the principle of causality is violated. Since a gravitational wave carried energy-momentum and the source of gravity is the energy-stress tensors, as Hogarth [29] pointed out, the presence of a non-zero energy-momentum in the source is necessary for a gravitational wave. Thus, to fit the Hulse-Taylor data of the binary pulsar, it is necessary to modify the Einstein equation [10] to

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = -\kappa\left[T(m)_{\mu\nu} - t(g)_{\mu\nu}\right] \quad (17)$$

Where $t(g)_{\mu\nu}$ is the energy-stress tensor for gravity. For radiation, the tensor $t(g)_{\mu\nu}$ is equivalent to Einstein's notion of the gravitational energy-stress. However, his notion is a pseudo-tensor and can become zero by choosing a suitable coordinate system, but the energy-momentum of a radiation cannot be zero, and thus must be a tensor [10].

It is crucial to note that the new tensor necessarily has a different sign for its coupling. Thus, the implicit assumption of Penrose and Hawking is proven necessarily invalid. Note that the absence of a dynamic solution and the presence of space-time singularities are related to the same invalid assumption.

It is the long standing bias and errors in mathematics that some theorists accepted one but rejected the other. Now, clearly the space-time singularity theorems dramatically illustrate that what could an applied mathematician do without the proper guidance of physics. Other victims are the positive mass theorem of Yau [30] and the positive energy theorem of Witten [31] because they used the same invalid implicit assumption as Hawking and Penrose.

VI. Discussions and Conclusions

Einstein was the major architect or foundation builder of three great theories of modern physics, namely: special relativity, quantum mechanics and general relativity. However, he was also the source of oversight in each theory [7]. In special relativity, he failed to see that $E = mc^2$ is only conditionally valid. In quantum theory, he failed to recognize that photons must include non-electromagnetic energy [32]. In general relativity, his principle of covariance and theory of measurement are invalid [8, 33]. However, related criticisms of Whitehead [34] and Zhou [35] were ignored. The lack of examples to illustrate his equivalence principle makes it possible to have popular misinterpretations and confusions in physics [36].

Some theorists such as Carroll [1] claimed "General relativity is the most beautiful physical theory ever invented." This reaffirms that beauty is in the eyes of the beholder. He probably simply regurgitates what he heard in Caltech, where Thorne [23] erroneously claimed his student's opinion, that Einstein neglected the tidal force as Einstein's, although Einstein explicitly pointed it out as wrong [37].[4] In addition to that analysis shows clearly that there are no bounded wave-solutions; there are many necessarily unbound "wave". Thus, it is a puzzle how the "experts" never reexamine the hand-waving "proofs" for such a long time. A problem of the Wheeler School and her associates is that they seldom read papers that are written by "outsiders" and thus their errors would continue regardless.

However, now it is clearly an incomplete theory that remains to be explored. In terms of physics, a basic problem is that just as in Maxwell's classical electromagnetism [38], there is also no radiation reaction force in general relativity. Although an accelerated massive particle would create radiation [24], the metric elements in the geodesic equation are created by particles other than the test particle [4]. (Thus, Carroll's [1] tendency, to think of general relativity as a field, would be valid.) Another problem is the exact field equation for the dynamic case. Because of the misinterpretation of $E = mc^2$, the study of gravitational effects of electromagnetism is clearly inadequate [7]. The discovery of the charge-mass interaction is a good beginning since the need for Einstein's unification is confirmed.

Unfortunately, these potentially great developments have been blocked because of the inadequacy of the theorists in mathematics and historical inadequacy in physics. Half of the book of Wald [4] dealt with "advanced topics", but they are actually at most unverified speculations. It is obvious that there is no perturbation approach since there is no bounded dynamic solution. The misunderstanding on the notion of gauge invariance [39] persistently presented by C. N. Yang [40, 41] was probably responsible for prolonging the incorrect acceptance of Einstein's covariance principle after it has been found to be invalid through explicit examples [33].

Historically, in the US, the Wheeler School has been responsible for recognizing the importance of general relativity. It is hoped that they are able to continue their efforts after rectifying their mistakes. A lesson to be learned is that nothing can damage sciences more than biased authority worship. Currently, the Einstein equation is served as guidance for the research in string theory. It would be a great disservice to the string theorists if the problem in the Einstein equation is withheld from them. It seems to me that the string theory, if correct, must be able to include the experimentally verified charge-mass interaction, newly discovered from an analysis of general relativity [7, 28]. It is hoped this paper would help theorists to look at unsolved problems squarely.[5]

IV. Acknowledgments

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a) Appendix A: on Invalidity of $e = mc^2$ and Related Errors

Based on special relativity, it is conjectured that mass can be equivalent to energy with the relation $E = mc^2$ [4]. This conversion is supported by fission and fusion in nuclear physics. In such a conversion the resulting energy is a combination of different types of energy.

However, there is no example that a single type of energy can be converted to mass. Einstein claimed that electromagnetic energy can be equivalent to mass. However, this is actually due to that Einstein failed to see that photons actually consist of gravitational energy [7]. This inclusion is natural after general relativity since a charged particle always has mass. Einstein tried to extend this relation to other types of energy for several years (1905-1909) but failed [27]. Recently, experiments have shown that electromagnetic energy alone is not equivalent to mass [28].

Some argued that the mass of a particle can be defined with the formula $f = ma$. A problem is that such a mass may not be related to the energy of such a force. For instance, although the electromagnetic force acting on a charged particle, this does not enable one to establish a relation between such a mass and the electromagnetic energy. In fact, this is also an error of Nobel Laureate G.'t Hooft made in his 1999 Nobel speech.

Moreover, before direct experimental evidence against the formula $E = mc^2$ are known, there exists a theoretical puzzle because the photons have no mass. For this, some defined an electromagnetic mass with $m_e = E_e/c^2$ in terms of the electromagnetic energy E_e, but few theorists questioned whether such a definition makes sense in physics. Now, it has been shown that this formula may fail, and thus cannot be considered as generally valid. Hence, one should have asked whether such a new definition of mass is equivalent to the inert mass and/or the gravitational mass. Now, clearly this line of thinking actually does not lead to any meaningful physics. In fact, it is probably due to a failure in distinguishing mathematics from physics that must be additionally supported by experiments.[3)]

b) Appendix B: The Question of Dynamic Solutions and the Maxwell-Newton Approximation

A problem in general relativity [10] is that, for a dynamic case, there is no bounded solution,

$$|g_{ab}(x, y, z, t)| < \text{constant}, \qquad \text{(A1)}$$

for the Einstein equation, where g_{ab} is the space-time metric [4]. In fact, eq. (A1) is also a necessary implicit assumption in calculating Einstein's radiation formula [42] and the light bending [23]. One might argue that requirement (A1) violates the covariance principle. However, the covariant principle is invalid in physics [33].

Moreover, Einstein's notion of weak gravity [4] is also in agreement with the principle of causality. However, although such a requirement can be satisfied for the static case, it fails for a dynamic case [10].

The question of valid dynamic solutions was raised by Gullstrand [2] the chairman of Nobel Prize Committee for Physics (1922-1929). He challenged Einstein and also Hilbert who approved Einstein's calculations [43]. Apparently Hilbert was unaware of the need of a bounded dynamic solution for the perturbation approach to this issue. However, Hilbert, being an excellent mathematician, did not participate in the subsequent efforts for the defense of Einstein's claim. Nevertheless, theorists such as Misner, Thorne and Wheeler [6] and Christodoulou & Klainerman [44], etc. failed to see this, and tried very hard to prove otherwise. Their efforts have been proven as futile [10, 45].

The failure of producing a dynamic solution would cast a strong doubt to the validity of the linearized equation that produces many effects including the gravitational waves. In fact, for the case that the source is an electromagnetic plane wave, the linearized equation actually does not have a bounded solution [46].

Nevertheless, when the sources are massive, some of such results from the linearized equation have been verified by observation. Thus, there must be a way to justify the linearized equation, independently. Such an investigation has led additionally to a modified Einstein equation that would have dynamic solutions. To this end, Einstein's equivalence principle [9] is needed, and thus this principle, though rejected by the 1993 Nobel Prize Committee for Physics implicitly [47], is crucial in general relativity. As a result, it becomes even clearer that the non-existence of a bounded dynamic solution for massive sources is due to a violation of the principle of causality [13].

i. *Gravitational Waves and the Einstein Equation of 1915*

Relativity requires the existence of gravitational waves because physical influence must be propagated with a finite speed [48]. To this end, let us consider the Einstein equation of 1915 [4]. Einstein believed that his equation satisfied this requirement since its linearized "approximation" gives a wave solution.

The linearized equation with massive sources [4] is the Maxwell-Newton Approximation [10],

$$\frac{1}{2}\partial_c\partial^c\bar{\gamma}_{ab} = -\kappa T(m)_{ab}, \qquad \text{(A2)}$$

where $\bar{\gamma}_{ab} = \gamma_{ab} - (1/2)\eta_{ab}$, $\gamma_{ab} = g_{ab} - \eta_{ab}$, $\gamma = \eta^{cd}\gamma_{cd}$, and η_{ab} is the flat metric. Eq. (A2) has a mathematical structure similar to that of Maxwell's equations. A solution of eq. (A2) is

$$\bar{\gamma}_{ab}(x_i,t) = -\frac{\kappa}{2\pi}\int\frac{1}{R}T_{ab}[y^i, (t-R)]\, d^3y,$$

$$\text{where } R^2 = \sum_{i=1}^{3}\left(x^i - y^i\right)^2 \qquad \text{(A3)}$$

Note that the Schwarzschild solution, after a gauge transformation, can also be approximated by (A3). Solution (A3) would represent a wave if T_{ab} has a dynamical dependency on time t' (= t – R). Thus, the theoretical existence of gravitational waves seems to be assured as a certainty as believed [25, 42, 49].

However, for non-linear equations, the physical second order terms can be crucial for the mathematical existence of bounded solutions. For Einstein equation (1), the Cauchy initial condition is restricted by four constraints since there is no second order time derivatives in G_{at} (a = x, y, z, t) [42]. This suggests that Einstein equation (1) and eq. (A1) may not be compatible for a dynamic problem. Einstein discovered that his equation does not admit a propagating wave

solution [50, 51]. Recently, it has been shown that the linearization procedure is not generally valid in mathematics [10, 52]. Thus, it is necessary to justify wave solution (A3) independently.

ii. *The Weak Gravity of Massive Matter and Einstein Equation of the 1995 Update*

For a massive source, the linear equation (A2), as a first order approximation, is supported by experiments [10, 39]. However, for the dynamic case, the Einstein equation is clearly invalid.

It will be shown that eq. (A2) can be derived from Einstein's equivalence principle. Based on this principle, the equation of motion for a neutral particle is the geodesic equation. In comparison with Newton's second law, one obtains that the Newtonian potential of gravity is approximately $c^2 g_{tt}/2$. Then, in accord with the Poisson equation and special relativity, the most general equation for the first order approximation of g_{ab} is,

$$\frac{1}{2}\partial_c\partial^c\gamma_{ab} = -\frac{\kappa}{2}[\alpha T(m)_{ab} + \beta\hat{T}(m)\eta_{ab}], \qquad \text{(A4a)}$$

where

$$\hat{T}(m) = \eta^{cd}T(m)_{cd}, \quad \kappa = 8\pi K c^{-2}, \quad \text{and} \quad \alpha + \beta = 1, \qquad \text{(A4b)}$$

where α and β are constants since Newton's theory is not gauge invariant.

Then, according to Riemannian geometry [42], the exact equation would be

$$R_{ab} + X^{(2)}_{ab} = -\frac{\kappa}{2}[\alpha T(m)_{ab} + \beta T(m)g_{ab}],$$

where

$$T(m) = g^{cd}T(m)_{cd} \qquad \text{(A5a)}$$

and $X^{(2)}_{ab}$ is an unknown tensor of second order in K, if R_{ab} consists of no net sum of first order other than the term $(1/2)\,\partial_c\partial^c\gamma_{ab}$. This requires that the sum

$$-\frac{1}{2}\partial^c[\partial_b\gamma_{ac} + \partial_a\gamma_{bc}] + \frac{1}{2}\partial_a\partial_b\gamma, \qquad \text{(A5b)}$$

must be of second order. To this end, let us consider eq. (A4a), and obtain

$$\frac{1}{2}\partial_c\partial^c(\partial^a\gamma_{ab}) = -\frac{\kappa}{2}[\alpha\partial^a T(m)_{ab} + \beta\partial_b\hat{T}(m)] \qquad \text{(A6a)}$$

From $\nabla^c T(m)_{cb} = 0$, it is clear that $K\,\partial^c T(m)_{cb}$ is of second order but $K\partial_b\hat{T}(m)$ is not. However, one may obtain a second order term by a suitable linear combination of $\nabla^c\gamma_{cb}$ and $\partial_b\gamma$. From (A6a), one has

$$\frac{1}{2}\partial_c\partial^c(\partial^a\gamma_{ab} + C\,\partial_b\gamma) = -\frac{\kappa}{2}[\alpha\partial^a T(m)_{ab} + (\beta + 4C\beta + C\alpha)\partial_b\hat{T}(m)]. \qquad \text{(A6b)}$$

Thus, the harmonic coordinates (i.e., $\partial^a\gamma_{ab} - \partial_b\gamma/2 \approx 0$), can lead to inconsistency. It follows eqs. (A5b) and (A6b) that, for the other terms to be of second order, one must have C = -1/2, α = 2, and β = -1. Hence, eq. (A4a) becomes,

$$\frac{1}{2}\partial_c\partial^c\gamma_{ab} = -\kappa[T(m)_{ab} - \frac{1}{2}\hat{T}(m)\eta_{ab}]. \qquad \text{(A7)}$$

Which is equivalent to eq. (A2a), has been determined to be the field equation of massive matter. This derivation is independent of the exact form of equation (A5a). The implicit gauge condition is that the flat metric η_{ab} is the asymptotic limit. Eq. (A7) is compatible with the equivalence principle as demonstrated by Einstein in his calculation of the bending of light. Thus, the derivation is self-consistent.

Einstein obtained the same values for α and β by considering eq. (A5a) after assuming $X^{(2)}_{ab} = 0$ [43]. His equation (A2) could also be "derived" from a more general linear equation, if one regards the gravitational field as a spin 2 field coupled to the energy-stress tensor [48, 49], and the existence of bounded dynamic solutions be assumed.

An advantage of the approach of considering eq. (A4) and eq. (A5b) is that the over simplification $X^{(2)}_{ab} = 0$ is not needed. Then, it is possible to obtain from eq. (A5a) an equation different from eq. (A2),

$$G_{ab} \equiv R_{ab} - \frac{1}{2}g_{ab}R = -\kappa[T(m)_{ab} - Y^{(1)}_{ab}]$$

where

$$-\kappa Y^{(1)}_{ab} = X^{(2)}_{ab} - \frac{1}{2}g_{ab}\{X^{(2)}_{cd}g^{cd}\}. \qquad \text{(A8)}$$

The conservation law $\nabla^c T(m)_{cb} = 0$ and $\nabla^c G_{cb} \equiv 0$ implies also $\nabla^a Y^{(1)}_{ab} = 0$. If $Y^{(1)}_{ab}$ is identified as the gravitational energy tensor of $t(g)_{ab}$, Einstein equation of the 1995 update [10] is reaffirmed. Note that eq. (A2a) is the first order approximation of eq. (A8) but may not be of eq. (A2). Note, however, that in Einstein's initial consideration, $t(g)_{ab}$ is a pseudo-tensor. It has been shown that it must be a tensor [10].

Endnotes

1. Edmond Bertschinger, B.S. (1979) in Phys., Caltech, Ph.D. (1984), Princeton Univ., advisor: Jeremiah P. Ostriker, whose advisor is S. Chandrasekhar. In 1995 Chandrasekhar, as the editor of the Astrophysical Journal, was finally convinced that there is no dynamic solution for the Einstein equation [10]. Another instructor is Scott A. Hughes, B.A. (1993) in Phys. Cornell Univ., Ph.D. (1998) Caltech under Kip Thorne.
2. Sean M. Carroll, Ph.D. (1993) Harvard University, Advisor George Field, a chemist turned Astrophysicist.

3. For a theoretical physicist, it is important to tell the difference between mathematics and physics. A good example is that although mathematically a non-Abelian gauge theory can be totally gauge invariant, a physical theory cannot be totally gauge invariant because a totally gauge invariant theory cannot represent distinct particles.
4. One should not be too surprised if some graduates of Caltech make errors in general relativity since Kip Thorne often made errors in general relativity, including mathematical errors at the undergraduate level [13, 14].
5. A well-known problem is NASA's discovery of Pioneer Space- Probe Anomaly. Recently, it was claimed that this problem has been resolved by a heat-radiation model. However, Erik Anderson (April 1, 2011 at 12:57) a discoverer of the anomaly commented, " I take the opposite viewpoint of Paul and Daniel. Science will have suffered the worst sort of dysfunction if the Pioneer Anomaly gets swept under the convenient rug of "the plausible." Even so, we will still have the Earth flyby anomalies and the so-called "A.U." anomaly left unco-vered. All three anomalies seem to be manifestations of a singular phenomenon — the latter two cannot be dismissed as heat radiation. Heat-radiation models, like string theory, can be customized to fit any set of observational parameters. There is no limit on sophistication. We should not be so easily impressed. Nothing has been resolved.

And it needn't have cost 100's of millions of dollars to do some authentic observational research. The New Horizons mission to Pluto could have been adapted to re-test the Anomaly if it was taken seriously enough in the first place. But Daniel is correct to point out that it wasn't even then. Still, that sum of money would have been a better investment than the 100's of millions of dollars wasted on LIGO — which I expect future historians of science to gossip about as their white elephant of choice."

References Références Referencias

1. Carroll, Sean. *An Introduction to General Relativity: Spacetime and Geometry* (San Francisco., Addison Wesley, 2003).
2. A. Gullstrand, Ark. Mat. Astr. Fys. **16**, No. 8 (1921).
3. A. Gullstrand, Ark. Mat. Astr. Fys. **17**, No. 3 (1922).
4. A. Einstein, *The Meaning of Relativity* (Princeton Univ. Press 1954).
5. R. M. Wald, *General Relativity* (The Univ. of Chicago Press, Chicago, 1984).
6. C. W. Misner, K. S. Thorne, & J. A. Wheeler, *Gravitation* (Freeman, San Francisco, 1973).
7. C. Y. Lo, Phys. Essays, **23** (2), 258-267 (2010).
8. C. Y. Lo, Phys. Essays **18** (4), 547-560 (December, 2005).
9. C. Y. Lo, Phys. Essays **12** (3), 508-526 (Sept. 1999).
10. C. Y. Lo, Astrophys. J. 455, 421-428 (1995); Editor S. Chandrasekhar suggests and approves the Appendix.
11. C. Y. Lo, Phys. Essays **13** (4), 527-539 (December, 2000).
12. N. Hu, D.-H. Zhang, & H.-G. Ding, Acta Phys. Sinica, 30 (8), 1003-1010 (Aug. 1981).
13. C. Y, Lo, Astrophys. Space Sci., **306**: 205-215 (2006).
14. C. Y. Lo, in Proc. of 18th Annual Natural Philosophy Alliance Conf., Vol. **8**, 354-362, Univ. of Maryland, USA. 6-9 July, 2011.
15. A. Einstein, Sitzungsberi, Preuss, Acad. Wis. 1918, 1: 154 (1918).
16. H. Bondi, F. A. E. Pirani, & I. Robinson, Proc. R. Soc. London A **251**, 519-533 (1959).
17. C. Y. Lo, International Meeting on Physical Interpretation of Relativity Theory, Imperial College, London, Sept. 12-15, 2008; Bull. of Pure and App. Sci., **29D** (2), 81-104 (2010).
18. Pring F, The Royal Society, "Board Member's Comments" (Jan. 8, 2007).
19. C. Y. Lo, Phys. Essays **18** (1), 112-124 (March 2005).
20. C. Y. Lo, Bull. of Pure and App. Sci., **27D** (1), 1-15 (2008).
21. R. Penrose, Rev. Mod. Phys. 37 (1), 215-220 (1965).
22. Liu H. Y., & Zhou, P.-Y.: Scientia Sincia (Series A) 1985, XXVIII (6) 628-637.
23. C. Y. Lo, Phys. Essays **10**, 424 (1997).
24. K. S. Thorne, Black Holes and Time Warps (Norton, New York, 1994), p. 105.
25. W. Pauli, *Theory of Relativity* (Pergamon Press, London, 1971).
26. H. C. Ohanian, *Einstein's Mistakes: The Human Failings of Genius* (Noton, New York, 2008).
27. "*Einstein's Miraculous Year*" edited and introduced by John Stachel, Princeton Univ. Press (1998), p. 118.
28. C. Y. Lo, GJSFR Vol. 12 Issue 7 (Ver. 1.0) (Sept. 2012).
29. J. E. Hogarth, 1953 Ph. D. Thesis, Dept. of Math., University of London.
30. R. Schoen & S.-T. Yau, Commun. Math. Phys. **79**, 231-260 (1981).
31. E. Witten, Commun. Math. Phys., **80**, 381-402 (1981).
32. C. Y. Lo, Completing Einstein's Proof of $E = mc^2$, Progress in Phys., Vol. 4, 14-18 (2006).
33. C. Y. Lo, Phys. Essays, **23** (3), 491-499 (Sept. 2010).
34. A. N. Whitehead, *The Principle of Relativity* (Cambridge Univ. Press, Cambridge, 1962).
35. Zhou Pei-yuan, "Further Experiments to Test Einstein's Theory of Gravitation," Proc. of International Symposium on Experimental Gravitational Physics (Guangzhou, 3-8 Aug. 1987), 110-116 (World Sci., Singapore).

36. C. Y. Lo, Bulletin of Pure and Applied Sciences, **26D** (2), 73-88 (2007).
37. J. Norton, "What was Einstein's Principle of Equivalence?" in Einstein's Studies Vol.1: *Einstein and the History of General Relativity,* Eds. D. Howard & J. Stachel (Birkhäuser, Boston, 1989).
38. J. D. Jackson, *Classical Electrodynamics*, (John Wiley & Sons, New York, 1962).
39. S. Weinberg, *The Quantum Theory of Fields* (Cambridge University Press, Cambridge, 2000).
40. C. N. Yang & R. L. Mills, Phys. Rev. **96**, 191 (1954);
41. Ron Shaw, Ph. D. thesis, Cambridge University (1955).
42. S. Weinberg, "Gravitation and Cosmology" (John Wiley, New York, 1972), pp. 69, 251-273.
43. A. Pais, 'Subtle is the Lord ...' (Oxford University Press, New York, 1996).
44. D. Christodoulou and S. Klainerman, *The Global Nonlinear Stability of the Minkowski Space* (Princeton University Press, 1993).
45. C. Y. Lo, GJSFR Vol. 12 Issue 4 (Ver. 1.0) (June 2012).
46. C. Y. Lo, David P. Chan, and Richard C. Y. Hui, Phys. Essays **15** (1), 77-86 (March 2002).
47. The 1993 Press Release of the Nobel Prize Committee (The Royal Swedish Academy of Sciences, 1993).
48. H. A. Lorentz, Proc. K. Ak. Amsterdam 8, 603 (1900).
49. H. C. Ohanian & R. Ruffini, "Gravitation and SpaceTime" (Norton, New York, 1994).
50. M. Born, "The Born-Einstein Letters" (Walker, New York, 1968), p.125.
51. A. Einstein & N. Rosen, J. Franklin Inst. 223, 43 (1937).
52. C. Y. Lo, in Proc. 7th Marcel Grossmann Meeting On Gen. Relat., 525 (World Sci., 1996).

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Rotating X-Ray Window for Multilayer Probing of Cells; Microfocussing Techniques

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Abstract - This project report covers soft X-ray generation of the X-ray microprobe and advances made at the Gray Cancer Institute. Schematics and benefits of the microprobe are presented and microfocussing techniques specifically for enhanced spatial image resolution of cellular structures are considered.

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ROTATING X-RAY WINDOW FOR MULTILAYER PROBING OF CELLSMICROFOCUSSING TECHNIQUES

Strictly as per the compliance and regulations of :

Rotating X-Ray Window for Multilayer Probing of Cells; Microfocussing Techniques

Dikedi P.N.

Abstract - This project report covers soft X-ray generation of the X-ray microprobe and advances made at the Gray Cancer Institute. Schematics and benefits of the microprobe are presented and microfocussing techniques specifically for enhanced spatial image resolution of cellular structures are considered.

I. Introduction

Soft X-rays optical components are outperformed by those of visible light due to a number of setbacks; they suffer from poor efficiencies, poor spatial resolution, large aberrations, strong chromatic aberration and low angular and wavelength band passes. These setbacks are ameliorated by the use of zone plates, multilayer mirrors, periodic mirrors and grazing incidence mirrors. The Gray Cancer Institute (GCI) for over ten years has been active in the development and use of microfocussing techniques for radiobiological purposes. In the next section, few techniques are discussed which are diffractive optics by the use of zone plates and reflective optics by the use of multilayer mirrors and grazing incidence mirrors.

II. Zone Plates

Application of Fresnel zone plate in achieving submicrometre spot size diameter on irradiated biological samples has been a common practice. They are vital optical elements used at the GCI and King's college in the ongoing development of a micro irradiation system that uses a focused X- ray microprobe to irradiate individual cells. At short wavelengths particularly in the soft X-ray region, the use of zone plates is employed because

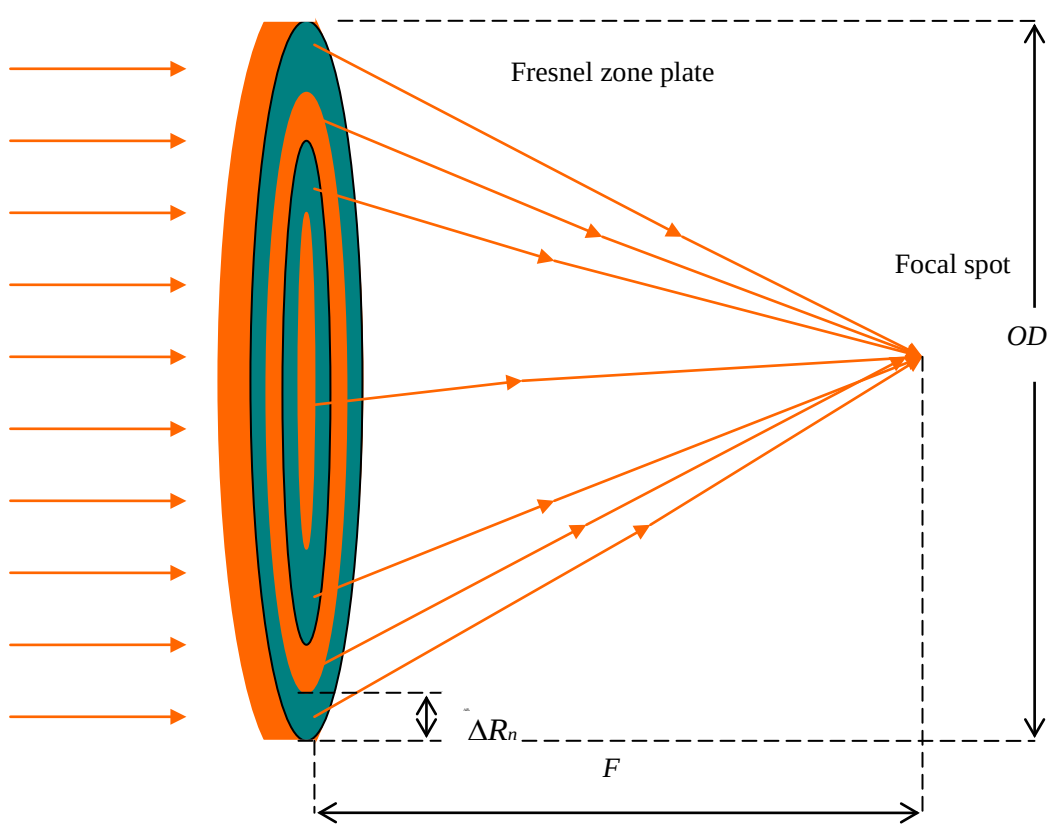


Figure 1.1 : Schematic of Fresnel zone plate of focal length, *F*, with *OD* as its diameter and ΔR_n as its outermost zone width

Author : Physics Department, King's College, London.

sof their ability to form images at very high spatial resolution; very close to the diffraction limit and sub15nm resolution has been achieved [5]. It is able to ameliorate most of the setbacks in X-ray optics highlighted in the previous section. Diffraction patterns and the energy which each pattern represents always propagate from diffracting structures such as disks, angles of order $\theta \approx \frac{\lambda}{D}$ where D is a characteristic dimension [6].

When interference occurs between diffracted and undiffracted radiation, interference takes place at well defined positions; distances from such positions represent focal lengths. Fresnel zone plate lens is one of the focusing devices used in synchrotrons. Zone plates form a focus by using constructive interference of rays from adjacent zones The focal length ,F, of a zone plate is related to its diameter, OD , its outermost zone width, ΔR_n , and the X-ray wavelength, λ by

$$F = \frac{OD\Delta R_n}{\lambda} \tag{1.1}$$

Fresnel zone plates consist of alternating transparent and opaque (amplitude of Fresnel zone plate) concentric rings (zones). The spatial resolution of the zone plate for an incoming wave is expressed according to the Raleigh criterion as

$$\varsigma = 1.22\ \Delta R_n \tag{1.2}$$

Where ς, is spatial resolution; equations 1.1 and 1.2 indicate that for a spatial resolution of less than1 μm to be achieved all values of outermost zone width less than 0.82 μm must be used and the achievable values of focal lengths are not more than 234.78mm provided the value of zone diameter is assumed to be 80 μm hence a resolution of less than1 μm can be achieved by fabricating zone plates with zones of outermost zone width diameter less than 0.82 μm etched on a material. The value of spatial resolution, ς, is limited by X-ray photon energy of 4.5KeV (0.276nm) for titanium. The micro focusing system at the GCI which employs the use of Fresnel zone plate of 0.2-0.8mm diameter is able to focus K_α X- ray of carbon or aluminum to a beam of less than 1μm diameter, forming zone plate images. The focused X-rays are aimed at sub cellular targets and about 3000 cells per hour can be irradiated individually. The use of zone plates for producing very fine probes is now well established [7, 8].

The proposed X-ray window will be positioned under a zone plate in a table source microprobe at the GCI, which is illustrated in figure 1.1

III. Multilayer Mirrors

Multilayer coated mirrors are artificial structures designed to enhance reflectivity, through constructive interference of beams reflected from many layer interfaces [9]. Reflection coefficient and absorption coefficient of multilayer mirrors contribute significantly to the degree of precision attained.

Bragg's law states,

$$m\lambda = 2d\sin\theta_m \tag{1.3}$$

Where m is an integer, d is the spatial periodicity, λ is the wavelength; X-rays, incident at angle θ with respect to the mirror surface will be strongly reflected at angles close to Bragg angle θ_m for *mth* order diffraction, but a maximum angle called an angle of peak reflectivity θ_{mp} may be achieved if this angle is made slightly greater than the Bragg angle [10]. i.e. $\theta_{mp} > \theta_m$. The reflectivity at an interface is determined by the Fresnel equation,

$$R = \frac{(n-1)^2}{(n+1)^2} \approx \frac{\delta^2}{4} \tag{1.4}$$

Where R, is the normal incidence reflectivity, δ is the refractive index decrement, β is the absorption index and n is the refractive index of the multilayer material. Higher reflectivities can be obtained by making the more absorbing layers thinner or making less absorbing layers thicker [10]. This reduces absorption and enhances reflectivity. Before making a multilayer mirror choice of suitable material must be considered. Three rules are normally adopted [10]:

- Select a material with a low absorption coefficient for the "transmitting" (spacer) layer.
- Select a second material to give a large reflection coefficient at the boundary with the first (means large difference in δ values). If several materials give similar reflection coefficients, use that with the lowest. value of β to give less absorption.
- Make sure that the two materials can form physically and chemically stable boundaries, and can be deposited with low roughnesses and interdiffusion.

Multi layer mirrors (multi layer interference coatings) are made by depositing alternating layers of two materials of differing refractive index to form stable interfaces. These materials are of high and low atomic numbers so as to obtain large or maximum difference in electron density. Multilayer mirrors are elliptically bent to produce smaller spot size, hence a better defined focal spot [11].

IV. Grazing Incidence

Grazing incidence optics is a reflective optics technique based on total external reflection. Grazing incidence mirrors are used to achieve grazing incidence and grazing angles.

$$\theta_c = \sqrt{2\delta} \quad (1.5)$$

$$n = 1 - \delta + i\beta \quad (1.6)$$

$$\theta_c \propto \lambda\sqrt{Z} \quad (1.7)$$

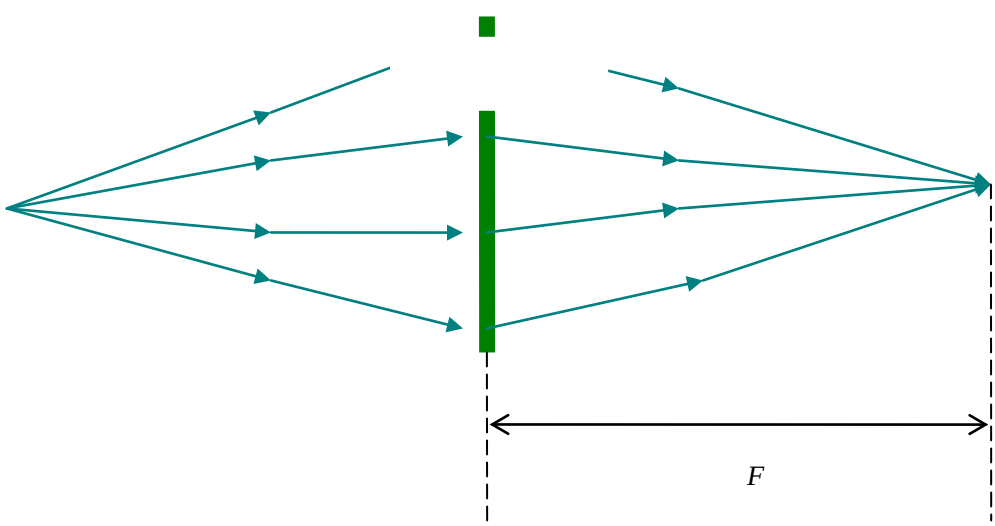
Where, θc, is critical angle, Z, is atomic mass, δ, is refractive index decrement, β, is absorption coefficient, and n is refractive index. Equation 1.7 shows that θ_c vary with λ; this infer that grazing incidence is limited by X-ray photon energy (wavelength). The use of a low Z material is also favourable to grazing incidence.

Grazing incidence X-ray optics facility has some advantages which are summarized as follows;

- The production of this focussing device is cost effective
- It has a large collecting
- High reflectivity, over 90% is achievable depending on the grazing angle; High reflectivity is achieved at grazing angle smaller than the critical angle
- Though this technique suffers from aberration, yet it provides high efficiency.

(a)

Flat optics



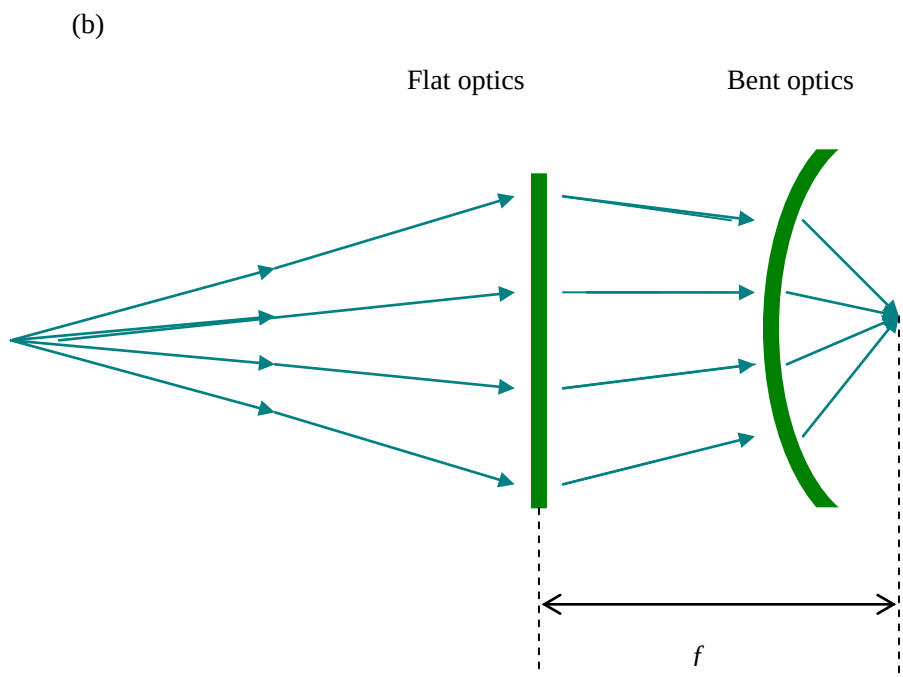


Figure 1.2 : (a) A schematic of flat optics–focal length achieved is *F*. (b) combination of flat and bent optics to improve resolution-Focal length achieved is *f* where. *F*> *f*

Since Rayleigh criterion, ς, has a limit, adopting bent optics as shown in Figure 1.3 (b) will reduce focal length *F* to *f* which results to an improvement in resolution over that delivered by the flat optics as indicated in figure 1.3(b). This agrees well with equations 1.1 and 1.2. By applying bent optics to both reflective and diffractive optics, through the use of zone plates, multi layer and grazing incidence mirrors resolution will be improved.

By using grazing incidence mirrors, bremsstrahlung radiation was reduced to 2%; Grazing incidence optics has been in use for several years. Grazing incidence mirrors have been used to produce high-resolution images of the structure and function in small animals. Adopting Grazing-incidence focusing optics provides an advanced understanding of biology, including human growth, development, and diseases.

V. Conclusion

Soft X-rays and their application in radiobiology have been considered. A brief description of the X-ray microprobe and its background has been studied. Microfocussing techniques such as diffractive, reflective and grazing incidence optics which involves the use of multilayer mirrors, Fresnel zone plate lenses and grazing incidence mirrors respectively have been considered as tools for high resolution.

Multilayer mirrors for the future must be made up of a highly reflective material i.e. high reflection coefficient and a material of low absorption index. Future work should be directed to micro fabrication of zone plates by etching zones of outer width, ΔR_n <0.82 μm on a material.

References Références Referencias

1. Pfauntsch S (2001). "*Developments in Soft X-ray Laboratory Systems for Microscopy and Cellular Probing*" PhD thesis pp15.
2. Folkard M (2005). "*A Variable Energy Soft X-ray Microprobe to Investigate Mechanisms of the Radiation- Induced Bystander Effect*" Work shop.
3. Pfauntsch S (2001). "*Developments in Soft X-ray Laboratory Systems for Microscopy and Cellular Probing*" PhD thesis pp159.
4. Michette AG, Pfauntsch S, Sahraei S, Mcfaul C, Morrison GR, Powell AK, Button T, Rodriguez-Sanmartin D, Dou Z, Dunare C, Parkes W, Stevenson T, Feldman C, Willingale R, Folkard M, HART D, Vojnovic B (2007). "Active Microstructured Arrays for X-rays Optics in" X-ray Micro and Nanoprobes, Methodologies and Applications. The international society for optical engineering, **6705**, PP670502.1-670502.12.
5. Chao W, Harteneck BD, Liddle, Anderson EH, Attwood DT "Zone plates Microscopy to sub-15 nm spatial resolution with XM-1 at the ALS in "*X-ray microscopy instrumentation* pp4-6 Proc. 8th Int. Conf. X-ray Microscopy, IPAP Conf. Series 7.

6. Attwood D (1999). "Soft *x-ray and Extreme Ultra Violet radiation; Principles and Application*" pp338 Cambridge University Press, New York.
7. Folkard M, Schettino G, Vojnovic B, Gilchrist S, Michette AG, Pfauntsch SJ, Prise KM, Michael BD (2001). "A focused Ultra soft X-Ray Micro beam for Targeting Cells Individually with Sub-micrometer Accuracy" *in Radiation Research A. Gray Cancer* Institute. pp 796-799, 156, Issue 6.
8. Folkard M, Schettino G, Vojnovic B, Gilchrist S, Michette AG, Pfauntsch SJ, Prise KM, Michael BD (2001). "A focused Ultra soft X-Ray Micro beam for Targeting Cells Individually with Sub-micrometer Accuracy" *in Radiation Research A. Gray Cancer* Institute. pp 800–804, 156, Issue 6.
9. Bart S, Chapman H (2008). "Multi layer mirror enables new science using X-ray free electron lasers" in *Physics and Advanced Technologies* Lawrence Livermore National Laboratory Livermore, CA Contract No.W-7405-ENG-48.SPIE , Pp 1-2.
10. Michette AG (2007). in *Multi-layer mirror* (Mres lectures on slides).
11. Flaccavento G, Atkinson KD, Barber PR, Locke RJ, Pierce G, Gilchrist S, Michette AG, Prise KM, Vojnovic B, Folkard M "*Performance of the GCI Multi target X-ray microprobe*" Extended Abstracts of the 7th International Workshop: Microbeam Probes of Cellular Radiation Response, *Radiation Research*, 166 (4) (2006) pages 660-661. Gray Cancer Institute, Mount Vernon Hospital, North wood, HA 62JR, United Kingdom.

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An Investigation on the Radiation Hazards Associated with the Use of Abakaliki Pyroclastic from Southeastern Nigeria as Construction Materials

By Chijioke M. Amakom & Okechukwu P. Aghamelu
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Abstract - This paper presents an investigation on the health risks that may be associated with pyroclastic rocks when used as construction materials. Radionuclides in the pyroclastic rocks from the Abakaliki and Ezillo areas (both in Ebonyi State, Southeastern Nigeria) were assessed. Data show that the uranium concentration in the pyroclastic rocks vary from 1 – 3 ppm (or 0.01 – 0.03 Bq.g-1) for the Abakaliki area, and 2 – 5 ppm (or 0.02 – 0.05 Bq.g-1) for the Ezillo area. The Radium equivalent activity of the Abakaliki pyroclastics varied from 20.0 – 62.90 mBq.g-1 while that of Ezillo varied from 62.9 – 145.8 mBq.g-1. A comparison with the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) recommended standard (that Radium equivalent activity in building materials must be below 370 Bq.kg-1 or 0.37 Bq.g-1) suggests that the radium equivalent activity for the pyroclastics from both areas in the southeastern Nigeria were all well below the maximum permissible level for dwelling homes. This therefore implies that they are safe, health wise, as construction materials for residential buildings.

Keywords : pyroclastics; radionuclides; health hazards; construction material; nigeria; recommended level.

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AN INVESTIGATION ON THE RADIATION HAZARDS ASSOCIATED WITH THE USE OF ABAKALIKI PYROCLASTIC FROM SOUTHEASTERN NIGERIA AS CONSTRUCTION MATERIALS

Strictly as per the compliance and regulations of :

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Chijioke M. Amakom [α] & Okechukwu P. Aghamelu [σ]

Abstract - This paper presents an investigation on the health risks that may be associated with pyroclastic rocks when used as construction materials. Radionuclides in the pyroclastic rocks from the Abakaliki and Ezillo areas (both in Ebonyi State, Southeastern Nigeria) were assessed. Data show that the uranium concentration in the pyroclastic rocks vary from 1 – 3 ppm (or 0.01 – 0.03 $Bq.g^{-1}$) for the Abakaliki area, and 2 – 5 ppm (or 0.02 – 0.05 $Bq.g^{-1}$) for the Ezillo area. The Radium equivalent activity of the Abakaliki pyroclastics varied from 20.0 – 62.90 $mBq.g^{-1}$ while that of Ezillo varied from 62.9 – 145.8 $mBq.g^{-1}$. A comparison with the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) recommended standard (that Radium equivalent activity in building materials must be below 370 $Bq.kg^{-1}$ or 0.37 $Bq.g^{-1}$) suggests that the radium equivalent activity for the pyroclastics from both areas in the southeastern Nigeria were all well below the maximum permissible level for dwelling homes. This therefore implies that they are safe, health wise, as construction materials for residential buildings.

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I. Introduction

External exposures to radiation arise from terrestrial radionuclides present at trace levels in soil, rocks and other materials that could be used in building construction projects. Irradiation from these materials is mainly by gamma emissions from radionuclides; ^{238}U and ^{232}Th series and from ^{40}K.

Building raw materials and processed products can vary greatly in radionuclide content depending on the character and the geology of the origin (Schuler et al, 1991). Radioactivity in building materials can lead to health risks in homes, offices and other working places. In the dwelling homes, the exposure rate depends on the concentrations of the radionuclides in the materials with which it was constructed, the quantity of these construction materials and the form of the dwelling home (Farai and Ademola 2004). In an airy room, the radon concentration depends mainly on the rate of radon exhalation from building materials, and the ventilation rate (Mustonen, 1984).

Hamilton (1971) reports that clay bricks contain typically 1.4 ppm of radium whereas, granite bricks have an elevated concentration of 2.4 ppm. All these natural sources of radiation in building materials result in internal and external dose to the public. About 54% of the total external dose received by the public in normal background areas originates from ^{40}K, ^{226}Ra and ^{228}Ra (UNSCEAR, 1980).

In the southeastern Nigeria (Figure 1), there are massive occurrences of pyroclastic rock bodies at Abakaliki and Ezillo (Ofoegbu and Amajor 1987), and at Uturu and Lokps-Ukwu areas (Onwughalu and Ukaegbu 2009). These rocks are used in virtually all forms of building construction in the area. However, the analyses on the samples of pyroclastics from the Abakaliki and Ezillo by Ofoegbu and Amajor (1987) have shown that they contain detectable amounts of radionuclides. Information is sparse on the environmental and health impacts of radiation from these rocks in the Abakaliki and Ezillo areas.

In this work, an attempt has been made to asses the radiation risks associated with the radionuclide in the Abakaliki and Ezillo pyroclastic rocks, when used as construction materials especially for residential buildings.

II. Previous Researches on Rocks as Construction Materials

The use of rocks in construction dates back to the days of the primitive man. However, the demand and utilization in various construction projects continue to increase proportionally to the sophistication in building technology and civil engineering.

Today, almost all types of rocks, as well as other naturally occurring and artificial materials, are employed in construction projects. Presently, rocks such as charnockite (Eze 1997), granite, dolerite and basalt (Krynine and Judd 1957), marble and slate (Bell 1993) are being utilized as building stones, highway-runway

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surfacing materials, foundation filling, concrete aggregates, surface finishings, as well as in dams and tunnels constructions. However, these rocks, in addition to being economically available, are supposed to pass some building, engineering and health safety standards.

In the Abakaliki and Ezillo areas, southeastern Nigeria (see Figure 1), pyroclastic rocks, found associated with the thick Albian Asu River Group and Turonian Eze Aku Group respectively (Reyment 1965) sediments, are being quarried and utilized in most projects that require rocks as construction materials. The occurrence and petrology of these rocks commonly to as the 'Abakaliki Pyroclastics' (Okezie 1965; Uzuakpunwa 1974; Ofoegbu and Amajor 1987) have been extensively studied (Farrington 1952; Olade 1979; Uzuakpunwa 1974). Figure 2 presents the geology of the southeastern Nigeria (i.e. the southern Benue Trough).

III. Materials and Methods

This research adopts data generated by Ofoegbu and Amajor (1987). They collected forty samples (twenty samples from each area) from some pyroclastic rock bodies in the Abakaliki and Ezillo areas. Details on the sampling and testing procedures are presented in their work, while the accessibility of the sampled localities is shown in Figure 3.

IV. Radium Equivalent Activity

Radium equivalent activity (Ra_{eq}) is a common index used to compare the total activity concentration of U, Th and K in a building material. Hamilton (1971) defines it as a weighted sum of the activity concentrations of the radionuclides. The Radium equivalent activity was calculated in this study using the equation below;

$$Ra_{eq} = A_{Ra} + 1.43A_{Th} + 0.077A_K \quad (1)$$

Where, A_{Ra}, A_{Th} and A_K are the activity concentrations of ^{226}Ra (^{238}U), ^{232}Th and ^{40}K respectively.

The third term in equation (1), ($0.077A_k$) was dropped since ^{40}K was not measured in the samples. Equation (1) was based on the estimation that 370 $Bq.kg^{-1}$ of Ra, 259 $Bq.kg^{-1}$ of Th and 4810 $Bq.kg^{-1}$ of K produce the same gamma ray dosage.

The following conversions were made:

Uranium, 1ppm = 0.33 $pCi.g^{-1}$, 1 $pCi.g^{-1}$ = 3 ppm

Thorium, 1ppm = 0.11 pCi.g-^{1}, 1 pCi.g-^{1} = 9.1 ppm

One Becquerel (Bq) = 27 picocuries (pCi)

One picocurie (pCi) = 0.037 becquerels (Bq)

V. Results and Discussion

The data for the uranium and thorium concentrations of the Abakaliki and Ezillo pyroclastic rocks are shown in Tables 1 and 2 respectively. The uranium concentration in the pyroclastic rocks were found to vary from 1 – 3 ppm or 0.01 – 0.03 $Bq.g^{-1}$ for the Abakaliki area and 2 – 5 ppm or 0.02 – 0.05 $Bq.g^{-1}$ for the Ezillo area. The thorium concentration ranges from 2 – 7 ppm or 0.002 – 0.07 $Bq.g^{-1}$ for the Abakaliki samples and, 8 – 15 ppm or 0.08 – 0.15 $Bq.g^{-1}$ for the Ezillo samples. These ranges thus, suggest that the Ezillo pyroclastics record slightly higher concentration of uranium and thorium.

The observed variations in concentrations of the radionuclides may be a reflection of the differences in the geochemistry of the samples. Ofoegbu and Amajor (1987) had classed the Abakaliki pyroclastics as alkaline basalts and Ezillo pyroclastics as sub-alkaline. They conclude that the geochemical difference in composition of the Abakaliki and Ezillo pyroclastics may be either primarily due to fractional differentiation of a single magma in which case both units are of the same age, or that they belong to different volcanic sources in time and/or space.

Tables 1 and 2 also contain the Radium equivalent activity obtained from the Abakaliki and Ezillo pyroclastic rocks. The Radium equivalent activity of the Abakaliki pyroclastics varied from 20.0 – 62.90 $mBq.g^{-1}$ while that of Ezillo varied from 62.9 - 145.8 $mBq.g^{-1}$. According to UNSCEAR (1982) recommendation, Radium equivalent activity in building materials must be below 370 $Bq.kg^{-1}$ or 0.37 $Bq.g^{-1}$. Comparing the results obtained and the standard given by UNSCEAR (1982), the Radium equivalent activity were all well below the maximum permissible level for dwelling homes.

VI. Conclusions

This study has shown that although the Ezillo pyroclastics have slightly higher concentrations of uranium and thorium than the Abakaliki pyroclastics, both have their Radium concentration equivalents well below the UNSCEAR recommended level for construction materials. This may imply that, on the basis of radium concentration equivalents, they are safe for use as building materials. In other words, evidences of significant irradiation in residential buildings constructed with the pyroclastics may be originating from other source(s) apart from the pyroclastics.

VII. Acknowledgements

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References Références Referencias

1. Aghamelu, O. P. 2007. A comparative study of the geotechnical properties of crushed shales from the Abakaliki, Awgu and Enugu Shale Formations, southeastern Nigeria. M.Sc Thesis, Univ Nigeria, Nsukka, 50pp.
2. Farai I.P and Ademola J.A 2004. Radium equivalent activity concentrations in concrete building blocks in eight cities in Southwestern Nigeria, jol of env. Rad. Pp 119-125.
3. Bell, F. G. 1993. Engineering geology. Blackwell Science, Oxford, 352pp.
4. Cothern C.R and Lapponbuoh W.L. 1983. Occurrence of uranium in drinking water in U.S.A.Health physics, vol. 45, pp 89-99.
5. Eze, E. O. 1997. Geotechnical assessment of some charnockites from Nigeria as construction materials. Quarterly Journal of Engineering Geology, Vol. 30, 231-236.
6. Farrington, J. L. 1952. A preliminary description of the Nigerian lead-zinc field. Economic Geology. Vol. 47, 583-608.
7. Hamilton E.I. 1971. The relative radioactivity of building materials; Am Ind. Hyg. Ass. Journal vol. 32, pp398.
8. Krynine, D. P. and Judd, W. R. 1957. Principles of engineering geology and geotechnics. McGraw-Hill, New York, 699pp.
9. Mustonen R. 1984. Methods for evaluation of radiation from building materials; Radiation protection dosimetry, vol. 7, pp 235-238
10. Ofoegbu, C. O. and Amajor, L. C. 1987. A geochemical comparison of the pyroclastic rocks from Abakaliki and Ezillo, southeastern Benue Trough, Nigeria. J Min Geol. Vol. 23 Nos. 1&2, 45-52.
11. Okezie, C. N. 1965. A preliminary report on the igneous rocks of Abakaliki town and environs and their relations to lead-zinc mineralization. Unpubl Geol Surv Nigeria Rept. 1349, 30pp.
12. Olade, M. A. 1979. The Abakaliki pyroclastics of the southern Benue Trough, Nigeria; their petrology and tectonic significance. J Min Geol, Vol 16, 17-24.
13. Onwualu-John, J. N. and Ukaegbu, V. U. 2009. Petrogenetic and geotectonic implications of the Lokpa-Ukwu pyroclastics in southeastern Benue Trough, Nigeria. 45th Nigerian Mining and Geosciences Society, Intl Conference, Owerri 2009, Abstract vol. pp20-21.
14. Reyment, R. A. 1965. Aspects of the geology of Nigeria. Ibadan Univ Press.
15. Schuler Ch., Crameri R. and Burkart W. 1991. Assessment of the indoor Rn concentration of Swiss building materials; Health physics, vol.60, pp 447-451
16. United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR 2000 Report to the General Assembly, New York: United Nations.
17. United Nations Scientific Committee on the Effects of Atomic Radiation, (UNSCEAR) 1980. Sources, effects and risks of ionizing radiation. New York: Report to the General Assembly.
18. United Nations Scientific Committee on the Effects of Atomic Radiation, (UNSCEAR) 1982. Ionizing radiation sources and biological effects. New York: UNSCEAR (A/37/45).
19. Uzuakpunwa A. B. 1974. The Abakaliki pyroclastics, eastern Nigeria: new age and tectonic implications. Geological Magazine, Vol. 111, 761-769.

Table 1 : Activity concentration and Radium equivalent activity of the Abakaliki Pyroclastics

Sample	*U (ppm)	U (Bq/g)	*Th (ppm)	Th (Bq/g)	Ra_{eq} (mBq/g)
A1	2	0.02	6	0.02	48.60
A2	1	0.01	4	0.01	24.30
A3	2	0.02	4	0.01	34.30
A4	2	0.02	7	0.03	62.90
A5	2	0.02	3	0.01	34.30
A6	2	0.02	3	0.01	34.30
A7	1	0.01	4	0.01	24.30
A8	2	0.02	7	0.03	62.90
A9	2	0.02	6	0.02	48.60
A10	2	0.02	4	0.01	34.30
A11	2	0.02	3	0.01	34.30
A12	2	0.02	2	0	20.00
A13	3	0.03	2	0	20.00
A14	2	0.02	3	0.01	24.30
A15	2	0.02	3	0.01	24.30

A16	2	0.02	4	0.01	24.30
A17	2	0.02	7	0.03	62.90
A18	2	0.02	5	0.02	48.60
A19	3	0.03	4	0.01	44.30
A20	2	0.02	5	0.02	48.60

*(*data from Ofoegbu and Amajor, 1987)*

Table 2 : Activity concentrations and Radium equivalent activity of the Ezillo Pyroclastics

Sample	U (ppm)	U (Bq/g)	Th (ppm)	Th(Bq/g)	Ra_{eq}(mBq/g)
E1	3	0.03	13	0.05	101.5
E2	3	0.03	9	0.03	72.90
E3	2	0.02	8	0.03	62.90
E4	2	0.02	10	0.04	77.20
E5	3	0.03	9	0.03	72.90
E6	3	0.03	9	0.03	72.90
E7	2	0.02	10	0.04	77.20
E8	3	0.03	12	0.05	101.5
E9	2	0.02	9	0.03	62.90
E10	2	0.02	10	0.04	77.20
E11	3	0.03	12	0.05	101.5
E12	2	0.02	10	0.04	77.20
E13	4	0.05	14	0.06	135.8
E14	5	0.06	15	0.06	145.8
E15	2	0.02	8	0.03	62.90
E16	4	0.05	12	0.05	121.5
E17	3	0.03	13	0.05	101.5
E18	2	0.02	8	0.03	62.90
E19	3	0.03	9	0.03	72.90
E20	5	0.06	15	0.06	145.8

*(*data from Ofoegbu and Amajor, 1987)*

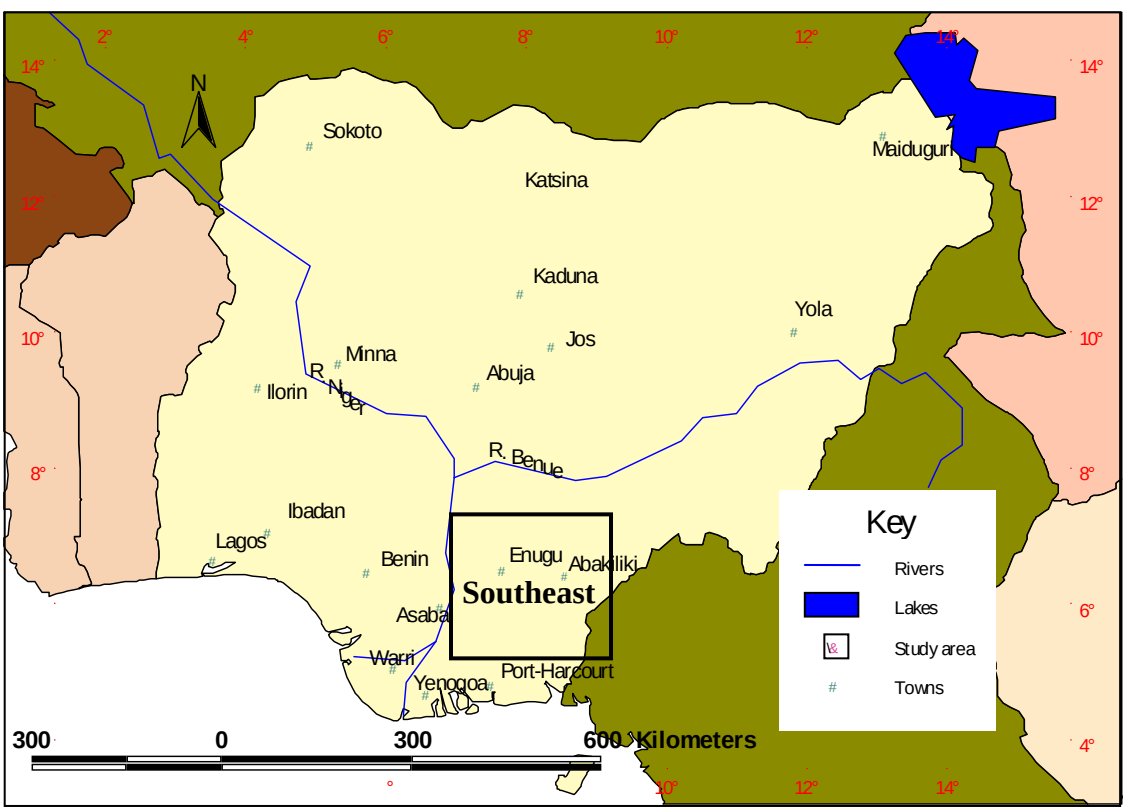

Figure 1 : Map of Nigeria showing the location of the southeast

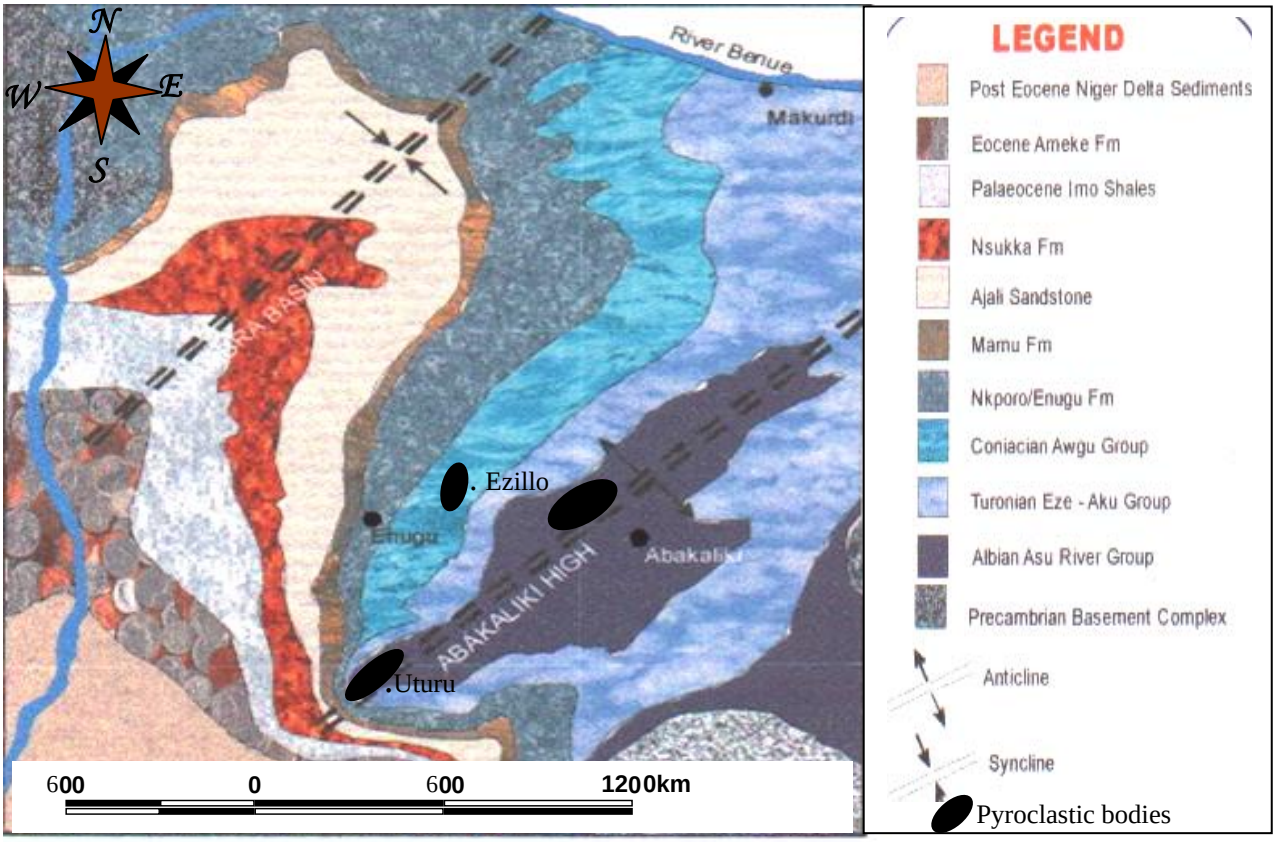

Figure 2 : Geological map of southeastern showing locations of pyroclastic rock bodies [Modified after Ofoegbu and Amajor (1987) and Aghamelu (2009)]

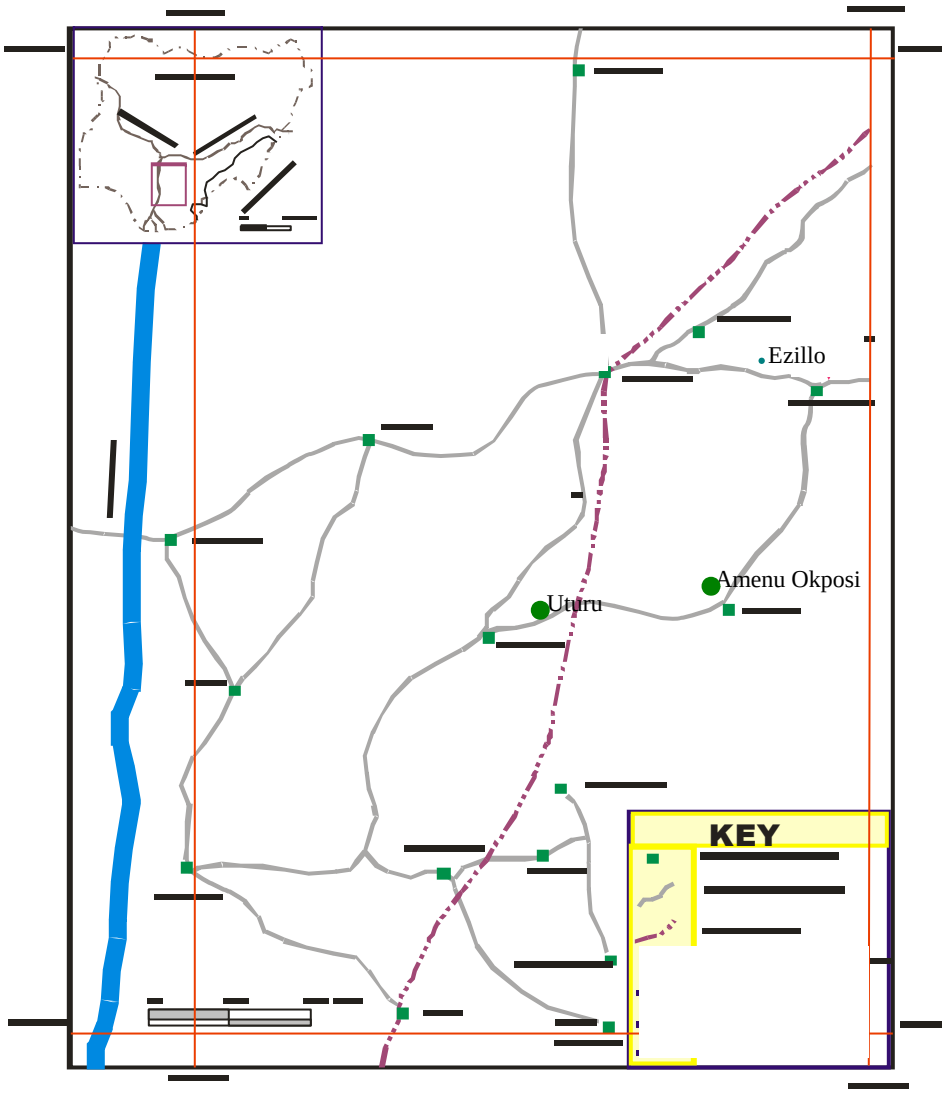

Figure 3 : Accessibility map of the southeastern Nigeria cities

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LRS Bianchi Type – II Universe in F(R,T) Theory of Gravity

By D. R. K. Reddy & R. Santhi Kumar
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Abstract - LRS Bianchi Type-II space – time is considered in the presence of a perfect fluid source in the framework of f(R,T) gravity proposed by Harko et al. [Phy.Rev-D 84, 024020(2011)]. An exact cosmological model with an appropriate choice of the function f(RT) is obtained using a special law of variation for Hubble's parameter proposed by Bermann (Nuovo Cimento B 74. 182,1983). The physical behavior of the cosmological model is, also, studied.

Keywords : "f(R,T)" gravity, Bianchi type-II model, Hubble's parameter.

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LRS BIANCHI TYPE II UNIVERSE IN FR,TTHEORY OF GRAVITY

Strictly as per the compliance and regulations of :

LRS Bianchi Type – II Universe in F(R,T) Theory of Gravity

D. R. K. Reddy [α] & R. Santhi Kumar [σ]

Abstract - LRS Bianchi Type-II space – time is considered in the presence of a perfect fluid source in the framework of f(R,T) gravity proposed by Harko et al. [Phy.Rev-D 84, 024020(2011)] . An exact cosmological model with an appropriate choice of the function f(RT) is obtained using a special law of variation for Hubble's parameter proposed by Bermann (Nuovo Cimento B 74. 182,1983). The physical behavior of the cosmological model is, also, studied.

Keywords :"f(R,T)"gravity, Bianchi type-II model, Hubble's parameter.

I. Introduction

Recent observational data suggests that our universe is accelerating. Supernova 1A data gave the first indication of the accelerated expansion of the universe [1-4]. Another major development in cosmology is that our universe is making a transition from a decelerating phase to an accelerating one. This was confirmed by anisotropies in the cosmic microwave background (CMB) radiation as seen in the data from satellite such as WMAP and large scale structure. Astrophysical observations indicate that the accelerated expansion of the universe is driven by exotic energy with large negative pressure which is known as dark energy (For a general complete review see [5]. In spite of all the observational evidences, the nature of dark energy is, still, a challenging problem in modern cosmology.

There are two major approaches to address the problem of cosmic acceleration. One approach is to introduce a dark energy component in the universe and study its dynamics. Another alternative approach is to modify general relativity itself. This is termed as 'modified gravity' approach [5-8]. Both the approaches have novel features with some deep theoretical problems. However, here, we are interested in modified gravity approaches, several modifications of general gravity have been proposed in the last few decades. Noteworthy among them are Brans-Dicke[9]and Saez-Ballester[10] scalar-tensor theories of gravitation. In Brans-Dicke gravity besides a gravitational part, a dynamical scalar field was introduced to account for variable gravitational constant This modification was introduced because of the fact that Einstein's theory does not fully incorporate Mach's Principle. Later Saez and Ballester formulated a scalar-tensor theory of gravity in which metric is coupled with a scalar field. Here the strength of the coupling between the gravity and the field is governed by a parameter ω. This theory also enables us to solve the 'missing mass" problem. Other than these approaches some authors [11-15] considered modified gravitational action by adding a function f(R) (R being Ricci scalar curvature) to Einstein-Hilbert Lagrangian where f(R) provides a gravitational alternative for dark energy causing late time acceleration of the universe. A comprehensive review on f(R) gravity is given by Copeland et al. [16].

Very recently, Harko et al. [17] developed another modified gravity known as f(R, T) gravity. In this the gravitational Lagrangian is given by an arbitrary function of the Ricci scalar R and of the trace T of the stress energy tensor. Adhav[18] has presented spatially homogeneous and anisotropic Bianchi type–I model in f(R,T) gravity while Reddy et al,[19-20]] have studied Bianchi type-III and Kaluza-Klein cosmological models in this theory,

Motivated by the above investigations, in this paper, we obtain LRS Bianchi type – II cosmological model in f(R, T) gravity. Bianchi type – II space time are of vital importance in describing cosmological models at the early stages of evaluation of the universe. This paper is organized as follows: Sect. 2, presents a brief description of f(R, T) gravity. In Sect. 3, we derive f(R, T) gravity field equations for LRS Bianchi type – II metric. In Sect. 4, the solutions of field equations and the model are obtained. Sect. 5 is devoted to the discussion of physical and Kinematical properties of the model. The last section contains some useful conclusions.

II. F (R,T) Theory of Gravity

In f(R,T) gravity, the field equations are derived from a variational, Hilbert-Einstein type, principle.

The action for the modified f(R,T) gravity is

$$S = \frac{1}{16\pi}\int f(R,T)\sqrt{-g}d^4x + \int L_m\sqrt{-g}d^4x \qquad (1)$$

Where f(R,T) is an arbitrary function of the Ricci scalar, R, T is the trace of stress-energy tensor of the matter, T_{ij} and L_m is the matter Lagrangian density. We define the stress-energy tensor of matter as

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$$T_{ij} = \frac{-2}{\sqrt{-g}} \frac{\delta(\sqrt{-g}L_m)}{\delta g^{ij}} \quad (2)$$

and its trace by $T = g^{ij} T_{ij}$ respectively. By assuming that L_m of matter depends only on the metric tensor components g_{ij}, and not on its derivatives, we obtain

$$T_{ij} = g_{ij} L_m - 2\frac{\partial L_m}{\partial g^{ij}} \quad (3)$$

Now by varying the action S of the gravitational field with respect to the metric tensor components g^{ij}, we obtain the field equations of f(R,T) gravity as

$$f(R,T)R_{ij} - \frac{1}{2} f(R,T) g_{ij} + \left(g_{ij} \Box - \nabla_i \nabla_j\right) f_R(R,T) = 8\pi T_{ij} - f_T(R,T)\, T_{ij} - f_T(R,T)\, \theta_{ij} \quad (4)$$

Where $\theta_{ij} = -2\, T_{ij} + g_{ij} L_m - 2 g^{lk} \frac{\partial^2 L_m}{\partial g^{ij} \partial g^{lm}}$ (5)

Here $f_R = \frac{\delta f(R,T)}{\delta R}$, $f_T = \frac{\delta f(R,T)}{\delta T}$ $\Box = \nabla^i \nabla_i$, ∇_i is the covariant derivative and T_{ij} is the standard matter energy-momentum tensor derived from the Lagrangian L_m. It may be noted that when f(R,T) ≡f(R) the equations (4) yield the field equations of f(R) gravity.

The problem of the perfect fluids described by an energy density ρ, pressure p and four velocity u^i is complicated since there is no unique definition of the matter Lagrangian. However, here, we assume that the stress energy tensor of the matter is given by

$$T_{ij} = (\rho + p) u_i u_j - p g_{ij} \quad (6)$$

And the matter Lagrangian can be taken as $L_m = -p$ and we have

$$u^i \nabla_j u_i = 0, \quad u^i u_i = 1 \quad (7)$$

Then with the use of Equations (5) we obtain for the variation of stress-energy of perfect fluid the expression

$$\theta_{ij} = -2T_{ij} - p g_{ij} \quad (8)$$

Generally, the field equations also depend through the tensor θ_{ij}, on the physicsl nature of the matter field. Hence in the case of f(R,T) gravity depending on the nature of the matter source, we obtain several theoretical models corresponding to each choice of f(R,T). Assuming

$$f(R,T) = R + 2f(T) \quad (9)$$

as a first choice where f(T) is an arbitrary function of the trace of stress-energy tensor of matter, we get the gravitational field equations of f(R,T) gravity from Eq. (4) as

$$R_{ij} - \frac{1}{2} R g_{ij} = 8\pi T_{ij} - 2f'(T)\, T_{ij} - 2f'(T)\theta_{ij} + f(T)\, g_{ij} \quad (10)$$

Where the prime denotes differentiation with respect to the argument.

If the matter source is a perfect fluid,

$$\theta_{ij} = -2T_{ij} - p g_{ij}$$

then the field equations become

$$R_{ij} - \frac{1}{2} g_{ij} R = 8\pi T_{ij} + 2f'(T)\, T_{ij} + [2pf'(T) + f(T)]\, g_{ij} \quad (11)$$

III. Metric and Field Equations

We consider a homogeneous LRS Bianchi type–II space–time given by

$$ds^2 = -dt^2 + A^2 dx^2 + B^2 dy^2 + 2B^2 x dy dz$$
$$(Bx^2 + A^2) dz^2 \quad (12)$$

where A and B are functions of cosmic time t.

Using co moving coordinates and equations (6)-(8), the f(R,T) gravity field equation(11) with the particular choice of the function (Harko et al.2011)

$$f(T) = \lambda \mathrm{T}, \ \lambda, a\ constant \quad (13)$$

for the metric (12) take the form

$$\frac{\ddot{A}}{A} + \frac{\ddot{B}}{B} + \frac{\dot{A}}{A}\frac{\dot{B}}{B} + \frac{1}{4}\frac{B^2}{A^4} = (8\pi + 3\lambda)p - \lambda\rho \quad (14)$$

$$]2\frac{\ddot{A}}{A} + \frac{\dot{A}^2}{A^2} - \frac{3}{4}\frac{B^2}{A^4} = (8\pi + 3\lambda)p - \lambda\rho \quad (15)$$

$$2\frac{\dot{A}}{A}\frac{\dot{B}}{B} + \frac{\dot{A}^2}{A^2} - \frac{1}{4}\frac{B^2}{A^4} = -(8\pi + 3\lambda)\rho + \lambda p \quad (16)$$

Where an overhead dot denotes differentiation with respect to cosmic time t.

IV. Solutions and the Model

The field equations (14)-(16) are a system of three independent equations in four unknowns A, B, ρ and p. Hence to obtain a determinate solution of the system we take the help of special law of variation proposed by Bermann [21] for Hubble's parameter that yields constant deceleration parameter models of the universe.

We consider constant deceleration parameter model defied by

$$q = -\frac{a\ddot{a}}{\dot{a}^2} = constant \quad (17)$$

where the scale factor a is given by

$$a = (A^2 B)^{1/3} \quad (18)$$

Here the constant is taken as negative because our theory corresponds to the accelerating model of the universe.

The solution of (17) is

$$a = (ct + d)^{1/(1+q)} \quad (19)$$

Where c≠0 and d are constants of integration. Also this equation implies that the condition for cosmic acceleration is $(1 + q) > 0$

The scalar expansion θ , shear scalar σ^2 in the model (12) are defined by

$$\theta = 2\frac{\dot{A}}{A} + \frac{\dot{B}}{B} \tag{20}$$

$$\sigma^2 = \frac{1}{3}\left(\frac{\dot{A}}{A} - \frac{\dot{B}}{B}\right)^2 \tag{21}$$

We also observe that the expansion θ in the model is proportional to the Shear scalar σ which leads to

$$A = B^m \tag{22}$$

Where m is constant [22]

Solving the field Equations (14)-(16) with the help of (19) and (22), we obtain the expressions for metric coefficients as follows

$$A = (ct+d)^{\frac{3m}{(2m+1)(1+q)}} \quad , \quad B = (ct+d)^{\frac{3}{(2m+1)(1+q)}} \tag{23}$$

After a suitable choice of constants (c=1,d=0) the metric (12) can be written as

$$ds^2 = -dt^2 + t^{\frac{6m}{(2m+1)(1+q)}}dx^2 + t^{\frac{6}{(2m+1)(1+q)}}dy^2 + 2t^{\frac{6}{(2m+1)(1+q)}}xdydz + \left(t^{\frac{6}{(2m+1)(1+q)}}x^2 + t^{\frac{6m}{(2m+1)(1+q)}}\right)dz^2 \tag{24}$$

This represents LRS Bianchi type – II universe in f(R,T) gravity.

V. Some Physical Properties of the Model

Equation (24) represents a perfect fluid Bianchi type – II cosmological model in f(R,T) gravity with the following physical and Kinematical parameters:

The Spatial Volume is

$$V^3 = A^2B = t^{\frac{3}{(1+q)}} \tag{25}$$

The Scalar Expansion is

$$\theta = \frac{3}{(1+q)} \tag{26}$$

The Shear Scalar is

$$\sigma^2 = \frac{3(m-1)^2}{(2m+1)^2\,(1+q)^2}\frac{1}{t^2} \tag{27}$$

The Generalized Hubble's parameter is

$$H = \frac{\dot{a}}{a} = \frac{1}{3}\left(2\frac{\dot{A}}{A} + \frac{\dot{B}}{B}\right) = \frac{1}{(1+q)}\frac{1}{t} \tag{28}$$

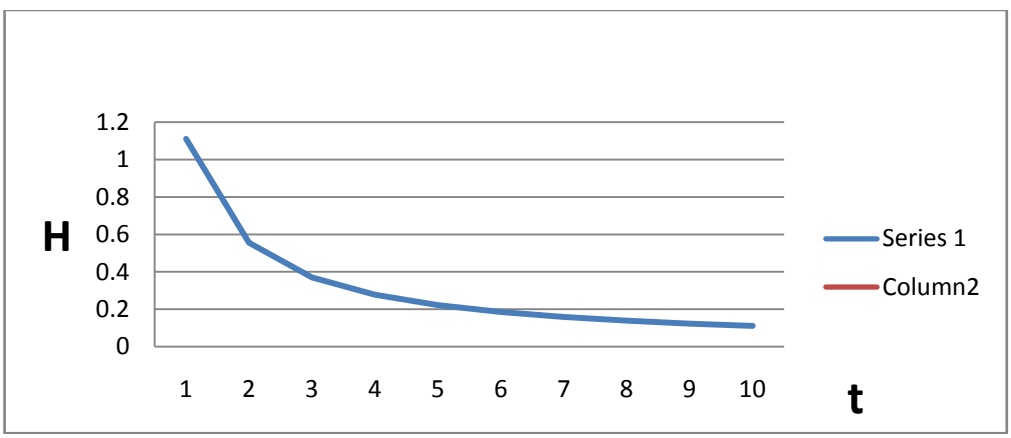

Figure 1 : The plot of Hubble's parameter H Vs. t. Here q= -0.1

The Average anisotropic parameter is

$$A_\alpha = \frac{1}{3}\sum\left(\frac{\Delta H_l}{H}\right)^2 \tag{29}$$

Where $\Delta H_l = H_l - H \ (l = 1,2,3)$

Which gives $A_\alpha = \frac{3}{4}$ (30)

Also

$$\frac{\sigma^2}{\theta^2} = \frac{(m-1)^2}{3(2m+1)^2} \tag{31}$$

The Pressure in the model is

$$p = \frac{1}{(8\pi+3\lambda)}\left\{\left[(10m^2 - 12qm^2 - 6m - 6mq) + \frac{\lambda^3(2m^2-6m-9)(1+q) - \frac{(8\pi+3\lambda)}{\lambda}4m^2}{\lambda^3-(8\pi+3\lambda)^2}\right]\frac{t^{-2}}{(1+q)^2(2m+1)^2} + \left(\frac{\lambda^2(2\pi+\lambda)}{\lambda^3-(8\pi+3\lambda)^2} - \frac{3}{4}\right)t^{-\frac{6(2m-1)}{(2m+1)(1+q)}} - \frac{\lambda^2(16\pi+5\lambda)6m}{(\lambda^3-(8\pi+3\lambda)^2)(1+q)^2(2m+1)^2}t^{-\left(2+\frac{q}{(2m+1)(1+q)}\right)}\right\} \tag{32}$$

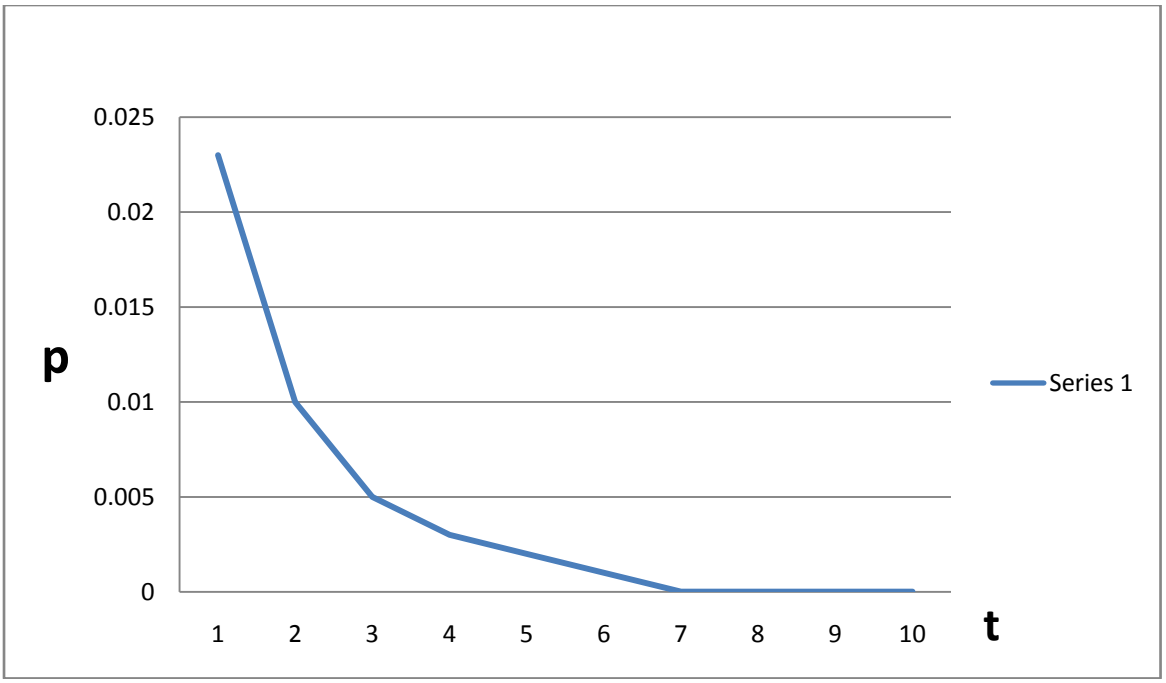

Figure 2 : The Plot of Pressure p Vs. t , Here q= -0.1, m=1.5, λ=1.5 π=3.143

The energy density in the model is

$$\rho = \frac{\lambda^2}{\lambda^3-(8\pi+3\lambda)^2}\left\{\left[(2m^2-6m-9)(1+q)-\frac{(8\pi+3\lambda)}{\lambda}4m^2\right]\frac{t^{-2}}{(1+q)^2(2m+1)^2}-\frac{(16\pi+5\lambda)6m}{\lambda(1+q)^2(2m+1)^2}t^{-\left(2+\frac{q}{(2m+1)(1+q)}\right)}+\left(\frac{2\pi+\lambda}{\lambda}\right)t^{-\frac{6(2m-1)}{(2m+1)(1+q)}}\right\} \quad (33)$$

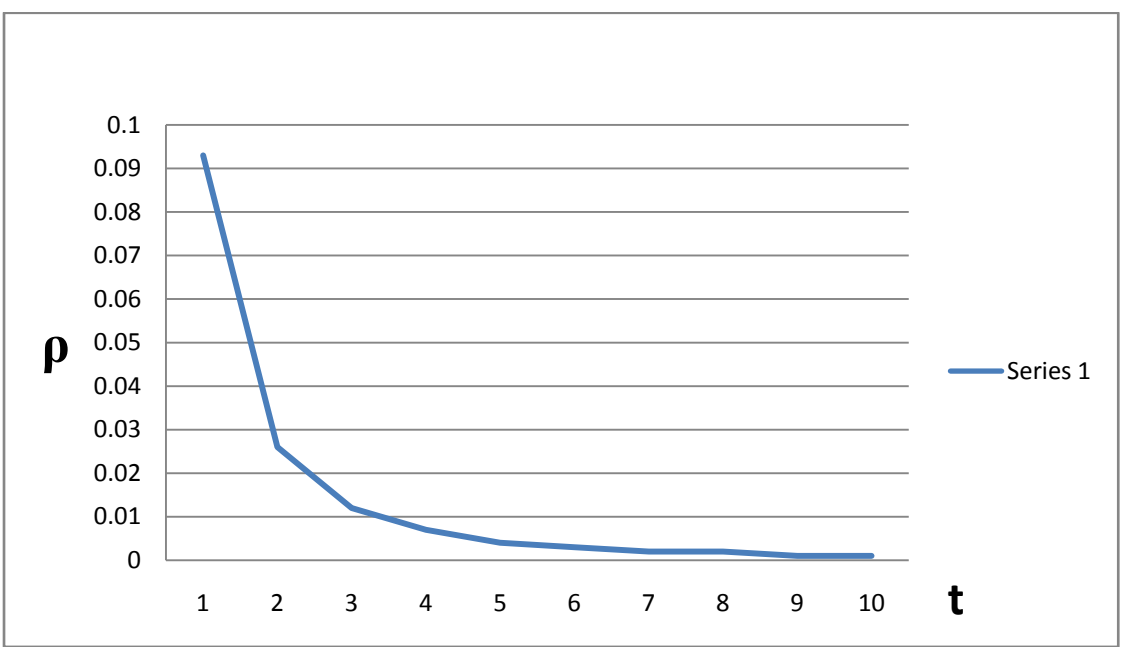

Figure 3 : The flot of energy density ρ Vs. t. Here q= -0.1, m=1.5, λ=1.5 π=3.143

From the above results it can be seen that the spatial volume is zero at t=0 and it increases with cosmic time showing the late time accelerated expansion of the universe. Also at t=0 the parameters θ, σ, H , ρ and p diverge while they vanish for infinitely large values of t. The mean anisotropic parameter is uniform through

the whole evolution of the universe which shows that the dynamics of the mean anisotropic parameter does not depend on the cosmic time t. Also, since $\frac{\sigma^2}{\theta^2}$ is constant the model does not approach isotropy through the whole evolution of the universe. It may also be observed that the model (24) has no initial singularity.

VI. Conclusion

Here we have studied LRS Bianchi type-II cosmological model in the presence of perfect fluid in f(R,T) theory of gravity. It is observed that the model has no initial singularity and shows the late time accelerated expansion of the universe for large t. It is also observed that all the physical and kinematical parameters diverge at initial epoch while they approach zero for infinitely large t. The model obtained, in this paper, is of considerable interest and may be useful to study the large scale dynamics of the early universe in f(R,T) theory of gravity.

References Références Referencias

1. Riess, A.G.,et al.: Astron.J.**116**,1009(1998).
2. Riess,A.G.,et al.: Astrophysics.J.**607**,665(2004).
3. Permutter,S.,et al.: Astrophys.J.**517,**565(1999).
4. Bennet, C.l.et al. AstroPhys.J.Suppl. Ser.**148**, 1(2003).
5. Nojiri.S, Odintsov.S.D.: Int. J. Geom. Methodsmod. Phys,**4**,115(2007).
6. Nojiri,S. Odintsov,S.D.: Phys.Rept.565,59(2011).
7. Sotiriou,T.P. and Faraoni,V.2010, Rev.Mod. Phys.**82**, 451-497.
8. Capozziello,S and Francariglice,M 2008,Gen.Rel. Grav.**40,** 357-420.
9. Brans, C.H.: Dicke, R.H.: Phys. Rev c. **24,** 925(1961).
10. Saez,D; Ballester,V.J.: Phys. Lett. A.11, 467(1986).
11. Capozziello,S: Int.J.Mod.Phys.D **11**,483(2002).
12. Carolll,S.M., Duvvuri,V.,Trpden,M.,Turnev,M.S.:Phys. Rev.D70,043528(2004).
13. Dolgov, A.D., Kawasaki,M.:Phys.Lett.B**573**, 1(2003).
14. Nojiri,S., Odintsov,S.D.:Phys.Rev.D**68**,123512(2003).
15. Nojiri,S., Odintsov,S.D:Phys.Lett.A**19**,627(2004).
16. Copeland ,E.J.,Sami,M.,Tsujikawa,S.:Int.J.Mod.Phy. **D15**,1753(2006).
17. Harko, T.Lobo, F.S.N Nojiri,S., Odintsov,S.D.:Phys. Rev.D**84**, 024020(2011).
18. Adhav, K.S.: Astrophys Space Sci.**339**,365(2012)
19. Reddy.D. R., Santhikumar.R., Naidu,.R.L. Astro-physics Space Sci,DOI 10.1007/s10509-012-1158-7(2012a).
20. Reddy.DRK, Naidu.RL.,Satyannarayana.B.: Int.J. The or. Phys, DOI 10.1007/s10773- 012-1203-x (2012b).
21. Bermann, M.S.: Nuovo Cimento B**74**,182(1983)
22. Collins,C.B., Glass,E.N.,Wilkinson,D.A.: Gen..Relativ. Gravit.**12** 805(1980).

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Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

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Acknowledgements: Please make these as concise as possible.

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21. 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 to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

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

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. **Think technically:** Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

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33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After 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 to 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 in your research.

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- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

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· Keep on paying attention on the research topic of the paper

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· Align the primary line of each section

· Present your points in sound order

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- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
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- Significant conclusions or questions that track from the research(es)

Approach:

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- Center on shortening results - bound background information to a verdict or two, if completely necessary
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- Exact spelling, clearness 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

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- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

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- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
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The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

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- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
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- Present a background, such as by describing the question that was addressed by creation an exacting study.
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	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 Above 200 words	No specific data with ambiguous information 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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