UNIVERSITY OF IBADAN

LIGHT AND THE PHYSICAL LAWS OF THE UNIVERSE

BY

E.A.ONI

INAUGURAL LECTURE 1989 - 90

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DEDICATION

This Inaugural Lecture is

dedicated

First to

THE GLORY OF ALMIGHTY GOD
WHO REVEALS HIMSELF IN DIVERSE WAYS

Second To the Memory of my late father

Mr. Moses Fadejuwon Adegbohungbe
(Grandson of Owa-Ofokutu of Ijesha land
1820 – 1857)

who ensured that I have sound and moral Education.

Third To my mother

Mrs. Mary Omotola Adegbohungbe
and my brother
Mr. Adetunji Adegbohungbe

and
Finally to my children
Martin, Ademuyiwa, Oluwaseun, Oluwagbemiga and Adeola.

ACKNOWLEDGEMENT

I acknowledge all my friends in Nigeria and all over the World who have remained loyal to me throughout my academic career.

I would like to acknowledge the inspiration I have derived from all the generations of students to whom I have taught PHYSICS for twenty-seven years. I have really enjoyed teaching them.

Finally, I would like to thank Mrs. Rose Akinola of the Department of Physics, University of Ibadan for typing this manuscript.

CHAPTER ONE

INTRODUCTION:

1.1 The Layman Meaning of the Title

When it first occured to me that I might be called upon to give an inaugural lecture, I chose a completely different topic from this one. If I had followed my first instinct I would have given a review of my published research work spanning a period of over two and half decades. About two years ago, I changed the title to what is before you today. My reason is a simple one. If anybody is really interested in my published work, I can always send the re-prints of the papers.

On the other hand I decided that I will share with you a little of some unpublished work that has occupied my time for the past fifteen years.

If a layman looks at the title of today's inaugural lecture, he or she will pick three terms: — light, physical laws and the Universe.

Light to many people in the cities means sunlight or NEPA (National Electric Power Authority). To rural dwellers, light comes from the sun everyday, during certain periods light can come from the moon and at night when it is dark light comes from oil lamps or in some cases kerosine lamps. To many people everything about the Universe can be summarized in a single common sentence like "The Sky is the limit."

1.2 Why the Physical Laws of the Universe

You may be wondering why at this point in time, I am focussing on the physical laws of the Universe. My answer to the above question can be summarized into two points.

(a) The Universe is now being forced on all of us by all these space-ships manned or unmanned. Our outer space is now full of so many artificial satellites — Television Satellites, Communication Satellites, Earth Resources Satellites, Geodesy Satellites etc. It is irrelevant whether we participate in space Explorations or not.

We are part of this planet Earth and will be treated as such.

(b) There are many unresolved problems in physics and it may well be that new grounds in space experiments will provide some of the answers.

Physics is an international subject and we cannot afford to be ignorant of new developments.

1.3 What is Light

Visible light is one example of what is more generally referred to as "Electromagnetic Spectrum." A few examples of the electromagnetic radiation apart from the visible light are X-rays, Gamma Rays, Ultra-violet, Infrared and of course Radio waves. The detailed study of light has been one of the important problems of modern physics. It is often difficult to describe light in simple terms because sometimes it acts like a wave and sometimes like a particle.

Light waves propagate through a vacuum with a constant velocity c which is 3×10^8 m.sec^{-1}. All the members of the Electromagnetic radiation propagate with the same constant velocity $c = 3 \times 10^8$ m.sec^{-1} in vacuum. Astronomers who are preoccupied with the study of the Universe and their physical laws, cannot put their hands on a star or study it in the laboratory. They infer the properties of the Universe by collecting and analyzing its light or other electromagnetic radiation like radio waves.

1.4 The Universe.

1. The Solar System

One can write a whole book on the Solar System, but I am only going to give a very short description. The sun is the light of the Solar System, around which our planets, nine of them, revolve. The nine planets in order of distance from the sun are as follows: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. Pluto the outermost planet was not discovered until 1930.

The moon is the only known natural satellite of the planet Earth. The United States of America landed a man on the moon in 1969. Since then there had been many manned and unmanned space ships from both U.S.A. and U.S.S.R. Our planets and their moons are right now invaded by many space probes sending signals and data back to Earth for detailed study and analysis.

The sun, our closest star, supplies the energy that maintains life on earth. The sun's energy is liberated by nuclear reactions in its central region.

2. Galaxies and the Universe

In the mid-nineteenth century, Lord Rosse discovered spiral structure in some of the diffuse objects that were referred to collectively as nebulae. The nature of these spiral nebulae was unclear then. But the nature of the spiral nebulae now called Spiral Galaxies, was established largely through the efforts of Edwin Hubble at the Mount Wilson Observatory. Using the 100 — inch Telescope, he was able to resolve some of the brighter stars in the outer parts of M31 — the famous spiral galaxy.

The recognition of spirals as truly extra galactic objects was a great step forward. Studies of many other objects termed nebulae disclosed that some of them were distant Galaxies although they lacked spiral shape. Several types of Galaxies are now known. It appears that most Galaxies occur in distinct group called clusters of Galaxies.

As of now we can observe on earth two basic properties of the Universe.

(a) The Galaxies have red shifts and the more distant the galaxy, the greater is its red shift.

(b) Radio Waves with a continuous spectrum corresponding to a black body of temperature 3K, are received by us on earth in equal amounts from all directions in space.

Cosmic Background Radiation.

One of the most remarkable discoveries about the general properties of the Universe is that of the Cosmic background radiation. The first evidence of this radiation was obtained in 1965 at the Bell Telephone Laboratories by Arno Penzias and Robert Wilson.

Cosmology is the field of Science that seeks to determine the nature and origin of the Universe. But the conclusions are often uncertain.

1.5 The Ultimate Space Age

Today, and to many inhabitants of our planet, space travel seems like a science fiction, but I can assure you that it is not. If the present civilization survives into the future, that is, assuming that human

beings had not wiped themselves off completely through global wars, then natural evolution will be allowed to take place. Let me give you a brief picture of what the ultimate space age is likely to be.

In about 6×10^9 years time, the sun, on which our planet depends, will evolve into a red-giant star and the earth will no longer be habitable. The requirements for liquid water, as opposed to ice or steam on our planet, demands a solar constant between 0.5 to 4 calories per square cm. per minute. But when the sun becomes a giant star, its luminosity will increase by 100 to 1000 times. As the process begins, the sun's surface temperature will decrease, its surface will appear redder, and its radius will increase. On our earth, the oceans will boil away and eventually the top layer of the atmosphere i.e. the exosphere, will be so hot that all atmospheric gas molecules will escape within a relatively short time. The probable length of the sun's red-giant stage is about several hundred million years. At the greatest extent, the sun's surface will reach the present orbits of Mercury and Venus and may reach as far as the planet earth.

Our temperature requirements for survival at that time could be met on the satellites of Saturn, Uranus and Neptune. Colonies would have to be established in these planets and the sun would be on the road to becoming a white dwarf — a star far too dim to supply energy requirements on Earth. That will be the eviction notice for the human race to quit the Solar System. If we are intelligent enough at that time to develop suitable technology for interstellar travels and the colonization of other planets circling other stars, then there is hope for the survival of human species.

CHAPTER TWO

THE RESTRICTED UNIVERSE OF SIR ISAAC NEWTON

There is no way one can discuss Sir Isaac Newton without first mentioning his predecessor Galileo Galilei (1564 – 1642). Galileo discovered that bodies fall at a rate independent of their mass. Galileo was trying to prove experimentally the ideas of old philosophers like Aristotle who strongly believed that heavy objects would fall faster than light objects. Galileo proved this wrong when he caused balls of different sizes and materials to be dropped at the same instant from the top of the leaning tower of Pisa. His results showed that they all reached the ground together. He concluded that the velocity of a falling object does not depend on its size and hence the free fall acceleration must be constant. The definition of inertial mass must be mentioned here. Inertial mass of an object is only meaningful when the particles move under the action of the same applied force. For example an object resting on a table will resist an attempt to make it move or if already in motion, it will resist an attempt to change its path of motion. Inertial mass of an object is a dynamic property of the object. Gravitational force does not come into it. The inertial mass which is mentioned in Newton's law has nothing to do with the gravitational mass which can be defined using the principle of the equal arm balance. This procedure for obtaining the mass of a body is based on the downward pull exerted by the earth's gravitational field and is correctly referred to as the gravitational mass of the body.

Sir Isaac Newton was born on December 25 1642, the very year that Galileo died. Building on what Galileo did, Newton formulated the basic concepts of his 3 laws of newtonian mechanics and also formulated the Universal law of Gravitation, on his return home from Cambridge University to escape the Plague at the age of 23 years i.e. in 1665. Newton was aware of the fact that the inertial mass in his second law of motion might not necessarily be precisely the same as the gravitational mass appearing in his Universal law of Gravitation.

$$F = m_i a$$

by Newton's second law of motion and we shall write the law of gravitation as

$$F = m_g g \text{ where}$$

g is a field depending on position and other masses in accordance with his Universal law of Gravitation. It does mean that if we equate both forces then

$$am_i = m_g g$$

$$a = \frac{m_g}{m_i} g$$

"a" will vary for different bodies with different values of the ratio

$$\frac{m_g}{m_i}$$

It was then necessary for Sir Isaac Newton to verify whether m_i in his second law is the same as m_g in his Universal law of Gravitation. Let us try a simple proof. Consider two particles A and B of gravitational masses m'A and m'B respectively. Let a third particle C of gravitational mass m'C acts on A and B. The gravitational force exerted on A by C in accordance with Newton's Universal law of Gravitation is given by

$$F_{AC} = \frac{Gm'_A m'_C}{r^2}$$

The gravitational force on B by C is given by

$$F_{BC} = \frac{Gm'_B m'_C}{r^2}$$

The ratio of the gravitational forces on A and B by C is given by

$$\frac{F_{AC}}{F_{BC}} = \frac{m'A}{m'B} \text{ which turns out to be}$$

the ratio of their gravitational masses. If we now want to reduce the above example to purely Newtonian motion on Earth then we can make the particle C the planet Earth. If we do this then the gravitational

forces on A and B i.e. F_{AC} and F_{BC} are weight of bodies A and B in the earth's gravitational field. Hence

$$\frac{W_A}{W_B} - \frac{F_{AC}}{F_{BC}} = \frac{m'A}{m'B}$$

This means that Newton's law of Universal gravitation contains within it the result that the weights of various bodies at the same place on the surface of the earth, are exactly proportional to the gravitational masses.

Suppose we measure the inertial masses m_A and m_B of the same particles A and B by some dynamical experiments based on Newton's second law of mechanics. Then we let the two particles fall freely from the same position in the earth's gravitational field and we measure their accelerations in accordance with Galileo experiments. We shall find that both masses A and B have the same acceleration g arising from the earth's gravitational field. But the weights of the two bodies A and B are the same as the earth's gravitational fields on them. If we use Newton's second law of motion we got

$$W_A = m_A g$$

$$W_B = m_B g$$

$$\frac{W_A}{W_B} = \frac{m_A}{m_B}$$

Hence we have proved that the weights of bodies at the same place on the earth are exactly proportional to their inertial masses. Hence at least on earth, it seems as if the inertial mass and the gravitational mass appear to be identical. Newton devised pendulum experiments to test directly the apparent equivalence of inertial mass and gravitational mass on earth. Newton tested this with pendulums of equal lengths but different composition and found no difference in their periods. This result was later verified more accurately by Friedrich Wilhelm Bessel (1784 – 1846) in 1830. In 1889, Roland von Eotvos by a different method, in showing that the ratio of gravitational mass m_g to inertial mass m_i (i.e. $\frac{m_g}{m_i}$) does not differ from one substance to another by more than 1 part in 10^9. In recent years a group under R.H. Dicke at Princeton has improved on Eotvos method by using the gravitational field of the Sun and the earth's centrepetal acceleration towards the

Sun, rather than the rotation of the earth, to produce the torque on the balance. Dicke and his group were able to show that aluminium and gold fall freely towards the Sun with the same acceleration. The gravitational accelerations differ from each other by at most 1 part in 10^{11}. It has also been shown with less precision that neutrons fall in the earth's gravitational field with the same acceleration as ordinary matter and that the gravitational force on electrons in copper is the same as on free electrons.

Let us now go on to the second part of Newton's Universal law of gravitation which says that the force decreases as the inverse square of the distance. This idea was not entirely original with Newton. Johannus Scotus Erigena had guessed that heaviness and lightness vary with the distance from the earth. This theory was taken up by Adelard of Bath in the 12th Century who realized that a stone dropped into a very deep well could fall no farther than the centre of the earth. We must note here that Adelard also translated Euclid from Arabic to Latin, thus making it available to Medieval Europe. The first suggestion of an inverse-square law may have been made around 1640 by Ismael Bullialdus (1605 – 1694). However it was certainly Newton who in 1665 first deduced the inverse-square law from observations. He knew that the moon falls towards the earth a distance of 0.0045 feet each second, and he knew that the moon is 60 earth radii away from the centre of the earth. Hence if the gravitational force obeys an inverse-square law, then an apple in Lincolnshire (which is 1 earth radius away from the centre of the earth) should fall in the first second 3600 times 0.0045 feet or about 16 feet which is in good agreement with the measured value. But Newton did not publish this calculation for 20 years, because he did not know how to justify the fact that he had treated the earth as if its whole mass were concentrated at its centre. But it became known to several members of the Royal Society including Edmund Halley (1656 – 1742), Christopher Wren (1632 – 1723) and Robert Hooke (1635–1703) that Kepler's third law would imply an inverse-square law of force if the orbits of planets were circular. That is, if the squares of the periods, $\frac{r^2}{v^2}$, are proportional to the cubes of the radii r^3, then the centripetal acceleration $\frac{v^2}{r}$ is proportional to $\frac{1}{r^2}$. However the planets actually move on elliptical orbits not circular orbits. No one knew how to calculate their centripetal acceleration.

Under Halley's instigation, Newton in 1684 proved that planets moving under the influence of the inverse-square law force, would indeed obey all the empirical laws of Johannes Kepler (1571 – 1630) that is they would move on ellipses with the sun at a focus. They would sweep out equal areas in equal times and the square of their periods would be proportional to the cube of their major axes. Finally in 1685 Newton was able to complete his lunar calculations of 1665. These major accomplishments were published on July 5, 1686 under the title 'Philosophiae Naturalis'' ''Principia Mathematica'' Newton died on March 20 1727, at the age of 85 years. In the following centuries Newton's Universal Law of gravitation met with a brilliant series of successes in explaining the motion of the Moon and plannets. Some irregularities in the orbit of Uranus remained unexplained until in 1846. They were independently used by John Couch Adams (1819 – 1892) in England and Urbain Jean Joseph LeVerrier (1811 – 1877) in France to predict the existence and position of Nepture. The discovery of Neptune shortly thereafter was perhaps the most authentic verification of Newton's theory. The motion of the Moon and Eneke's comet (and later Halley's comet) still showed departures from Newtonian theory but it was clear that non-Gravitational forces could be at work.

CHAPTER THREE

THE UNIVERSE AS PERCEIVED BY ALBERT EINSTEIN

We all see the world through light and it is therefore not surprising that light or any other member of the electromagnetic spectrum assumes a very important role in formulating physical laws. Information is sent between two positions in free space by the use of light signals or any other electromagnetic wave signal. The speed is fast enough for us. It is 3×10^8 m.s.$^{-1}$. So far we have not succeeded in establishing faster mode of transmitting information in our terrestrial Universe. The idea of a limiting speed of motion to terrestrial particles contradicts Newtonian concept of the Universe. Hence it seemed at the time that there was a wedge between the physical laws of Mechanics and the physical laws of Electrodynamics.

Albert Einstein came to the rescue. He made two postulates on which the Special Theory of Relativity rests.

1. The speed of light in vacuo is the same in all inertial systems moving with uniformly relative velocity to one another.
2. The laws of nature are invariant in all inertial systems moving uniformly with relative velocity to each other.

The concepts of absolute space and absolute time assumed in Newtonian Mechanics have been changed by Einstein. We must now think of space in terms of inertial systems and in order to find a reference frame for time we use the constancy in vacuo of the speed of light. The theory of relativity is sometimes criticized for giving without justification, a central theoretical role to the propagation of light in vacuo. But for now the constancy of the speed of light in vacuo is a real physical significance about which we know so much. It is therefore convenient both from the theoretical development of relativity and experimental measurements to relate the concept of time to the propagation of light in vacuo.

The elegance of Einstein's Relativity is that it does not overthrow Newtonian Mechanics but extends the region of the validity of the laws of physics from R^3 to R^4. Space – Time Physics was born and a whole range of physical laws was subjected to Relativity test using Lorent z – Einstein Transformations from one inertial system to the other. The Special Theory of Relativity expands our horizon in both Space and Time but its limitation was also obvious to Einstein.

In Special Theory of Relativity we have assumed the equivalence of all inertial systems in the description and formulation of the physical laws of nature. The immediate question that arises is the nature of the effect of other systems that are not inertial systems. It is very difficult to conceive of nature preferring our cleverly defined Space – Time based on inertial systems and dis-regarding non-inertial systems. We have to justify the preference for inertial systems. The weakness of the principle of inertial lies in the fact that it involves an argument in a vicious circle.

A mass moves without acceleration if it is sufficiently far from other bodies that can influence the motion. But we deduce its isolation or farness from other bodies in the first instance, from the fact that it moves without acceleration. It looks as if we have to look carefully again at our Space–Time continuum of R^4. In other words what region of the Universe is clearly defined by our Space-Time continuum of R^4. It seems that to a high degree of approximation we may look at the principle of inertial as established for the space-time continuum of our planetry system provided we neglect the perturbation effects due to the sun and other planets. We can put it in a more exact form by stating that there are finite regions of space in the Universe where material particles move freely without acceleration with respect to a suitably chosen space of reference, and in which the laws of Special Theory of Relativity hold with remarkable degree of accuracy. Let us call such region "Galilean Regions".

If we proceed from the considerations of such regions as a special case of known properties, then the principle of equivalence demands that in dealing with such regions, we should also consider non-inertial systems i.e. systems that are not free from accelerations and rotations relative to inertial – systems.

Now we have got ourselves entangled with preferred co-ordinate system as against the ones that are not preferred. We must look again at the property of the Space-Time we tried to define in the Special Theory

of Relativity. If we run into difficulties with the definition of Space-Time relative to Inertial Systems, then we shall also run into difficulties if we try to define non-Inertial Systems relative to the Space-Time of Special Theory of Relativity.

Hence we must admit that Space-Time cannot be defined with respect to non-Inertial Systems as they were in the Special theory of Relativity. What we can do however is to define non-Inertial frames as a system at rest, with respect to which there is a Gravitational field influences (field of Centrifugal force and force of Coriolis). We therefore can say that the gravitational field influences the Space-Time or determines the metrical laws of the Space-Time Continuum.

Looking at it this way the laws of configuration of ideal rigid bodies in the presence of a gravitational field will result in non-Euclidean Geometry. Einstein thus extended the Special Theory of Relativity to the General Theory of Relativity where the Space-Time R^4 is non-Euclidean. But if the gravitational field is negligible in a small region then we have the Galilean Region of Special Theory of Relativity.

In the immediate neighbourhood of an observer that is falling freely in a gravitational field there exists to the observer no gravitational effect. If we take such general view of the Space-Time R^4, we can always regard an infinitesimal small region of such R^4 as Galilean Region. Albert Einstein took us out of the difficulties of defining our finite R^4.

Riemannian Geometry became a readily available mathematical tool for the General Theory of Relativity Inevitably the theory of Space-Time is now linked with Gravitation.

The actual applicability of Einstein's equations in their classical forms to such enormous dimensions as we may witness in Space Explorations is not well established as in the case of phenomena on a more limited scale. This means that on a cosmic scale, these equations will require modifications. The time scale in some of the solutions is nearer the terrestrial scale than cosmic scale.

CHAPTER FOUR

SOME OF THE UNRESOLVED PROBLEMS IN PHYSICS

In this chapter I am going to share my own views with you all. I have selected five areas in some of the Unresolved Problems in Physics.

1. Wave — Particle Duality

A physicist when confronted with the concept of Wave-Particle Duality in Atomic Physics cannot but be confused. I must confess that I have never succeeded in making my students to understand it. Since they have to pass the examinations, and I am setting the questions, they all conspire to pretend to understand the concept and reproduce exactly whatever I said in as much as it does not contradict what they have read in the standard textbooks on Atomic Physics.

Let me quickly recall the observations which have led to the concept of Wave — Particle Duality.

i) The Interaction of light with matter as in the case of photo-electric effect leads to the particle like behaviour of light radiation.

ii) The observation of the pressure of light radiation can also be interpreted in terms of particle like behaviour of photons of light.

iii) Compton Scattering which can also be described as the interaction of photons radiation with matter, can be satisfactorily explained by treating photons as behaving like particles.

iv) Light or any other electromagnetic radiation propagates in free space as a wave and with velocity of propagation which is a constant $c = 3 \times 10^8\ m.s^{-1}$

v) A beam of small particles like electrons, moving with high velocity can also exhibit wave-like behaviour if allowed to interact with matter within a very small space.

In all the above observations there are 3 keynote terms — matter, radiation and space. It is obvious that the interaction of any 2 of the 3 will lead to separate events and such separate events for the purpose of clarity have to be treated differently. When we move on to the physical laws of the Universe we may have to re-examine our definitions of matter, radiation and space.

2. Relativity and Nuclear Physics

It is the relativity effect on fast moving particles in Nuclear Physics that has led to the numerous experimental and mathematical difficulties encountered in elementary particle physics. Any particle travelling with velocity c in free space has no mass, no length etc. and can only be treated as a photon of energy. If we can capture the photon or its residual effect after interactions, we are satisfied with its existence. Hence we can go on further to state that it is the relativistic effect on particle moving in our terrestrial space that has imposed the limitations of velocity c on our experimental or observational capabilities as of now.

The Wave-Particle Duality in Nuclear Physics is obviously a logical consequence of the above. So far Quantum Mechanics in its full development has provided some significant satisfactory mathematical tools for dealing with the situation. But we have not reached the limit yet.

3. Is Planck's Constant a Universal Constant

The exchange of energy between electromagnetic radiation and electrons, leads to the failure of classical physics to explain the experimental results of photoelectric effect in atomic Physics. Einstein used Planck's constant h to make it possible for his theory to fit the experimental results. Since then h has been regarded as a Universal constant.

In my opinion the question of regarding Planck's constant as a Universal Constant needs a reexamination especially now that Space Exploration is also going to involve the effect of Relativity on matter, fields, Energy, Unlimited Space and Time.

4. Problems of Space Exploration, Measurements in Space, and the Interpretation of results

Space-Time Physics will really come to its own in Space Exploration, measurements in Space and the Interpretation of results. One disturbing aspect of Space Experiments is the wide possibility of carrying out experiments in atomic and elementary particle physics in space. We now have a situation where the Space age and the Nuclear age will become concurrent in Space. It may well be that some of the unresolved problems in Nuclear Physics are going to be solved in Space Experiments.

5. How General is the General Theory of Relativity?

It is obvious from all the points I have listed in this chapter that Relativity cuts across both Nuclear Physics and Space Physics. The next chapter is therefore my own little contribution to thoughts on the Physical laws of the Universe.

CHAPTER FIVE

LOOKING BEYOND ALBERT EINSTEIN

Many physicists throughout the world will agree that Einstein's Theory of Relativity is difficult to understand. The question that may follow is:- "Why should we want to look beyond Albert Einstein". This question has been asked by physicists many times since the inception of the theory.

This is one area where one can be both a physicist and a prophet. The following reasons have occured to me in the last 15 years.

1. The Space Age has started in earnest and the Universe as constructed within the framework of the General Theory of Relativity may have to be stretched far beyond Einstein's cautious dimensions.

2. Space-Time physics now has more tangible meaning during the present Space Age than it had at the time Einstein formulated his theory of Relativity. Space whether Euclidean as in the Special Theory of Relativity or Non-Euclidean as in the General Theory of Relativity can now be violated by Astronauts and many unmanned Space ships.

3. The Search for Extra Terrestrial Intelligence (SETI) has already started in earnest. We do not know the exploding revelations of the Universe SETI may bring, but we must be prepared. If we are to reach far beyond our galaxy towards far away galaxies then the possibility of violating Time Reversal of Events cannot be completely ruled out

4. Accelerated frames of reference hence Gravitational fields constitute the core of the General Theory of Relativity. This of course blends beautifully with the Geometry of Space-Time. But in a more general form, geometry should be seen as a mathematical tool valuable in extending Special Theory to General Theory. Such limita-

tions are not essential for the extension of the basic ideas although no one will deny the immense contributions made by such geometrical development.

5. We know that Gravitational fields are central to the General Theory of Relativity, but it should not be seen as the inevitable limitation to the Principle. We know that a particle accelerated to the velocity of light in space has no mass and can only be quantified in terms of photons of Energy. But we cannot claim to have achieved sufficient technological and theoretical skill to evaluate all photons of energy being radiated in the Universe. The distribution of all forms of photons of energy, whether detectable in our Terrestrial laboraotry or not, is a valid property of Space-Time. It deserves as much attention as Gravitational fields. It is immaterial whether we can at the moment evaluate them or not.

All these thoughts have occupied my mind at one time or the other during the past 15 years. I shall now share with you some of my own thoughts on "Looking Beyond Albert Einstein".

Here I want to explain the physical concept that will enable me do *3 basic things.*

1. Approach the General Theory and Special Theory of Relativity from a different concept of coupling of any two regions in a sub-space S^A in S.

2. Extend the concept beyond Albert Einstein's General Theory of Relativity by defining another sub-space S^B in S with a coupling property other than Gravitational fields. This will enable me to bring into my concept the distribution of all forms of photons of energy in the Universe irrespective of whether they are measurable or detectable in our Terrestrial Laboratory or not.

3. Speculate or prophesy on the consequence of the above two steps on the Search for Extra-Terrestrial Intelligence (SETI) and the non-Universality of Planck's constant h.

Let us suppose we can approach the general theory of relativity from the following angle. Assume that a space S exists in the Universe in

which all physical laws are defined. S must not be confused with the physicist concept of space. S must be generalized in the way mathematicians do. Consider sub-spaces S^A, S^B of S and assume that these sub-spaces are distinguishable within S in such a way that there are certain physical laws that form an integral part of all natural laws and are true in each sub-space S^A, S^B of S. Suppose the physical laws in a sub-space S^A cannot be wholly true when transformed to another sub-space S^B unless certain modifications of ideas governing the laws in S^A are made in S^B and vice-versa.

Let us say that certain well known physical laws exist in S^A. S^A can be sub-divided into regions in S^A. We define a region where physical laws are true irrespective of the inertial frames of reference. If we define another region within S^A but impose a condition that there is a coupling between the two regions in S^A, such that the physical laws true in the first region, need to be modified when transformed to the second region and vice versa. One can say that the invariance of physical laws in a region of S^A irrespective of the inertial frames of reference within that regions, corresponds to Einstein's special Theory of Relativity. Einstein himself touched on such similar region when trying to extend the Special Theory to the General Theory. He called it Galilean – Euclidean region.

But such invariance of physical laws in the first region of S^A when transformed to a second region within S^A requires modifications because of the effect of coupling of the two regions of S^A which is not detectable in the first region but is detectable in the second region. If we do this, we can arrive at Einstein's General Theory of Relativity where such detectable coupling in the second region is equivalent to the effect of accelerated frames of reference in Space-Time physics or the effect of Gravitational vector fields in Space-Time Physics. We can go on to say categorically that the detectable coupling effect in the second region is a unique characteristic of that region. We can go further still and call such a region "Einstein–Non-Euclidian". This terminology is mine.

On the basis of the above approach we can look beyond Einstein's General Theory of Relativity if another unique sub-space S^B in S exists. There is no justifiable reason why we should assume that S^A is unbounded. We can now take another sub-space S^B in S and assign to it

another unique property different from the gravitational vector fields of S^A. We shall say that in S^B, the detectable coupling effect of any two regions in S^B is characterized by the detectable photons of energy in any of such region.

In order not to confuse S^B with our terrestrial space we shall impose a condition that S^B could be anywhere in the Universe and the distribution of the sources of such photons of energy could be anywhere in the Universe. Since photons have no mass, gravitational fields are automatically excluded. We can go further and state that the detectable photons of energy in our terrestrial laboratory form only a small part of all the photons of energy distribution in the Universe. Our own inability to detect the rest in our terrestrial laboratory could be a consequence of our technological and theoretical limitations.

This argument will fit in with our Search for Extra-Terrestrial Intelligence (SETI) as well as the results of future High Energy experiments that may be carried out in space laboratories.

The distribution of matter in n-dimensional space constitutes vector fields. Gravitational vector fields are associated with mass distribution. In the infinitesimally small space encountered in atomic physics and Elementary particle physics, the momentum vector field of a photon does not contain the mass m but it contains planck's constant h and the wavelength λ. In fact it is $\frac{h}{\lambda}$. The space we are dealing with here is so small that λ is significant. But in a more general form of considering the distribution of photons of Energy in the Universe we can make h equal to any suitable constant or even 1. This is what is at the back of my mind when I speculate that Planck's constant h does not necessarily have to be regarded as a Universal constant. Admitedly it is sufficient to make $h = 6.6 \times 10^{-34}$ J.s in all our Terrestrial experimental and theoretical work.

I must not go on beyond this point because of my audience. But one thing makes me happy about my concept in looking beyond Albert Einstein and I will like to share this with you. I became a member of the PLANETARY SOCIETY in 1989. I formulated my concept in the late seventies but I have never published it because I keep on revising it everytime something else occured to me. The Planetry Society sent me "The Planetry Report" Vol. 9 Number 2 of March/April 1989. On

page 13 of that report is an article on the Concept of Extra Terrestrial Intelligence — An Emerging Cosmology. On that page is a paragraph which gives me more confidence in my approach to the concept of looking beyond Albert Einstein. I quote:-

> "We see the Universe through the lens of our cosmology. This all-encompassing world view determines how we conceptualize our planet, our solar system and the entire Universe around us. Cosmologies change with time, fashions, and scientific developments and what was once accepted as the true nature of the Universe may gradually become a measure of our ignorance."

CHAPTER SIX

CONCLUDING REMARKS

It is obvious from this Inaugural Lecture that physics in the 21st century is going to expand to an explosive dimension, and space experiments will throw more light on some of the unresolved problems in physics. In this lecture I have given in chapter 5 a brief outline of my own concept on the subject of "Looking Beyond Albert Einstein."

The mathematical tool that will be required to support this concept must reach the cosmological scale and dimensions far beyond the cautious scales of Einstein's General Theory of Relativity.

The search for Extra Terrestrial Intelligence (SETI) in space may completely modify some of the physical laws of the Universe and consequently reveal to us our ignorance of what at the moment we think we know about the Universe.

The 20th Century is coming to an end but the remaining few years should be spent in preparing for the explosive Universe and knowledge which the 21st century will bring to our doorstep. One consequence of the coming explosive Universe is how to save this our planet Earth and all that is in it — that is the ever-recurring decimal of WORLD PEACE AT THE INTERSECTION OF SPACE AGE AND NUCLEAR AGE. If many of you cannot work out the 21st century mathematics of SPACE-TIME PHYSICS, you can at least try your hands at the problems of saving our planet Earth during the 21st century.

I have therefore divided my concluding remarks into 3 sections.

Section A: The Physical laws of the Universe and Religion.

Section B: The Strategies Physicists Worldwide should adopt towards Peace in the 21st century.

Section C: Warning to Africa.

Section A

The Physical Laws of the Universe and Religion

I decided to include this section in my concluding remarks because I want my views on this aspect to be on record. I do not want a situation whereby other physicists in future will try to interprete my concept in a manner that contradicts my own perspective of the Universe and Religion. I would like to put in a small box everything I have said in Chapter 5 and label it "LIGHT AND SPACE–TIME PHYSICS"

When I mention light here, it includes all the members of the Electromagnetic Spectrum like X-rays, γ -rays, radio waves etc. Space-Time Physics will lead us to all that we know now and all that we shall be able to know in future about the Universe. This question will then arise: — "Is my little box static in Eternity or dynamic."

All my thoughts on the answer to that question, though philosophical in concept, lead me to one conclusion that is — My little box so labelled is indeed dynamic in ETERNITY. There is only one ETERNITY AND GOD IS THE ALPHA AND OMEGA.

Section B

The Strategies Physicists should adopt towards world Peace in the 21st Century

You may first of all wish to ask why it is necessary for physicists Worldwide to adopt some specific strategies towards WORLD PEACE in the 21st century. My answer to the above question is that scientific discoveries and knowledge lose their meaning and relevance the moment it becomes obvious that if some concrete and careful precautions are not taken, the scientific knowledge with all the immense benefits, could eventually lead to the total destruction of the whole human race.

From the physicists perspective, we have reached that dangerous crossroad in time. Hence there is an urgent need for strategies towards World Peace especially among physicists worldwide, whose discoveries are becoming more frightening Military wise everyday. The Nuclear Age which has dominated the 20th century is bad enough, but the

Space Age which from all indications will dominate the 21st century is going to be a Universal suicide if adequate care is not taken.

It is absolutely impossible for me to exhaust all strategies physicists worldwide can adopt towards WORLD PEACE in this lecture but I shall try my best to share with you some of my thoughts on the subject. If we must continue to advance our knowledge of the physical laws of the Universe, we must also explore all possible ways of saving the human race from Universal suicide.

1. The need for a more careful plan in the training of physicists Worldwide.

Whereas doctors, because of the nature of their jobs to save lives, have ethical codes in the training and practice of medicine worldwide, the physicists are absolutely free to use their knowledge without adequate precautions. Physicists are absolutely free to pass on their discoveries to the Military who may misuse the knowledge as they like.

Few physicists in advanced countries have opted out of some research programmes voluntarily on moral grounds, because of their devastating Military Use. But these physicists are few in number compared with a large number of them who see their roles in the world differently. The result of this free for all attitude is a tendency for physicists to work very hard at some problems which will lead to immense technological benefits to mankind as well as immense Military potentials without any serious concern for the latter.

The whole world has witnessed the negative consequences of the Nuclear Age and the very important roles some physicists played in the final decision to drop nuclear bombs on Hiroshima and Nagasaki in 1945. I am now calling on physicists throughout the world to prepare WORLD ETHICAL CODES for the training of physicists and the practice of the profession as they affect the problems of WORLD PEACE in the 21st century.

2. The Piper and the Tune

Many times I have wondered about those who pay the piper and those who dictate the tune. It is a well known fact throughout the advanced countries that there are a large number of physicists who have

become quasi-Military researchers because of the Military applications of their work. The more relevant the research is to Military use, the more fund the physicists get for their work hence many of them no longer think anymore about the destructive consequences of their work. I think we have reached a crucial point in the world today where this unholy wedlock between Physicists and the Military must be made holy if we are all to survive the SPACE AGE which is now dangerously balanced on the NUCLEAR AGE.

If you now ask me about those who dictate the tune in the world we are today, I would simply say that a greater percentage of the tune is in fact dictated by these physicists behind the scene.

I think the time has come for the International Council of Scientific Unions (ICSU) to interact with International Military Bodies in a joint concerted effort to map out strategies for PEACEFUL USE OF SCIENTIFIC RESEARCH that will guarantee WORLD PEACE in the 21st century.

Section C

Warning to Africa

The rapidly warming up of the cold war between U.S.A. and U.S.S.R. is inevitable and it is a natural consequence of the advancement of their SPACE RESEARCH PROGRAMMES and the unavoidable collaboration in SPACE RESEARCH AND TECHNOLOGY.

The rapidly disappearing of the political and economic walls between the Western and Eastern European countries has also not come as a surprise because the whole world — East, West, North and South can now be viewed and reached through Satellite Communications within a very short period. Rapid locations of positions on Earth from Space ships and Satellites are now almost becoming routine.

The inevitable political and economical consequences of the advancement in SPACE RESEARCH AND TECHNOLOGY on the African Continent are now clear and loud. All the above facts pose greater challenges to physicists in Africa. They must sharpen their brains more than ever before, and must work harder than ever before to face the challenges of explosive physics knowledge in the 21st century if the African Continent is to survive the SPACE AGE.

Whether the Africans like it or not, whether they are prepared for it or not, whether they are developing or underdeveloping, whether they are politically and economically stable or not, the Universe is being brought to their doorsteps by the advanced countries.

History is not on our side because Africans have sold their fellow men and women into slavery before to work on new continents. I hope that history will not repeat itself whereby Africans will be sold into SLAVERY to work on the MOON AND OTHER PLANETS in space during the 21st Century — the GOLDEN CENTURY OF SPACE ADVENTURE. Time is not on our side unless we are ready to pull AFRICA up to face the challenges of the EXPLOSIVE KNOWLEDGE OF THE UNIVERSE which the 21st Century will surely bring.

THE AUTHOR

Professor Ebun Adefunmilayo Oni (Nee Adegbohungbe) was born in Ilesa, Osun State on May 21, 1935. Her father is the late Mr. Moses Fadejuwon Adegbohungbe a prince and the grandson of Owa Ofokutu of Ijesaland, who reigned from 1820–1857. Her mother is Mrs Mary Omotola Adegbohungbe from the Fatunwase family of Ifewara. She attended Saint John's primary school Iloro, Ilesa and from there proceeded to the Methodist Girls' High School, Yaba, Lagos. She was admitted to the University of Ghana, Legon, Accra in 1957. She passed out in 1960 with B.Sc. Hons., Physics and Mathematics Second Class, Upper Division. She carried out her postgraduate studies at Imperial College, London. She obtained the degrees of M.Sc. London, Ph.D. London and D.I.C. (Diploma of Imperial College).

She started her teaching carrier at the Department of Physics, University of Ife in August 1963, and transfered her service to the Department of Physics, University of Ibadan in October 1968. She was promoted Professor of Physics on October 1, 1983.

Professor Oni has travelled throughout the World to present scientific papers at many International Conferences – namely Cambridge University 1967, Spain Madrid 1969, Moscow, USSR 1971, Kyoto Japan 1973, Boulder Colorado U.S.A. 1974, Seattle Washington U.S.A., 1977, Marnue Germany 1978, Camberra Australia 1979, Istanbul Turkey 1980, Edinburgh U.K. 1981, Hamburg Germany 1983, Pune, India 1985, Switzerland 1986, Vancouver Canada 1987, Erice Sicily 1989 and Nairobi, Kenya 1990.

Professor Oni has published extensively in many International Scientific journals. She is the leader of the following active research group in the Department of Physics University of Ibadan – "SOLID EARTH AND SPACE PHYSICS". Professor Oni is a member of many National and International Scientific Organisations. In 1989 in Erice Sicily, she was elected a member of the "WORLD LABORATORY" in 1990 in Nairobi Kenya she was appointed the Vice-President of the International Commission for Earth Sciences in Africa (ICESA).

Professor Oni has served in many committee in the University and has held a number of Administrative positions including the Headship of the Department of Physics from February 1, 1983 to July 31, 1985.

Professor Oni has also served the Nation as a foundation Director of Integrated Data Services Limited IDSL (A Subsidiary of NNPC).

Professor Oni has trained many postgraduate students and she is still a very active scientific researcher and a teacher in the Department of Physics, University of Ibadan.

Professor Ebun Adefunmilayo Oni
August 14, 1995.

Whether my contribution to knowledge

looks great or small in your opinion

PLEASE GLORIFY

GOD ALMIGHTY.

I am only the CLAY,

He is

THE EVERLASTING POTTER.

Ebun Adefunmilayo Oni

August 25, 1995.