UNIVERSITY OF ILORIN

THE ONE HUNDRED AND TWENTY-NINTH (129th)
INAUGURAL LECTURE

"THE MANDATE: THE RADIO AS AN INSTRUMENT OF DOMINION"

By

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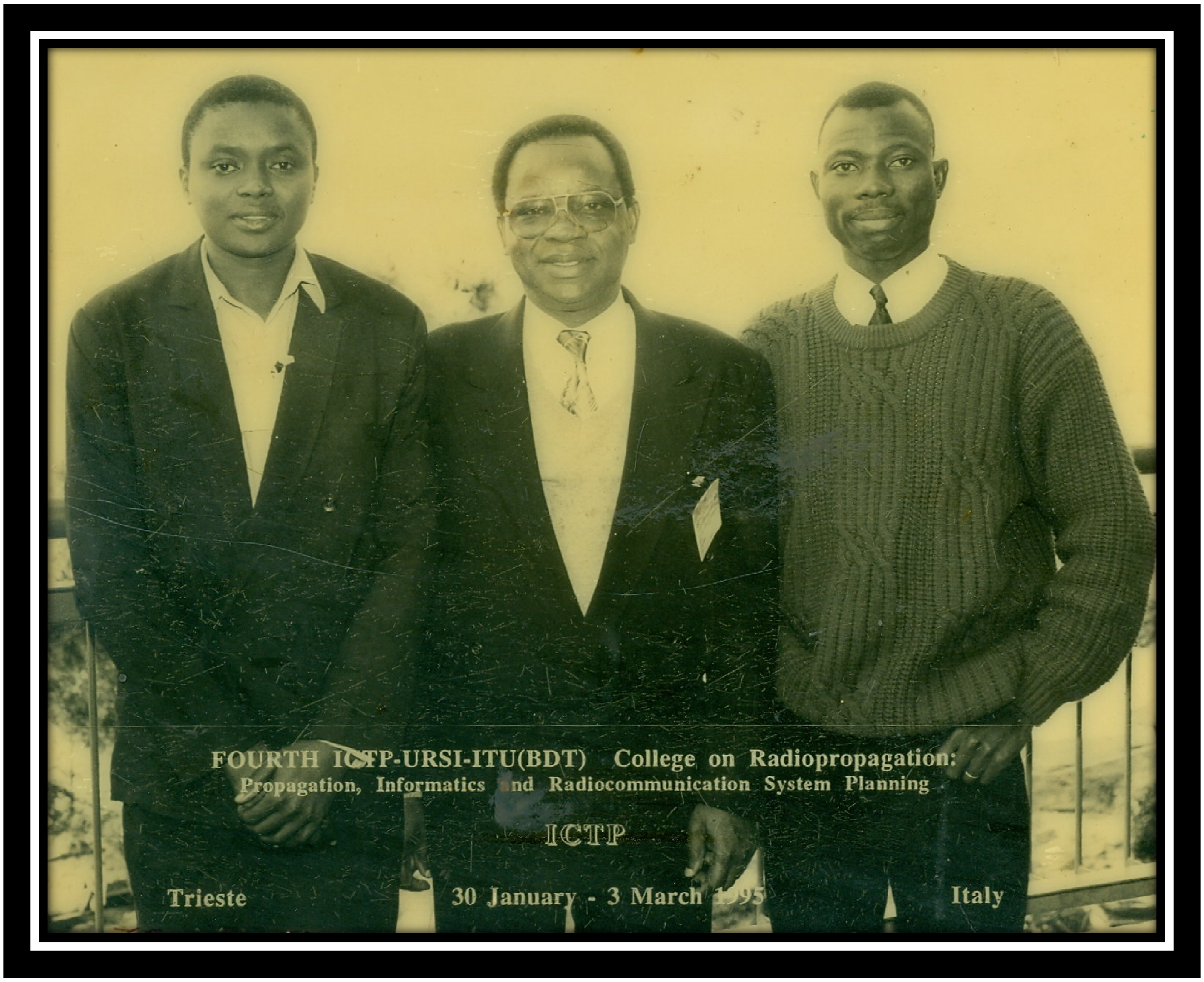
In the beginning . . . . .

That we may have dominion….



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My lords spiritual and temporal

Members of my Family – Nuclear and Extended, Friends and Relatives

Distinguished Invited Guests,

Gentlemen of the Press,

Distinguished Ladies and Gentlemen

My Dear Students and other Students here present

1.0 Preamble

God's Mandate to Man

God at creation exercised His authority over the things that were and the things that were not. At the end of six days, God completed His works, rested on the seventh day and thereafter handed over the mandate of dominion to man. God specifically gave this charge to the man He has created

> *And God said; Let us make man in our image, after our likeness: and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth.* Gen. 1: 26

This mandate has been our challenge since creation and we are still very far from the set mark. God entered into His own rest on the 7th day, it is therefore left for man to complete his own work and thereafter enter into rest.

I give all glory to God Almighty through the Lord Jesus Christ and the University for giving me the opportunity to deliver this 129th Inaugural lecture of the University and the 6th from the Department of Physics, titled "**The Mandate: Radio as an Instrument of Dominion**"

Mr Vice-Chancellor sir, God the first and true "physicist" in the exercise of His dominion used electromagnetic waves (light) to bring order to an otherwise chaotic situation when He said ***let there be light*** as the first work in creation. In fulfilling the mandate of dominion, I have taken up the challenge of subduing the earth's environment and space through the understanding and use of electromagnetic waves, which serves as the foundation of all creation.

I thank the University for giving me the opportunity to make a full proof of my calling. In pursuant of this calling, I have focused my attention on things that are ahead and forgetting those things that are behind: not as though I have already attained, but I press on (not by brute force like an animal, but by deep thinking and advancing reasons for things which are or are not) if by any means I may attain to the place of the dominion of my environment. We all have this responsibility from our maker and those that are idle, lazy, fraudulent etc. have no place in this work of dominion. In the quest for dominion, different shades of opinion have emerged and these opinions confront us the possibility of making choices. I have made a choice and I thank the University of Ilorin for giving me the enabling environment and opportunity to press onwards in my choice.

Mr Vice-Chancellor sir, permit me to quote an American poet as follows:

> *Nature is thoroughly mediate. It is made to serve. It receives the dominion of man as meekly as the ass on which the Saviour rode. It offers all its kingdoms to man as the raw material which he may mould into what is useful. Man is never weary of working it up*
>
> Ralph Waldo Emerson, 1803 – 1882.

The dictionary defines dominion as, the power or right of controlling and governing a territory, land or domain. Inherent in man is the desire to have dominion over his immediate environment. This is a noble desire as long as it is done to improve living conditions.

Every journey into space begins at the ground level. Space affects all things on the surface of the earth; in fact, our planet is hanging in space, Fig.1. The earth also affects space and both earth and space interact in a very complex form.

In this lecture we shall be talking about the Earth's Magnetic field, Troposphere and Ionosphere. All these affect the radio wave signal propagating on the earth and beyond in a very complex form.

Specifically, we shall attempt to provide answers as to why while watching a popular TV show the screen suddenly gets scrambled or the pictures suddenly become snowy; radio signals especially at shortwave frequencies fade in the afternoon hours or why is the GPS data concerning my position not constant?

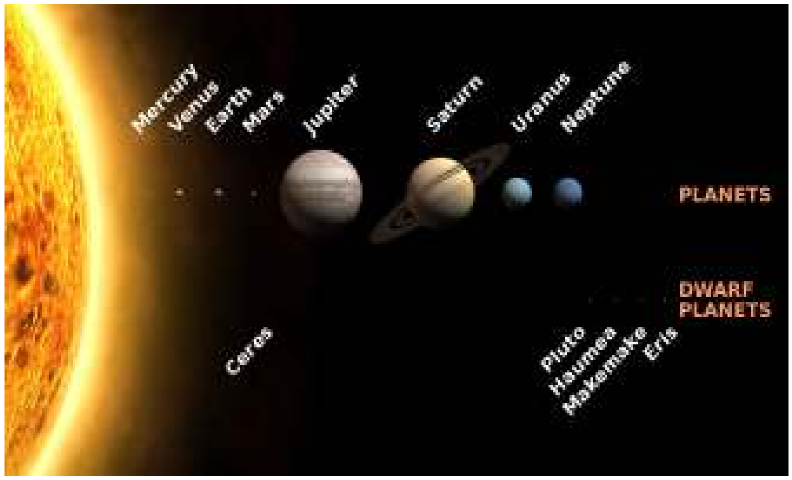


Fig.1: The Solar system Source: wikimedia.org

We will take our discourse from the earth especially the University of Ilorin to the Sun.

2.0 Radio as an Instrument of Dominion

Introduction

> *In the matter of physics, the first lessons should contain nothing but what is experimental and interesting to see. A pretty experiment is in itself often more valuable than 20 formulae extracted from our minds; it is particularly important that a young mind that has yet to find its way in the world of phenomena should be spared from formulae altogether.* Albert Einstein, 1879 - 1955

In this lecture use of formulae will be avoided as much as possible and I shall explain the concept of our mandate in very simple terms.

2.1 Electromagnetic Waves.

Mechanical or electromagnetic waves are two important ways by which, energy is transported around us. Mechanical waves require a medium of propagation unlike electromagnetic waves that can propagate through space and matter. The electromagnetic waves cover a broad spectrum from the very long radio waves to the very short gamma waves. The human eye can detect a little portion of the spectrum called visible light.

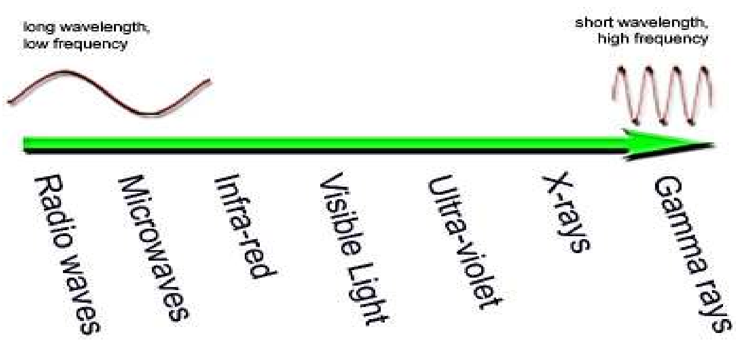


Fig.2: The Electromagnetic Spectrum

James Clerk Maxwell (1831-1879) in the 19^{th} century developed a scientific theory to explain electromagnetic waves. He found that perpendicularly vibrating electric and magnetic fields can couple together to form electromagnetic waves. Subsequently, two important properties of the waves were discovered by Heinrich Hertz (1857-1894). He found that the electromagnetic waves travel with the speed of light and can travel through vacuum. Electromagnetic waves have revolutionized science and today our radio, television, phone (text or voice), microwave oven, remote controls, radiology, etc. all use electromagnetic energy for their operations.

2.2 The Radio

Radio is the wireless transmission of signals through free space by electromagnetic radiation at frequencies from about 30 kHz to 300 GHz. Electromagnetic radiation travels by means of oscillating electric and magnetic fields that pass through space. Information, such as sound, video, data are carried by systematically modulating some property of the radiated waves, such as their amplitude, frequency, phase, or pulse width. When radio waves strike an electrical conductor, the oscillating fields induce an alternating current in the conductor. The information in the waves can be extracted and transformed back into its original form by the process of demodulation.

The radio has become one of the most potent instruments of terrestrial and space exploration and any nation that cannot control her space environment will lose out in this IT economy. Today, the radio has become a veritable tool in the hands of the global community. It is now used in guided instruments, weaponry, precision instruments, meteorology, probes, etc

2.3 Uses of Radio

Earlier uses of radio were in maritime for communication between ship and land. The Japanese navy used the radio to scout the Russian fleet in the battle of Tsushima in 1905 as an edge over the Russians and ever since, the radio has become a potent instrument in warfare. Radio was extensively used in wars to pass messages between armies and also as instrument of propaganda. A major early use of radio in war and peaceful purposes is in detection of aircraft and ships by the use of RADAR, voice transmission, telephony, television, remote controls, etc. Today its uses include wireless and mobile communications of all types, Bluetooth and microwave devices to mention a few. Radio has become a veritable resource for all mankind from the lowest to the highest in the land as everybody now carries a mobile phone as a necessary part of our daily attire. Global Navigation Satellite System, GNSS, (example of which is Global Position System, GPS) technology is now available on mobile phones and anybody can locate his or her position on the surface of the earth by the use of these devices, Fig. 3, (http://www.gps.gov/systems/gps/space/). Unmanned Aerial Vehicles (Drones) are pilotless aircrafts used for surveillance and attack purposes. Drones are becoming veritable military tools, minimizing dangers to the owners. They are guided by on board radios both for target detection, take-off and landing. In the next few years, pilotless commercial aircrafts should be available. The original motivation for satellite navigation was for military purposes, but now satellite navigation is finding many applications in civilian and commercial uses.

Satellite navigation allows great precision in the delivery of weapons most notably guided bombs to targets, greatly increasing their lethality whilst reducing casualties from mis-directed weapons. Satellite navigation also allows forces to be directed and to locate themselves more easily. Satellite navigation system is an essential asset for any aspiring military power. The ability to supply satellite navigation signals is also the ability to deny their availability.

The operator of a satellite navigation system in the exercise of his dominion over others potentially has the ability to degrade or eliminate satellite navigation services over any territory it desires.

Today, information on what obtains beyond our planet is readily available through the use of electromagnetic waves.

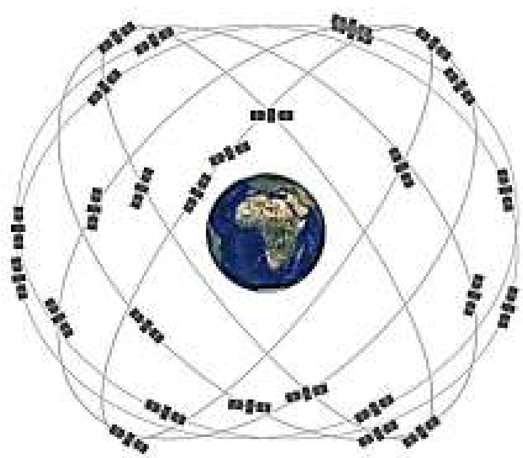


Fig. 3: GPS satellite constellation flying in the Medium Earth Orbit (MEO)

3.0 The Earth's Atmosphere

Two major classifications of the earth's atmosphere are normally employed; temperature gradient such as troposphere, stratosphere, mesosphere, thermosphere and exosphere, and by the degree of ionization such as neutrosphere, ionosphere and protonosphere, Fig. 4, (Radicella and Adeniyi, 1999)

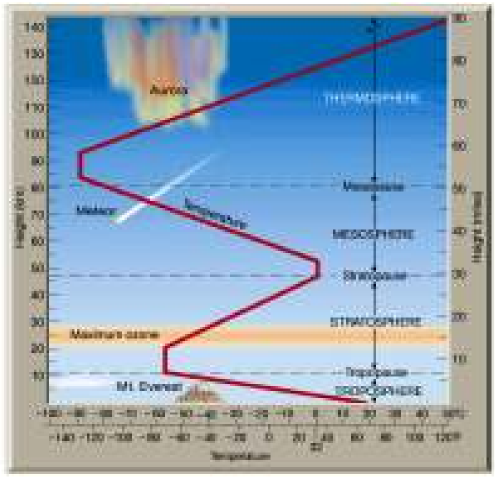


Fig. 4: Classification of the earth's atmosphere

3.1 The Troposphere.

The troposphere is the lowest portion of the earth's atmosphere with a mass of about 75% of the earth's atmosphere and 99% of the earth's water vapour and aerosols. It is primarily composed of nitrogen (78%), oxygen (21%) and inert and other gases (1%). In the troposphere, a lot of turbulence or mixing of the atmospheric constituents takes place. Most of the phenomena associated with our day - to - day weather take place in the troposphere which extends from the earth's surface to about 8km in the high latitudes to about 16km around the equator. Temperature decreases with height at a rate of about 6^oC per km. Since temperature decreases with height, warm air near the surface can rise within the troposphere because the air above is less dense. This vertical motion of air mass allows molecules to move up the troposphere in few days and back. This motion or convection of air generates clouds and ultimately rain from the moisture within the air, and gives rise to much of the weather which we experience.

At the top of the troposphere is the tropopause which is a region of constant-temperature. Above the tropopause is the stratosphere which is a region of increasing temperature with height. This temperature increase prevents any form of convection, thus limiting most of the weather phenomena to the troposphere. Occasionally, temperature does not decrease with height but increases, creating a temperature inversion. This inversion prevents air mixing leading to air being trapped in the troposphere. This has a problem of trapping pollutants emitted from the surface of the earth.

The refractive index of the troposphere is about 1.003 in clear sky, and varies in height due to variations in temperature, pressure and humidity. The refractive index normally decreases with height, if however instead of the normal decrease of temperature with height, an inversion occurs, the increase in temperature causes a rise in the refractive index of the atmosphere. The refractive index changes have great effect on radio signals in the troposphere. The higher refractive index causes the signal to bend and hence travel over longer distances for radio signals in the very high frequencies (VHF) and ultra-high frequencies (UHF) range. At super high frequencies (SHF), the effects of clouds, rain, snow, atmospheric gases, etc. create much greater challenges to radio propagation in the troposphere. Fig.5 depicts the atmospheric gases' contribution to the zenith attenuation, (ITU_R, P676, 2012).

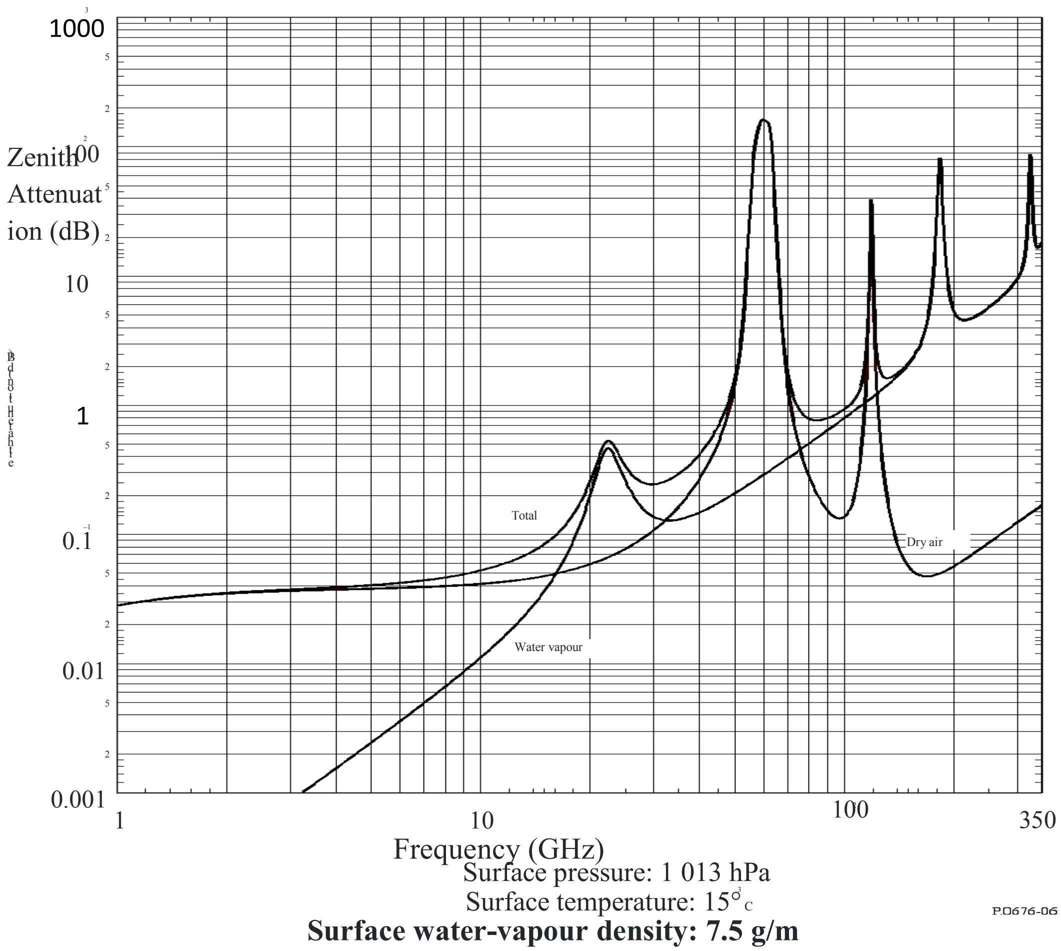


Fig. 5: Atmospheric gases contribution to zenith attenuation

3.2 The Ionosphere

The ionosphere is a part of the upper atmosphere from about 50km to 1000km, distinguished because it is ionized by solar radiation particularly Extreme Ultraviolet Radiation (EUV), from the sun. It has sufficient electrons and ions to affect the propagation of radio waves and together with the troposphere play an important part in atmospheric electricity.

Ionization depends primarily on the sun and its activity. Thus, there is diurnal variation (time of day) due to earth's rotation on its axis and seasonal effects due to earth orbiting the sun, the activity of the sun which is associated with geographical location, (polar, auroral zones, mid-latitudes and equatorial region) sunspot cycle, with more radiation occurring with more sunspots. There are also solar flares with the associated release of charged particles into the solar wind which reaches the earth and interacts with the earth's geomagnetic field that affects the ionization.

3.3 Ionospheric Layers

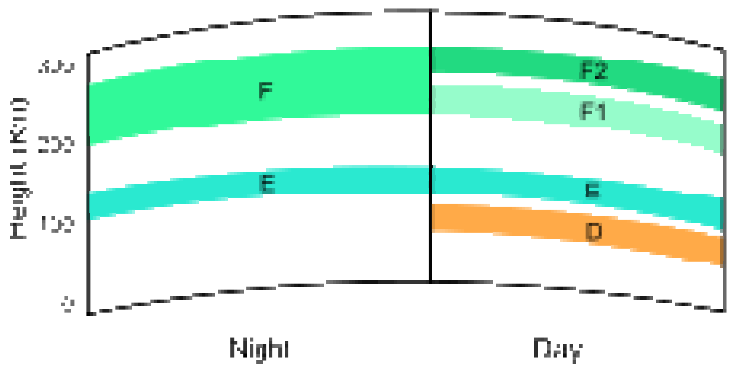
Depending on the level of ionization, the ionosphere is divided into three distinct regions called D, E and F, with the term layer referring to the ionization within a region. The lowest is the D region extending from about 50 km to 90 km. Ionization is primarily due to Lyman-alpha at a wavelength of 121 nm ionizing Nitric Oxide (NO). In addition, during high solar activity, hard X-rays may ionize Nitrogen, (N_2) and Oxygen (O_2). Recombination is high and net ionization is low. Loss of wave energy is high due to frequent collisions of the electrons; as a result, absorption of radio waves is high in the D layer.

The E-region lies above the D region from about 90 km to 150 km above the surface of the earth. Ionization is primarily by soft X-rays and far Ultra Violet (UV) solar radiation of molecular oxygen. The region supports radio propagation up to a frequency of about 10 MHz. However, during intense sporadic E events, the E_s layer can reflect up to 50 MHz. The E layer is weak at night because the primary source of the ionization is longer there. The E_s layer is a thin cloud of intense ionization which can support the reflection of radio waves at far higher frequencies. E_s events can last from a few minutes to several hours. Within the E – region is the worldwide solar driven wind resulting in the Sq (solar quiet) current system. Arising from this current is an electrostatic field directed east-west (dawn-dusk) in the equatorial ionosphere. At the magnetic dip where the magnetic field is horizontal, this electric field results in an enhanced eastward current flow within $\pm 3^{o}$ of the magnetic equator. This is known as the equatorial electrojet EEJ.

The F region also known as the Appleton layer, extends from about 150 km to up to 1000 km from the surface of the earth. At higher altitudes the amount of oxygen atoms decreases and lighter ions such as hydrogen and helium becomes dominant, this is the topside ionosphere. Ionization is by extreme UV solar radiation of atomic oxygen. The F layer is characterized by distinct ionization layers in the day called F_1 and F_2, with F_1 disappearing at night. The F_2 is responsible for most sky wave propagation of radio waves over long distances. Above the ionosphere is the magnetosphere extending to tens of thousands of kilometres. Figure 6a &6b show the ionospheric layers and their electron concentrations

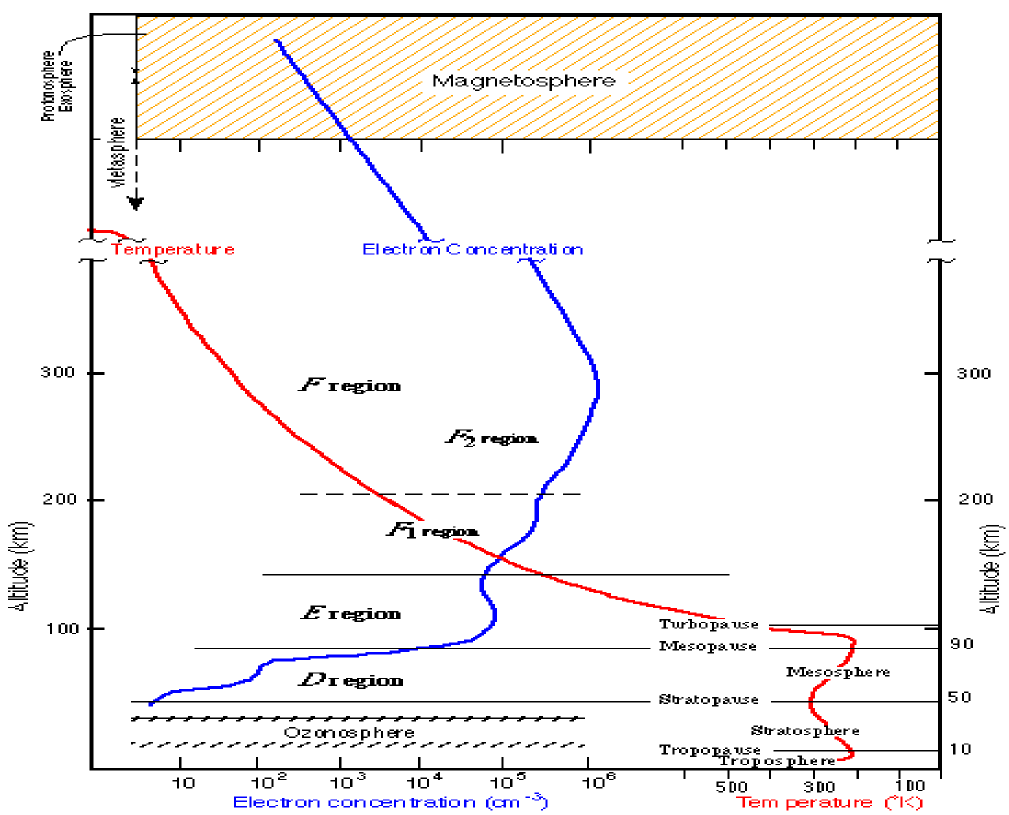
3.4 Ionospheric Models

Mathematical models dependent on location, altitude, day of year, sunspot cycle and geomagnetic activities are variously used to describe the variation of the ionosphere. Models are either empirical or statistical. One of the most widely used is the International Reference Ionosphere (IRI) model that is based on electron density, electron and ion temperature and ionic composition. Radio propagations depend uniquely on electron density. The IRI model is updated from time to time as more data are available world-wide. Prof. J. O. Adeniyi of the Physics Department, Unilorin is a member of the IRI task force. There are however, anomalies to this ideal ionospheric model such as; winter anomaly noticeable in summer time in mid-latitudes, equatorial anomaly, which is an occurrence of a trough on concentrated ionization in the F_2 layer and the equatorial electrojet, which is an enhanced current flow within $\pm 3^{o}$ of the magnetic equator.



Source http://en.wikipedia.org/wiki/File:Ionosphere_Layers_en.svg

6(a)



6(b)

Fig. 6 Ionospheric layers.

3.5 Ionospheric Scintillations

Scintillations are rapid variations of the amplitude of the radio signal caused by small scale irregularities embedded in large scale ambient ionosphere. Scintillations occur in the troposphere due to refractive index variations and in the ionosphere when plasma irregularities are generated after sunset in the equatorial ionosphere. At high latitudes, ionospheric irregularities may be generated either during the daytime or night. The irregularities are prominent during the solar cycle maximum. The bigger the amplitude of the fluctuations of the scintillated signals the greater the impact on the communication systems. The amplitude scintillation index, S_4, is defined as the ratio of the standard deviation of signal intensity, I and the average intensity and represented as

$$\boldsymbol{S_4} = \frac{(<I^2>)-<I>^2}{<I>^2} \tag{1}$$

3.6 The Earth's Magnetic Field (Geomagnetic field)

The earth's magnetic field extends from the earth's inner core (Fig. 7a) to about six earth radius (the solar wind). The earth's outer core consists of molten iron alloy that is in constant motion (dynamo effect), and produces the earth's magnetic field. The field is approximately the field of a dipole tilted at about 11^o with respect to the axis of rotation. The magnetic north pole changes slowly over time but remains useful for navigation purposes. Typical magnetic reversals (when the magnetic North pole changes with the South Pole) take hundreds of thousands of years (American Science Dictionary, 2002). The earth's magnetic field protects the earth from cosmic rays and solar wind, without which the earth's atmosphere cannot exist and in essence, life on earth, Figs. 7b and 7c. The only time the solar wind is observable on the earth is only when it is strong enough to produce auroras and geomagnetic storms. The magnetic field of Mars turned off and today the atmosphere is virtually lost and Mars is not habitable and our own earth is also gradually losing its magnetic intensity. Since the 19^{th} century when the first measurement by Gauss (1839) was done, the intensity has decreased by about 10%. This means that if the decrease continues at this rate, in 1200 years the earth field will be zero. However, in the earth's long history there have been many reversals and disappearances of the magnetic fields. Fossils of foraminifers in shallow sea waters suggest that 40% of them died at a magnetic reversal.

Animals like birds and turtles have been known to use the earth's magnetic fields for navigation when migrating.

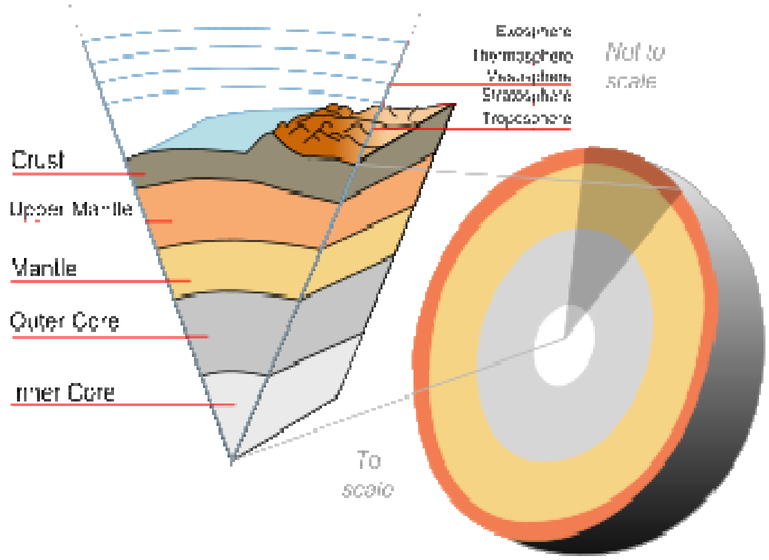
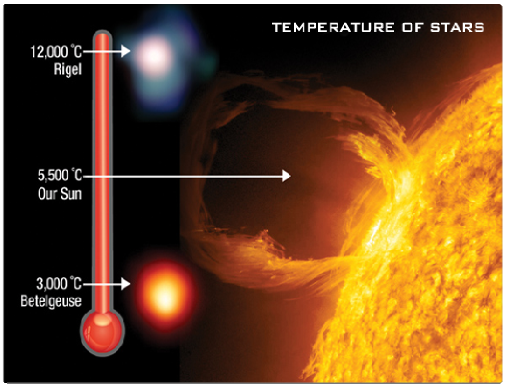


Fig. 7a: **The Earth's core** Source: wikipedia.org

3.7 The Sun

The Sun is an average sized star at the centre of our solar system; it is almost perfectly spherical and consists of hot plasma (mainly hydrogen and helium, Fig. 7b) interwoven with magnetic fields. The Sun is about 330,000 times the mass of the earth. The Sun generates its energy by nuclear fusion of hydrogen nuclei into helium. At a distance of about 149.6 million kilometres to the earth even though the distance varies as the sun moves from perihelion (perigee) in January to aphelion (apogee) in July. Light travels from the sun to the earth in about 500 secs. The energy of the sun supports almost all life on earth by photosynthesis and drives climate and weather. The surface temperature of the sun is about 6,000 K even though the temperature of the core may reach up to 15.7 million Kelvin. The sun is magnetically active with magnetic field varying year to year and reverse direction at about every eleven years around the solar maximum, Fig. 8.

- Sunspots are dark spots on the surface of the sun with lower temperature than the surroundings and are regions of intense magnetic fields. Magnetic field lines above sunspots block the escape of charged particles from the solar surface. When the pressure is too large, the lines burst, and solar storms then erupt with powers in millions of the power of the hydrogen bomb. If the storm is aimed towards the earth, then within 2 to 4 days later on the earth, the storm in addition with or without space debris and cosmic rays can cause induced currents as a result of the compression of the earth's magnetic field. The induced currents can cause corrosion on pipelines, destroy power grids, GPS errors, orbital drag on satellites, disrupt electric and magnetic monitoring of earthquakes, volcanoes etc. Navigation and communication satellites can be damaged, and astronauts can be in danger of high radiation doses. At the poles, these storms can cause auroras. 01solar_H-He.mpg



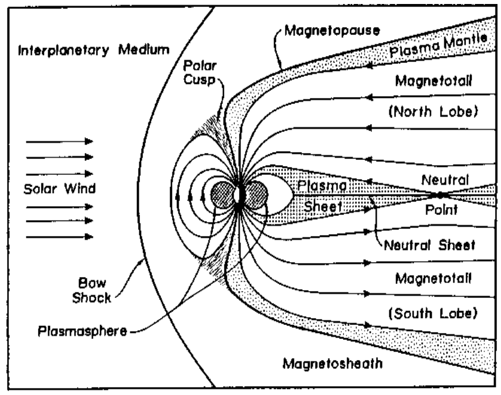
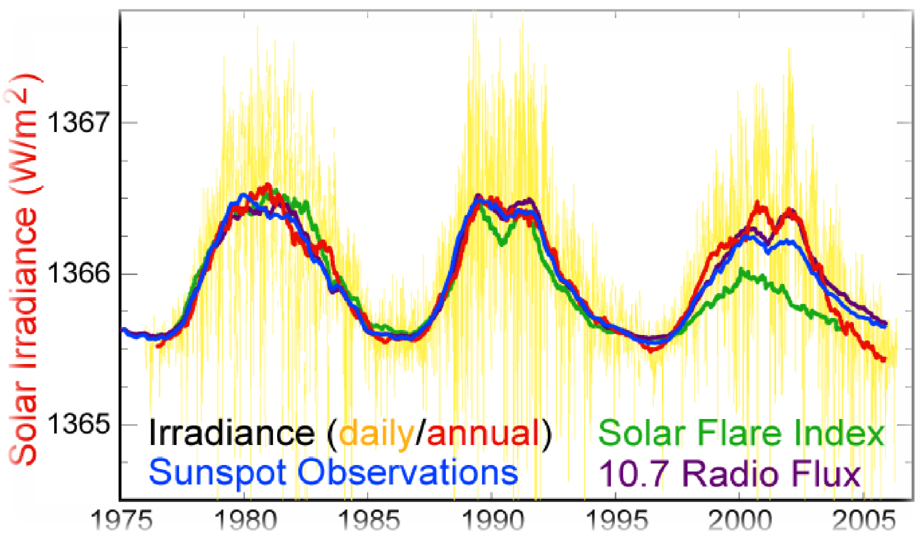


Fig. 7b: The Sun in an Eruption **Fig. 7c: The Earth's Magnetic field.**

The solar cycle is the periodic change in solar activity which includes changes in solar radiation and ejection of solar materials from the sun. This variation causes changes in space weather and to some extent in our weather and climate.



` **Fig. 8: Solar cycle variations**

4.0 Space Studies at the University of Ilorin

Mr. Vice-Chancellor sir, my contributions. Space studies in the University of Ilorin started as early as 1981 with the installation of the IPS 42 ionosonde in the Department of Physics for the study of ionospheric phenomena. In 1998 the Baseline Surface Radiation Measurements (BSRN) came on board for the study of sun radiation and weather phenomena in collaboration with University of Maryland at College Park, USA. Earth's magnetic measurement started in earnest in Ilorin in June 2006 using a flux gate magnetometer in a collaborative work with Space Environment Research Centre (SERC), Kyushu University, Japan and in 2010 the Unilorin Digisonde was installed in collaboration with US Air Force Academy (USAFA) and University of Massachusetts, Lowell, Center for Atmospheric Research (UMLCAR). Figure 9 shows the installation of the Magnetometer and the Digisonde

The installation team The magnetometer sensor

Dr. Ikeda doing the final testing of the magnetometer

Fig. 9a Installation of the Unilorin Magnetometer

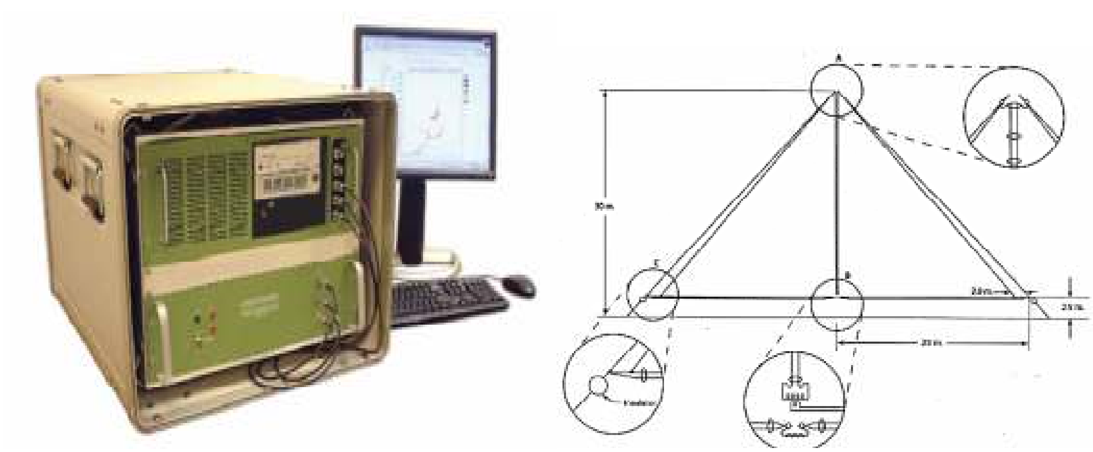


Fig.9b Portable Digisonde Sounder and Schematic Diagram of the Antenna system for DPS 4

4.1 Magnetic Field Measurements and calculations

The University of Ilorin flux gate magnetometer is the first in Nigeria and recently two other stations in Redeemer's University, Redeemer city, Mowe, Lagos and National Space Research and Development (NASRDA), Abuja have been added. Concurrent measurements from these three stations will allow for the characterization of the equatorial electrojet over Nigeria. The measurements of the Horizontal (H), Declination (D) and Vertical (Z) components of the magnetic field have been made every second since 2006 with over 75% availability, 25% unavailability mainly due to equipment maintenance and power problems. Figure 10 is a typical measurement for the period 1 – 10 April, 2010. The measurement shows the signature of magnetic storm commencing on the 5th of April with effects still seen till the 8th of April, (Adimula and Oladipo, 2010).

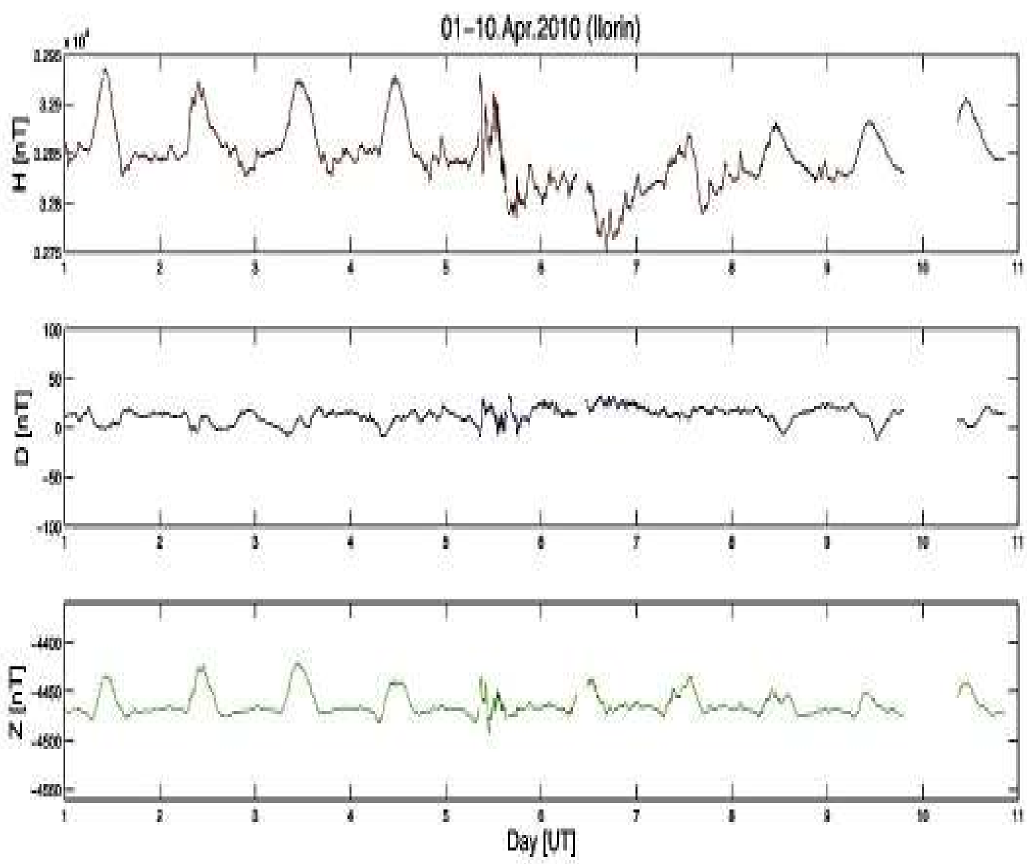


Fig. 10: Ilorin Magnetogram showing the effects of a magnetic storm.

Measurements of the magnetic field variations show a regular variation during the quiet sun with pre-noon enhancement due to the equatorial electrojet. The H component of the magnetic field is an indication of the current flowing in the atmosphere at any time. The signatures of Sq, (Rabiu, et. al, 2009) in H and Z at Ilorin as reflected in Figs. 11a and 11b respectively, indicates a steep build up in intensity at about the sunrise, a peak at about local noon and a gentle fall towards the sunset period. Fig. 12 is the Sq in D showing the directional changes in the magnetic field with the earth's rotation about the sun; the declination begins to increase at sunrise, maximizes at about noon and then decreases towards sunset, then shows a slow increase into the night time.

The MAGDAS measurements have been used to construct a basic algorithm to monitor in real time, (Uozumi et. al, 2008) the long term variations of the EEJ and the CEJ leading to the definition of new EE indices (EDst, EU, EL) consisting of EDst (Equatorial disturbance in Storm time), from which the EEJ and CEJ components defined as EU and EL can be extracted for the monitoring of the geomagnetic phenomena.

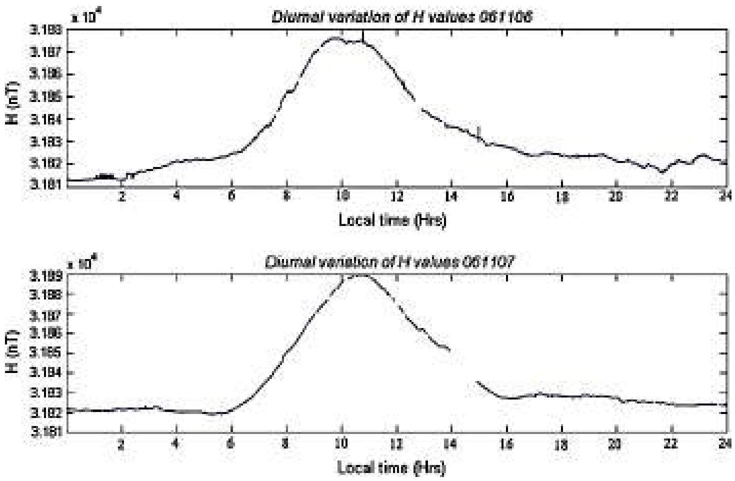


Fig. 11a: Diurnal variation of the Horizontal component of the Earth's magnetic field

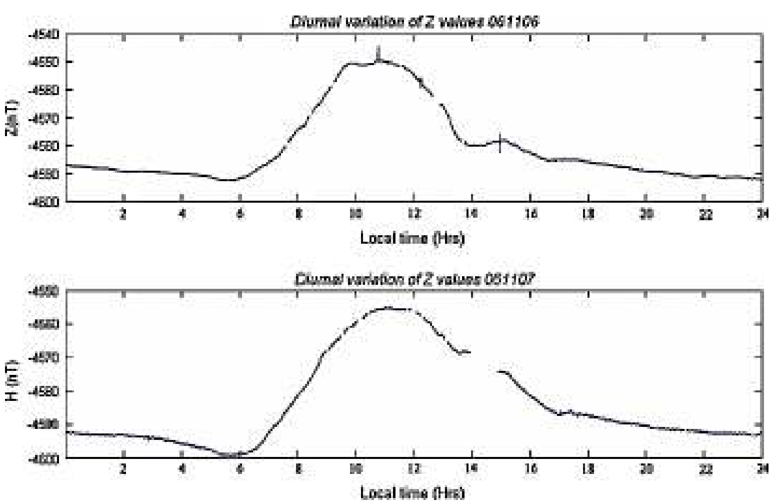


Fig. 11b: Diurnal variation of the vertical component of the magnetic field

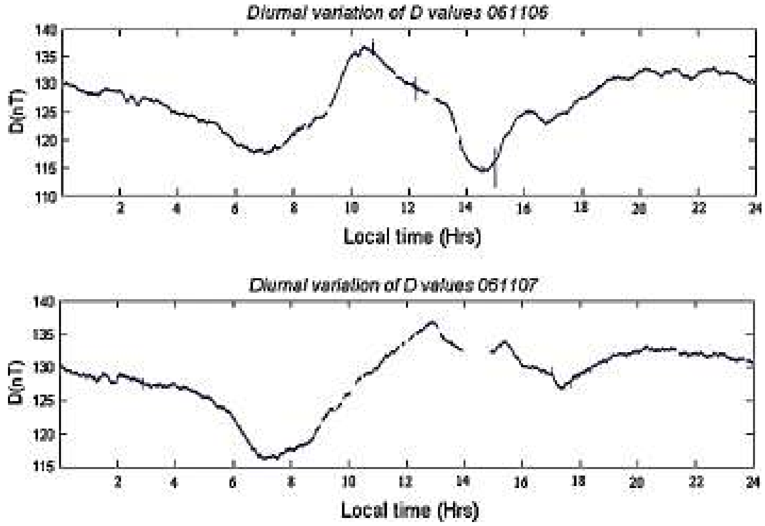


Fig. 12: Diurnal variation of the earth's declination.

Using measurements of H components from equatorial electrojet stations, it was found that, there could be substantial variations in the peak magnitude of the EEJ strength and correlations between pairs of stations decrease as distance increases, which indicates that, there may be some other local sources contributing to the measured current apart from the EEJ (Adimula, et. al., 2011, Bolaji, et.al., 2013).

4.2 Tropospheric Measurements

Rainfall and Temperature Measurements in Nigeria and Other Countries

Rain is a form of precipitation in which water falls back to the earth as liquid, and more generally hail or snow from the troposphere. Rainfall is measured in units of depth per time, using rain gauges typically in mm/h. One millimetre of rainfall is equivalent to one litre of water per square meter.

Measurements of temperature and rainfall at one minute interval have been carried out in the University of Ilorin since 1989 using a combined temperature-humidity sensor for temperature and a tipping bucket rain gauge and Distrometer drop counter, (Adimula, 1995). During this period, the rain types, the cumulative distribution, the year to year variability and estimates of the speed of the rain cloud for different types of rain have been estimated, (Bryant, et. al.,2001a; Adimula, 2003). Rain type in Ilorin is mainly convective accounting for more than 60% of the precipitations. During this period the average speed of the convective cloud is estimated to be about $9.7ms^{-1}$ (Adimula, 1997). Two peaks of rain intensities were identified between May/June and September/October with September/October accounting for about 33% of the total accumulation in certain instances, (Adimula, 2003; Adimula and Oyeleke, 2005).

The diurnal temperature (T_d) relation in Ilorin (Adimula and Willoughby, 2008) follows a fairly periodic variation and described by the relation

$$T_d = T_o(m) - C_m * \sin(15(t+1)) * \exp(\sin 2t) \qquad (2)$$

where $C_m = 0.33T_o(m) - 5.13$ (3)

m is month of the year, T_0 is the average temperature of the month and t is time in hours

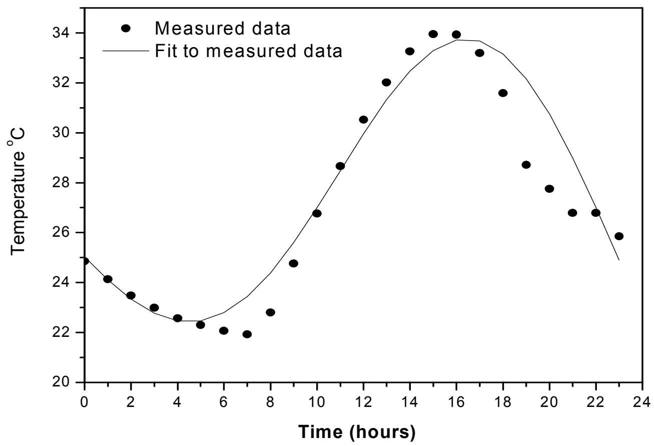


Fig.13: Diurnal Temperature variation in Ilorin.

Temperature variation during the dry (T_{dry}) and wet (T_{wet}) months have also been found to obey the relations

$$T_{dry} = 24.8 + 0.024d_n \ (^oC) \qquad (4)$$

Where d_n is the day number varying from 1 to 182. Where '1' represents October 1st and '182' represents March 31st.

The rate of decrease of the average temperature for the wet months from April to September was also calculated and the governing equation was found to be

$$T_{wet} = 22.3 + 6.7*\exp(-0.013d_n). \quad (^oC) \qquad (5)$$

d_n is the day number

4.3 Radio Refractivity

Measurements of temperature, pressure, relative humidity from the University of Ilorin meteorological station have shown that the refractive index can be highly variable in both the wet and dry months although the dry months' values are usually lower than the wet months. The variability in the dry months range from about 265 N-units to about 375 N-units, in the wet months, however, the refractivity ranges from about 345 to about 385 N-units (Willoughby, et al, 2002). The diurnal variations show that the refractivity values on the average peak at about 2200hrs and 0600Hrs (LT). In the dry season, there may be a sharp drop in refractivity of about 60 N-units in certain instances. Using values from different meteorological stations in Nigeria, we obtained the expression $N = N_S \exp(-0.11h)$ which is useful in predicting refractivity up to 2 km, N_S is surface refractivity (Igwe and Adimula, 2009). Calculations of the refractive index gradients over Minna, Nigeria showed that in the dry seasons the atmosphere is mainly sub-refractive with values ranging from -34 N-units/km to -38 N-units/km and super refractive during the wet seasons with values ranging from -41 N-unit/km to -57 N-units/km. A consequence of super refraction is the extension of the radio horizon leading to interference with neighbouring stations and sub refraction reduces the radio horizon. The refractivity gradient is useful in the prediction of the path of radio wave propagating in the troposphere.

4.4 Rainfall in the Tropics

Rain occurs in cells and, the size of the cells is usually dependent on the intensity of the rain. At lower rain rates, the intensity distribution within the cell is fairly uniform, however, at high rain rates, strong up convective forces and winds make the intensity distribution non-uniform. This presents a lot of challenges in modelling and planning. Most of tropical rainfalls are convective (Adimula, et.al, 1995). With an intensity below or equal 100mm/h, the intensity distribution is fairly uniform. However, above this threshold lots of instabilities set in, and this is normally referred to as the breakpoint, (Bryant, et.al, 2000, 2001a), Fig 14.

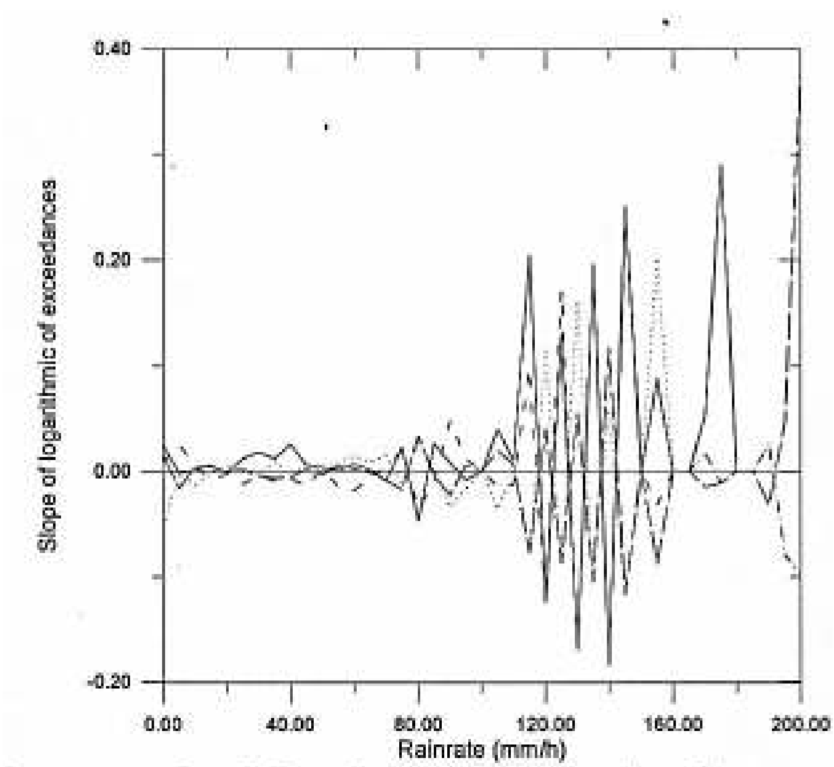


Fig. 14: Logarithmic exceedances slope for PNG

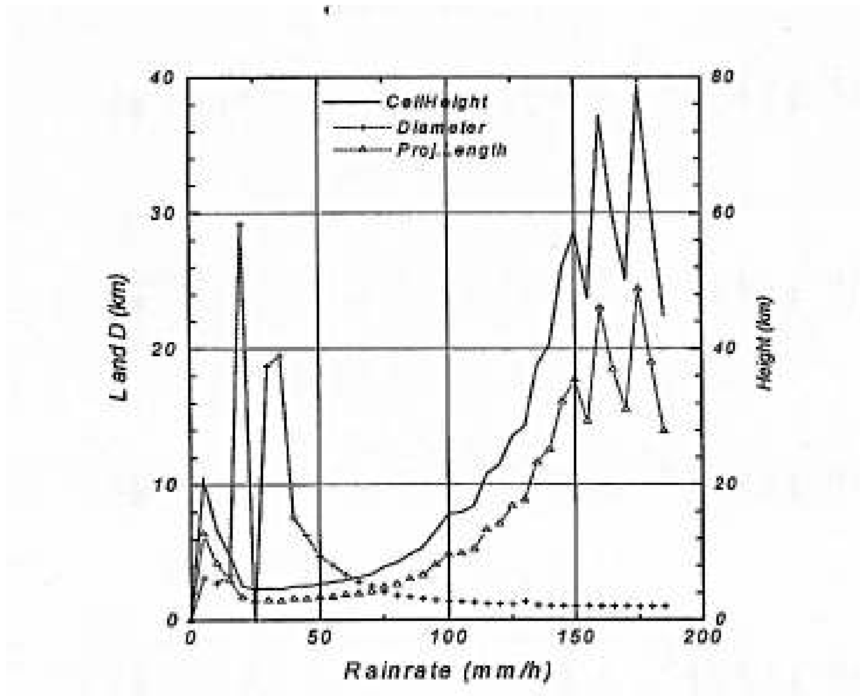


Fig.15: projected path length, cell diameter and attenuation exceedances

Using information from Fig. 15, the rain cell diameter, D_m and the rain height, H_R were calculated as functions of their rain rates, R.

$$D_m = 340R^{-1.2} \text{ km}$$
$$H_R = 4.5+0.0005R^{1.65} \text{ km} \quad (6)$$

4.5 Raindrop sizes

A drop is a column of liquid (usually spherical) bounded by a free surface. Rains fall in drops, however, during the transit from cloud to earth, the forces of gravity, atmospheric drag, aerodynamic pressure, etc., counteract the effect of the surface tension on each drop leading to the deformation of the drop and the raindrop acquires a general oblate or flattened base shape. The degree of distortion of the drops is dependent on the sizes.

Measurements of raindrop sizes have been carried out in Ilorin, Ile-Ife, Calabar and Zaria (Adimula, 1986, Adimula, et. al., 1993 Adimula and Ajayi, 1996, Adimula, 2003). The results show that the drop size distribution is lognormal from a rain rate of greater than 20mm/h and negative exponential for rain rates less than 20mm/h.

$$N(D) = \frac{N_T}{\sigma D\sqrt{2\pi}} exp\left[-\frac{1}{2}\left(\frac{lnD-\mu}{\sigma}\right)^2\right] \; mm^{-1}m^{-3} \quad (7)$$

N_T is the total number of drops of all sizes, μ is the mean of the distribution and σ is the standard deviation. The rain rate from the drop sizes is calculated from

$$R = 6\,x\;\; 10^{-6}\pi \int N(D)D^3V(D)dD \text{ mm/h} \quad (8)$$

The parameters of the lognormal distribution obtained for the Ilorin rain are

$$N_T = 285\ R^{0.209}\ ;$$
$$\mu = -0.544 + 0.234 \ln R \qquad (9)$$
$$\sigma = 0.206 - 0.010 \ln R$$

The lognormal parameters were also obtained for other Nigerian stations. (Adimula, 1986; Adimula, 1997) and an overall model obtained for Nigeria.

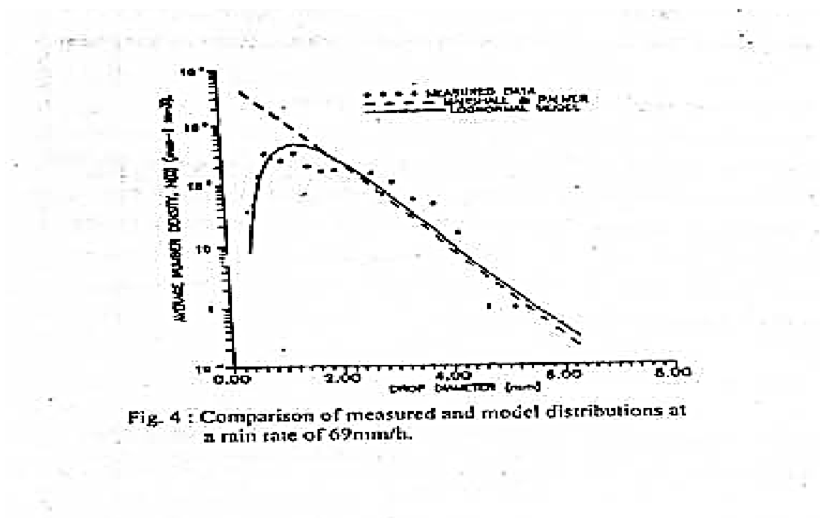


Fig. 16: Comparison of model and measured distribution at a rainrate 69mm/h.

The negative exponential distribution is given by

$$N(D) = N_O \exp(-\Lambda D)\ mm^{-1}m^{-3} \qquad (10)$$

Where N_O is the intercept of the distribution on $mm^{-1}m^{-3}$ and Λ is the slope in mm^{-1}

The parameters of the negative exponential distribution obtained for Ilorin

$N_O = 6300\ mm^{-1}m^{-3}$ and $\Lambda = 3.9\ R^{0.21}\ mm^{-1}$ (11)

4.6 Rain in Radio Propagation

At frequencies utilizing ground wave propagation (i.e. propagation close to the surface of the earth), rain improves the moisture content, the conductivity and the permittivity of the ground. Consequently during rain, there is an enhancement of the signal strength especially for frequencies below 3 MHz. However, at microwave frequencies used extensively for slant path propagation, rain becomes a major attenuator of the signal strength. The attenuation increases with frequency and hence the challenges of utilizing these frequencies become more with increasing frequency.

4.7 Rainrate Models

A useful rain attenuation prediction tool must be able to correctly predict the rain intensities from different geographical areas. Using measurements from some African and Asian countries, a model of rain distribution was developed using two regimes of rain, before and after the break point.

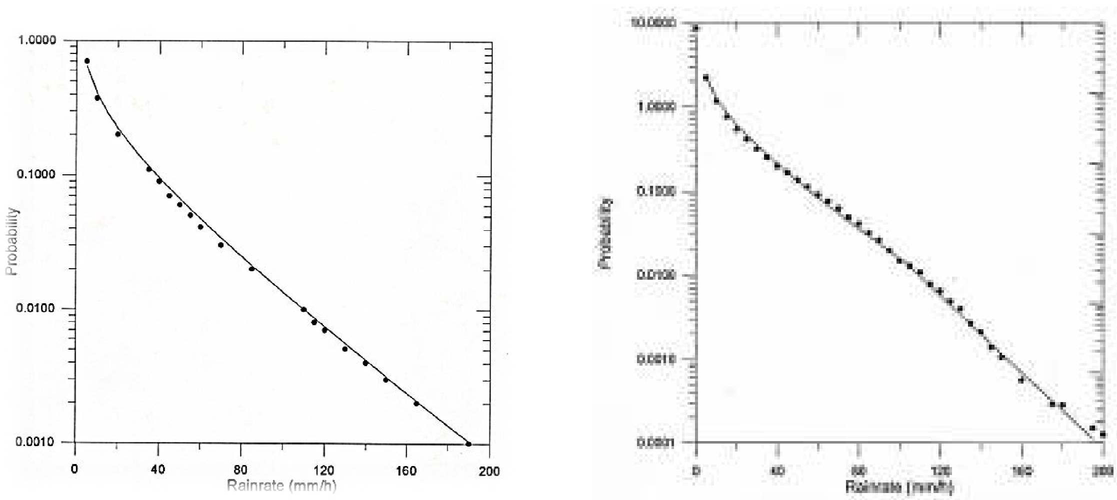
The model developed (Bryant et. al., 2001) which is based on an earlier one by Mouphouma, 1995, is given by

$$P(R \leq R_{BK}) = P_{BK}\left(\frac{R_{BK}}{R}\right)^{b} exp\big(u_1 R([R_{BK}/R] - 1)\big) \qquad (12a)$$

$$P(R > R_{BK}) = P_{BK}\left(\frac{R_{BK}}{R}\right)^{b} exp\big(u_2 R([R_{BK}/R] - 1)\big) \qquad (12b)$$

$$b = 8.15 R_{BK}^{-0.6} \qquad (13)$$

Where u_1 and u_2 are constants that are dependent on geographical locations and topographies.
This model was found to accurately predict rain intensity distribution with over 75% accuracy, Fig. 17.



(a) (b)

Fig. 17: Comparison of measured and model distributions for (a) Kampala, Uganda and (b) Lae, Papua New Guinea (PNG)

5.0 Rain Attenuation

The congestion of the lower frequency bands has necessitated the use of higher frequencies for radio propagation. At these frequencies, rain becomes a major attenuator of the signal strength, (ITU-R P 618-10, 2009). Rain, because of its large dielectric constant produces heavy displacement current and hence absorption. The displacement currents induced in the droplet of rain are sources of scatter radiation and in the direction of interests; such scatter causes attenuation and interference to other systems. Other losses come from dissipation of radio wave energy as heat, depolarization due to non-spherical nature of the drops, antenna gain degradation and bandwidth coherence reduction in digital systems, (Ippolitto, 1986).

The challenge of the radio scientist is how to have dominion over these natural effects.

Figure 18 is a time series attenuation measurement from the ITALSAT data showing increasing attenuation with frequency and rain rate (Mauri, et.al. 1997).

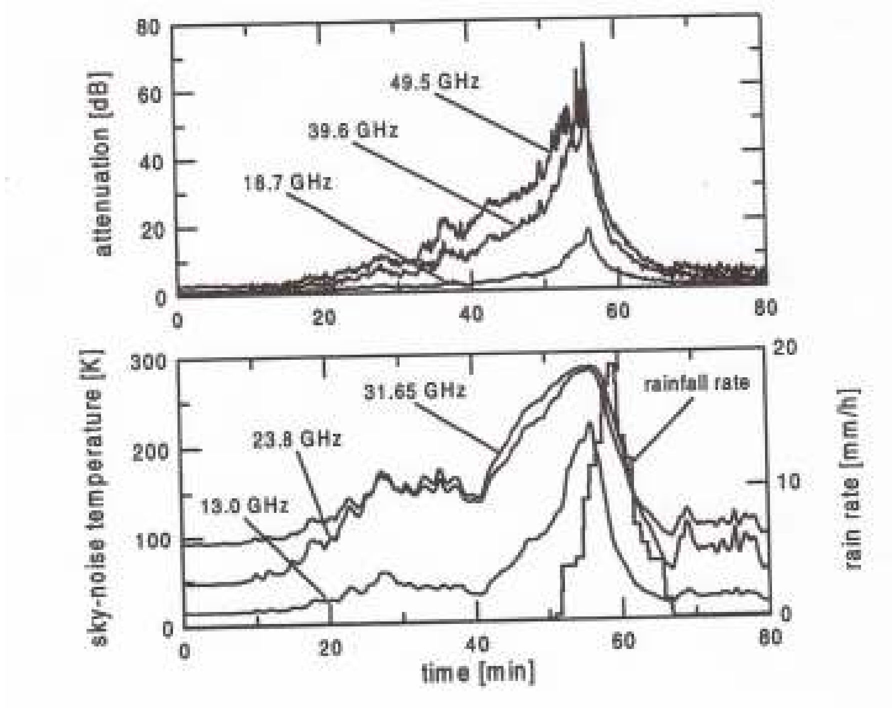


Fig. 18: *ITALSAT* Sample attenuation, radiometric and rainfall rate data

Raindrops act as attenuator at centimetre and millimetre waves. The attenuation of radio wave traversing a volume of rain extent L in the direction of propagation encountering uniformly distributed spherical drops is given by

$A = \int_0^L \gamma dx$ (14)

where γ, the specific attenuation in terms of drop size distribution is given by

$\gamma = 4343\frac{\lambda^2}{\pi}\sum R_e S_{H,V}(o)N(D)\Delta D\ (db/km)$ (15)

Where $ReS_{H,V}(o)$ is the real part of the forward scattering amplitude for horizontal and vertical polarizations.

The phase shift is given by

$\beta = 90\frac{\lambda^2}{\pi}x10^3\sum ImS_{H,V}(o)N(D)\Delta D\ (°/km)$ (16)

In some applications, it is convenient to express γ and β by an approximate power law in the rain rate.

$\gamma = aR^b$; $\beta = j\alpha R^\beta$ (17)

Where a, b, α and β are constants depending on frequency, canting angle, polarization and rain temperature.

Using slant path attenuation data from some tropical stations including Nigeria, a model was developed using only three input parameters (rain rate, cell diameter and rain height). The model was found to perform excellently well for tropical countries with data in the ITU-R data bank. In most cases, the errors of the prediction model are in agreement with the year to year variability of the measured data.

The radio-satellite path is as shown below:

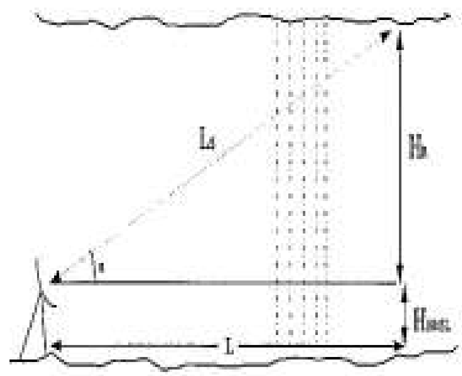


Fig. 19: Earth – Satellite path

The parameters of the model are as follows:

Rain Height $H_R = 4.5 + 0.0005R^{1.65}$ km

Cell Diameter $D_M = 340R^{-1.2}$ km

Multiple cells (rain dependent) $k_n = \exp\,(0.007R)$

No of cells elevation dependent $\xi = \frac{1}{\sqrt{2}}\exp(sin\theta)\ \theta \leq 55°$

$= 1.1\tan\theta \quad \theta > 55°$

The slant path along the satellite path, ITU_R, 1996

$$L_s = \frac{H_R - H_{HMSL}}{\sin\theta}\ \theta \geq 5° \tag{18}$$

$$L_s = \frac{2(H_R - H_{HMSL})}{[\sin^2\theta + 2(H_R - H_{HMSL})/R_E]^{0.5} + sin\theta}\ km\ \ \theta < 5° \tag{19}$$

H_{HMSL} is the height of the receiving or transmitting antenna above mean sea level and R_E is the equivalent radius of the earth.

The input parameter is the rain rate exceedances given by the rain rate model.

The slant path attenuation A,

$$A = 1.57\ D_m k_n \gamma \frac{L_s}{\xi L + D} \quad R > 3 \text{ mm/h} \tag{20}$$

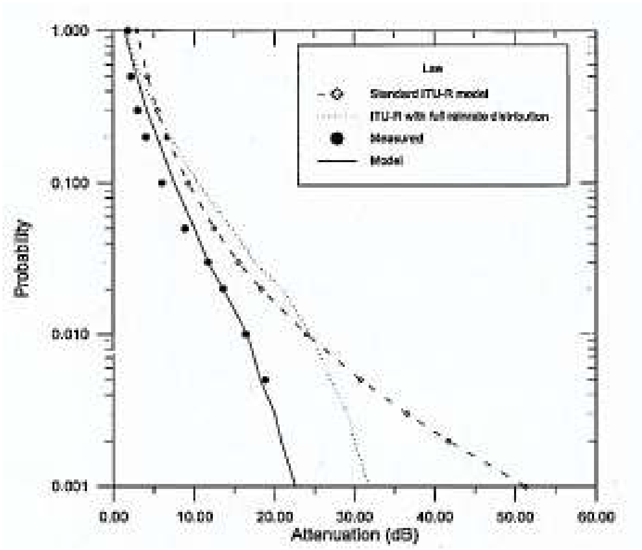


Fig. 20: Test of the attenuation model compared to other models.

Fig. 20 is the test of the tropical attenuation model with measured data in Lae, Papua New Guinea, PNG. Attenuation calculations from the drop size measurements in Nigeria indicate that raindrops of diameters within the range 1.70mm to 4.00mm (Fig. 21) contribute more to the rain attenuation. The percentage relative contribution is shown in the Figure 21, (Adimula, et. al., 2005)

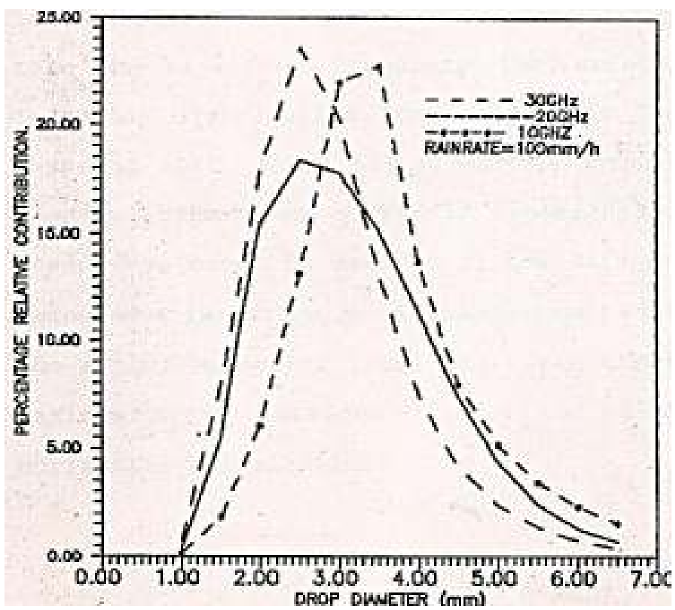


Fig. 21: Percentage relative contribution by the dropsizes to the rain attenuation.

Apart from rain attenuation, there are other sources of signal degradation like atmospheric gases,(ITU_R 676, 2012), but the contribution of the rain attenuation to the total attenuation calculations is much more significant.

6.0 Rain Induced Depolarization

Due to the distorted dropsizes, differential attenuation exits between the minor and major axes of the drops

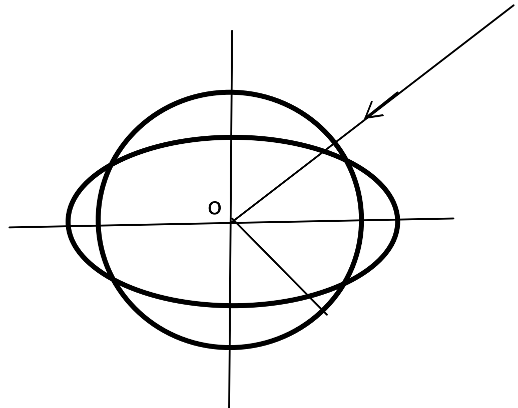


Fig. 22: Distorted shape of a raindrop

Horizontally polarized waves experience greater attenuation above the vertically polarized waves. The differences in the attenuations and phase shifts between the two orientations are called differential attenuation and phase shift respectively. The existence of the differential attenuation is to rotate the polarization of the incident wave while the differential phase shift changes the polarization ellipticity. Depolarization may not be a problem in conventional communication system using single polarization, but it becomes a serious problem in frequency reuse systems. Calculations of the cross polarization discrimination (XPD) using dropsize measurements from Ilorin, Ile-Ife, Zaria and Calabar have been done and the results show that up to a rain rate of 12.5mm/h, with frequencies below 100 GHz, XPD is identical for both polarizations and typically less than -50 dB. However, at rain rates greater than 50mm/h, XPD on both polarizations could differ by up to -10 dB, and reaching up to -12dB in certain instances, (Ajayi,et.al, 1987; Adimula, 1997))

7.0 Atmospheric Aerosols Loading in Ilorin

The dwindling annual rainfall in the Sahel region and the consequent shrinking of the Lake Chad indicates that aerosol loading from the region will be on the increase. The most obvious effect of aerosol loading is the reduction in visibility and air quality. Increased Aerosol Optical Thickness (AOT) values are indicative of large amount of aerosols in the atmosphere and because of their light scattering properties results in lower visibility. Aerosols measurement from the University of Ilorin Baseline Surface Radiation Network (BSRN) and visibility records from Nigerian Meteorological Agency were analysed for aerosols classifications and visual properties. Results show that a coarse aerosol regime exists in Ilorin with an average relative size of 0.32 giving rise to high level of atmospheric turbidity. Visibility calculations from the AOT show that between

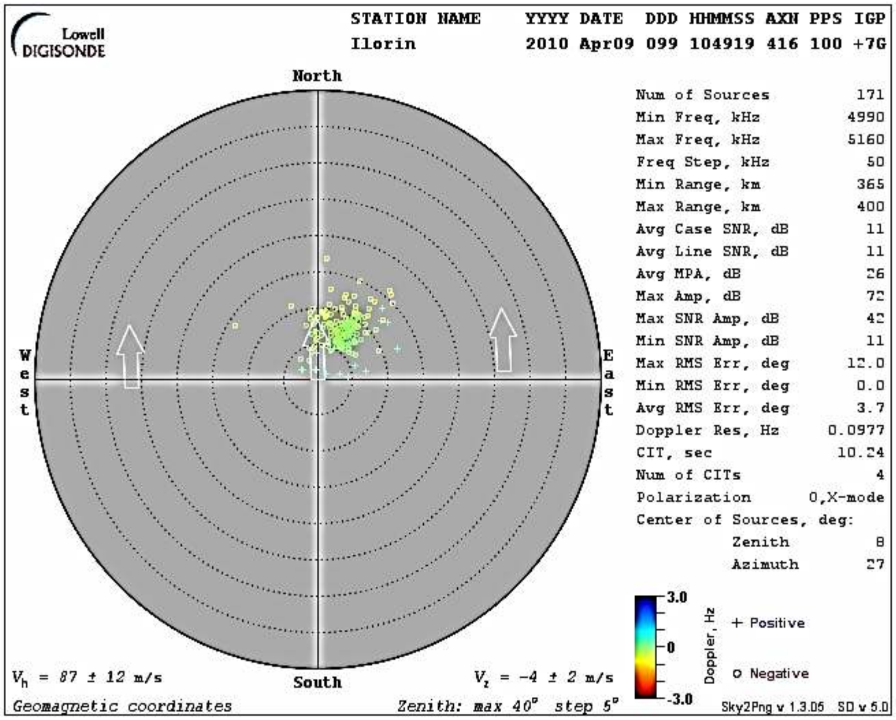
December and January, visibility could be reduced to less than 25% (Adimula, et. al, 2010) of the clear sky values. Increased aerosols levels have been shown to produce ecological stress in both man and animals (Babatunde et.al, 2008).

8.0 The Ionosphere in Radio Propagation

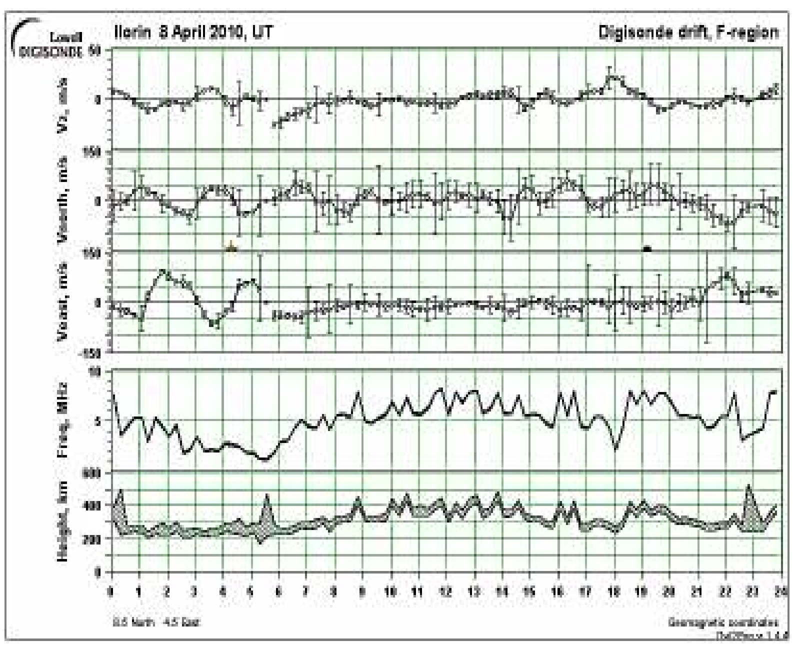
When an electromagnetic wave enters the ionosphere it experiences a complex refractive index n given by $n = \mu - i\xi$. The refractive index generally reduces with height up to the maximum electron density. Consequently, a propagating wave in the ionosphere is eventually reflected back to earth through successive refraction. At vertical frequencies, the condition for O-wave reflection from a layer of electron density N (m^{-3}) is given by $f = 9\sqrt{N}$.

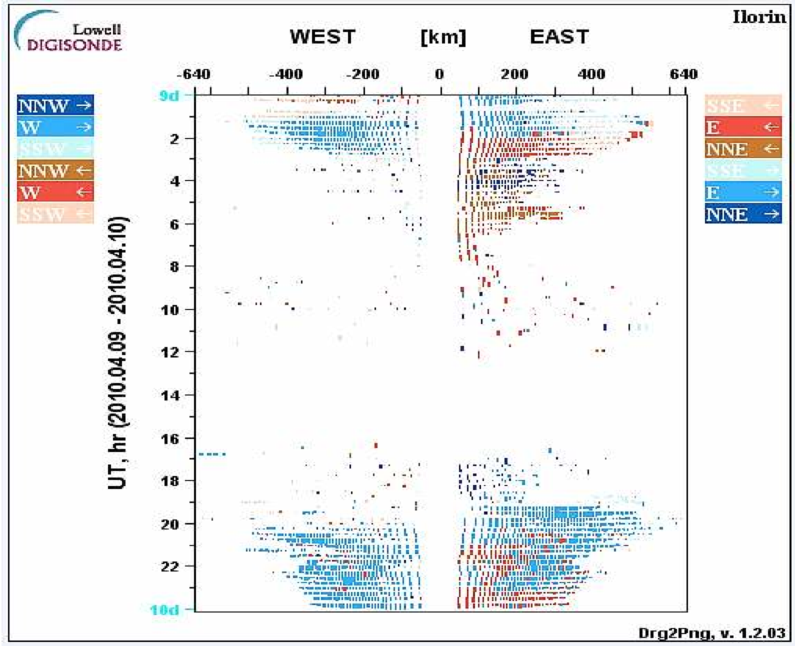
8.1 The Unilorin Ionosonde.

In the early days of ionospheric research in this University, the Department of Physics operated the IPS-42 Ionosonde for the ionosphere probing. Digisonde Portable Sounder (DPS_4) was successfully installed at Ilorin, between 21st and 31st of March, 2010. This is for collaborative research between US Air Force Academy (USAFA), University of Massachusetts, Lowell, Center for Atmospheric Research (UMLCAR) and Department of Physics, University of Ilorin, Nigeria. The DPS_4 transmits radio signal using delta antenna and receives the down coming signal (reflected signal) from the ionosphere using a set of four crossed magnetic loop turnstile antennas The arrangement of the four crossed magnetic loop turnstile antennas is shown in figure 9b. The arrangement of these antennas makes the digisonde capable of making simultaneous measurement of seven (7) observable parameters of the reflected signals received from the ionosphere. These observable parameters are: frequency, range, amplitude, phase, Doppler shift and spread, angle of arrival and wave polarization. All these provide opportunity of studying the ionosphere in great detail. Sample measurement of the Unilorin digisonde is shown in Fig. 23



Sky map and plasma drift.





Blue = eastward drift; Red = westward drift

Fig. 23: Sample measurements from the Unilorin Ionosonde

Measurements from the University of Ilorin IPS-42 Ionosonde during periods of low solar activities have shown a general good agreement with the IRI model and observed B0 (thickness of the bottom side profile of the model) in the night hours. There is however, an over estimation during the daytime especially between 0600 – 1000 LT, (Adeniyi, et. al., 2008). The model prediction for B1 (the shape profile below the height of the F2 peak electron density) shows a fairly good agreement during the day and night. A formulation of the form $B0 = A[\cos(\chi)^n]$ was proposed as an improvement to the IRI model.

Data from Ouagadougou and Ibadan for years of low and high solar activities have shown that the variability of the night time foF2 is higher in the solstices than in the equinoxes. The daytime variability of the foF2 and hmF2 are comparable in values but larger at night for foF2 than hmF2. The deviations of foF2 and hmF2 about the median suggest that in about 10% of the cases, the two parameters act to reduce the maximum usable frequency in a radio circuit, (Adimula, 2006). There is much interest in the seismic – ionospheric coupling due to the fact that, new results show that foF2 variability decreases significantly at least about 2 months before an earthquake, (Liperovsky, et.al. 2004). Results of variability study of electron density at fixed heights show that the electron density deviates from the simple Chapman model at heights of about 200 km. Daytime minimum variability of between 2.7% and 9.0% was observed at the height range of about 160 and 200 km during low solar activity and between 3.7% and 7.8% at the height range of 210 and 260 km during high solar activity, The night time maximum variability was observed at the height range of 210 and 240 km at low solar activity and at the height range of 200 and 240 km at high solar activity (Oladipo, et. al, 2011).

On the 29th of March, 2006, an eclipse of the sun, Fig. 24 occurred in Ilorin. The maximum obscuration of the eclipse at the Ilorin station was 99% and it occurred before midday. The effect of the eclipse was a drastic decrease in the E and F1 electron densities with maximum decrease percentages of 60 and 68 for the E and F1 respectively, Fig. 25, (Adeniyi et. al. 2007, 2009). Decrease in foF2 began at about 1hr 20 min after those in the lower layers had begun. Variation of electron density with height showed that the decrease in the electron density occurred throughout the E and F1 heights at about the same time while that of the F2 region began at lower heights and extended progressively toward the peak of electron density height of the layer. The recovery in the E and F1 layers has already reached an advanced stage before the effect of the eclipse got to the maximum in the F2 region.

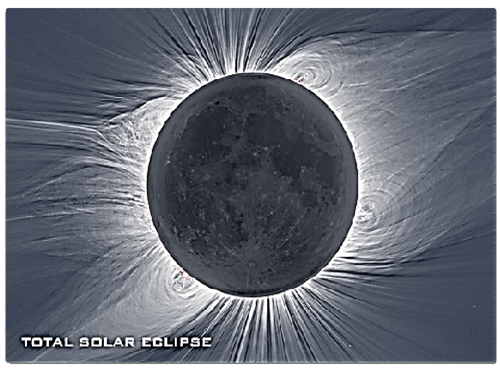


Fig. 24: Total Eclipse of the Sun.

Results further show that the transition height between the regions where linear and quadratic loss coefficients hold is around 200km.

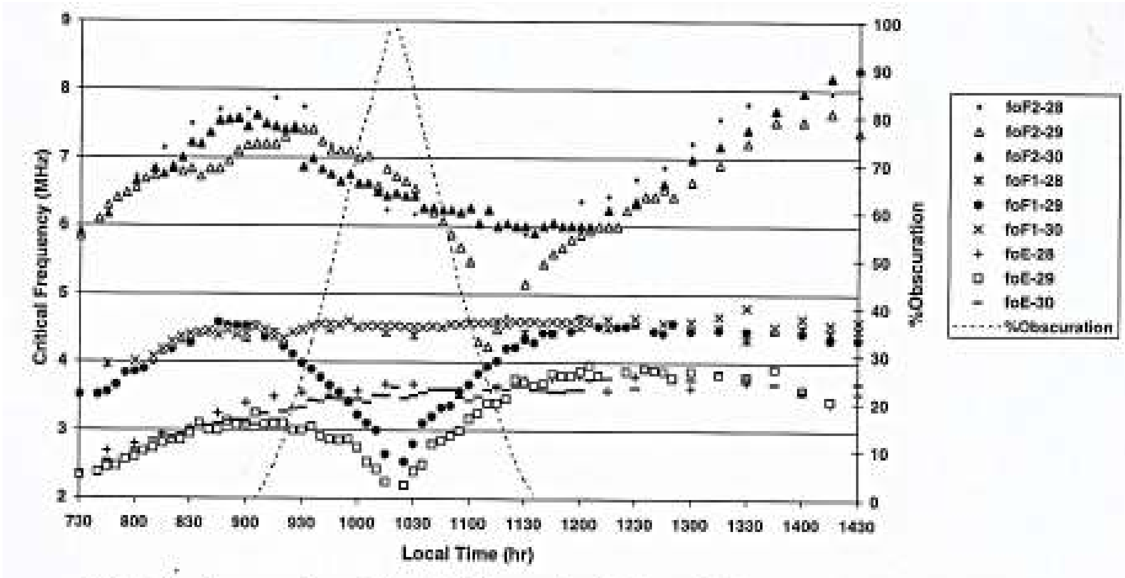


Fig.25: The comparison of the critical frequencies of E, F1, and F2 layers on the eclipse day 29 March with those of the control days 28 and 30 March, 2006. The dashed line shows the variation of the percentage obscuration of the eclipse

9.0 Optical Fibres

The first lesson in optics teaches that light travels in straight lines, however this is a major constraint offered by light. For many applications where transmission is necessary in obscure or inaccessible places, it is necessary to find a way through this property. One way of achieving this is the use of optical fibres.

An optical fibre is a flexible, transparent fibre made of glass or plastic, typically slightly thicker than the human hair. It functions like a wave guide or light pipe to transmit light between its two ends. Light is transmitted through multiple reflections from one end of the fibre to the other. Fibres are used instead of metal cables because of low losses and less electromagnetic wave interference. Information inside the fibre is transmitted at the speed of light and thus transmission delays are minimal. Optical fibres are replacing electrical cable transmission in core networks. Today optical fibres operate at 14TB/s over a 160km without a repeater station. The University of Ilorin has installed a modern communication system with fibre backbone. Presently it is possible for the University to deploy video and VOIP systems. It is expected that in the next few months the University will begin to take advantage of this facility in pursuance of her exercise of dominion in teaching and research. Fig. 26 is an optical fibre illuminated at one end in which light has been made to travel in circles. The fibre shows that light could be made to bend and thus used in hitherto unreachable areas.

Fig. 26: A fibre optics cable illuminated at one end

10.0 Conclusions

Mr Vice-Chancellor sir, though radio is universal, its propagation greatly depends on local effects. I have in the process of this lecture spoken about my work in making a radio signal an effective tool of dominion. Our quest for the understanding of this resource can only continue to increase realising the advantages inherent in the use of radio. “Let there be light and there was light” as being the first work in dominion. God in his sovereignty used the electromagnetic wave (light) to overcome darkness, and ever since man has been using light for dominion.

The measurements of raindrop sizes, rain rate, and their distributions, ionospheric and magnetic measurements in Nigeria have been discussed and these are vital information for the design and manufacture of appropriate radio infrastructure in the country and in the tropics generally, (up till now most radio infrastructure in the country are based on models developed for the temperate regions).

In a few years from now, we expect wireless transfer of electrical energy, research is at an advanced stage in this field, and Nigeria should not be on the side lines. Research in the development stage may appear costly, but the cost of a finished work is costlier. In the future radio services will determine how we run our lives. Today mobile phones are pointers to how we shall be running our lives. Few years ago, it would take the Boeing 747 (the biggest commercial aircraft ever made) aircraft about 6 hours to travel with tons of books from UK to Nigeria, that same tons of books are carried by radio in optical fibres in a matter of seconds to our computers or mobile devices. Several years ago, it took days to know what was happening in other parts of the world and even Nigeria, now information is readily available on the Internet and digital TVs. Giant steps are being made but many steps are yet to be covered in our match towards dominion.

The University of Ilorin should rise up to the challenge of the 21st century. We are in the Space and ICT age which is primarily driven by radio, the University of Ilorin and indeed Nigeria cannot afford to be left behind. Loose the control of space over you and lose all. The University of Ilorin being a foremost University in the country and blessed with highly resourceful manpower must make extra effort in investing in radio and space research. Space is not an unlimited resource, it is already getting congested.

11.0 Recommendations

1. The Federal Government of Nigeria has established National Space Research and Development Agency, NASRDA and Nigerian Communications Satellite, NIGCOMSAT, National Mathematical Centre, NMC, these are developments in the right directions, however, for these agencies to function effectually, competent scientists with proven records should head these agencies. The matter of space and radio should be above mere political considerations.
2. There must be improved welfare and infrastructure for secondary school teachers in the sciences. Teaching of the sciences should be experimentally based. In line with this, there is need for a general overhaul of the sciences curricula in the secondary schools, polytechnics and the universities. University curricula should be developed in conjunction with relevant industries, local communities and stakeholders. A situation where somebody will sit in the comfort of his sitting room and provide generalized curricula for all Nigerian Universities cannot hold in this age if there should be accelerated match towards growth and development.
3. The various stations in the University of Ilorin for the study of space weather and radio sciences should be adequately funded, maintained and promoted to National and International recognition.
4. Companies operating in Nigeria must be made to have a Research and Development unit with relevant government agencies enforcing and monitoring the practices. Annual research reports of these companies and agencies must be published nationwide; this will enhance collaborative work for greater and sustainable achievements.
5. Electricity is a necessity; the government should not treat electricity as a luxury. Individual power generation increases overhead and, it is also a source of health hazard.
6. Academic communities must be cosmopolitan, this allows for cross fertilization of ideas and robust debates on issues.
7. Most often only about 10% of the society's population is innovative, while others take cues from this 10%. Innovation and merit should not be compromised for whatever reasons. Thus the right environment must be provided to this group. Government and leaders must urgently harness this group and make them productive. They don't necessarily have to be sent outside the shores of Nigeria where most will not return to the country, but let a conducive environment be in place and societal problems can be solved.

Acknowledgments

1. I am here only because the Lord has been my strength. He has taught my fingers to fight and my hands to war, to the extent that the bow of the enemy is broken by my hands. I thank the Lord God Almighty through my Lord and Saviour Jesus Christ for making this day a reality.
2. I thank the University of Ilorin, under the able leadership of Prof. Abdul Ganiyu Ambali and the immediate past Vice-Chancellor, Prof. I. O. Oloyede for giving me opportunities to serve in various capacities, which opportunities and challenges have equipped me in pursuance of my mandate.
3. I thank all of you who are here for this lecture, without all of you, there is no lecture. Thanks for coming.
4. I thank the First Lady, Kwara-State, Her Excellency, Deaconess Omolewa Ahmed for her support and love to the family.
5. HRH Oba M. A. Adimula, the Olota of Odo-Owa for his fatherly role always.
6. One of the most common challenge of man is the choice a leader to offer protection, direction, mentoring, etc,. Some are lucky to ride at the back of giants, in this wise, I thank the following giants, Late Profs J. O. Oyinloye, former VC, Univ. of Ilorin, D. K. Bamgboye, G. O. Ajayi, Aldo Paraboni, Geoff Bryant. Your works follow you.
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12. I thank my brothers and their wives, Mr. Abiodun Oni, Dr. and Mrs. Henry A. Adimula, (he is more than a brother, we have lived like twins and our families have come to appreciate that we are twins), Mr. And Mrs. Olubunmi Adimula, Mr. and Mrs. Sunday Adimula, Mr and Mrs Adetayo Adimula and Mr and Mrs Olakunle Adimula.

13. I appreciate "our" children, the greater Adimulas, Ayobami of blessed memory, Queenette, Ayodeji, Clinton, Testimony, Ayomikun, Emmanuella, Sharon, Michael, Becky, Daniel, Rachael, Mikel, Ewaoluwa, Marvel and Darasimi.
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BRIEF CV

Prof. Isaac Abiodun Adimula was born in Odo-Owa, Kwara-State, about 5 decades ago to the family of late Prince Emmanuel Oladipo and Mrs. Rachael Emiola Adimula. He had his primary education at the St. Marks Anglican Primary School, Offa, secondary education at Mount Carmel College, Ilorin, from where he proceeded to the University of Ilorin where he obtained his B.Sc, Physics with a Second Class (honours), Upper Division in 1983. He was a post graduate scholar in the Department of Electronic and Electrical Engineering at the University of Ife, now Obafemi Awolowo University, Ile-Ife from 1985 to 1986. He obtained his Ph.D degree in Physics of the University of Ilorin in 1997. He was a research fellow at the Politechnico di Milano, Italy, from January 1997 to May, 1998, where he was privileged to work with top researchers in the field radio propagation.

Prof. Adimula has attended many conferences and workshops in all the continents of this world. He has been a member of different scientific working groups both locally and internationally. He has over 50 publications to his credit. He was appointed a Professor of Physics on the 19th Sept.2011.

Prof Adimula was awarded the Young Scientist Award by the International Union Radio Science in 1991 for outstanding young scientist contribution to General Assembly of the Union in Kyoto, Japan.

In recognition of his leadership qualities, he was in 2009 voted the best Head of Department by the Faculty of Science Students' Association and in 2012 was elected President of the International Union of Radio Science Nigeria.

Prof. Adimula is presently the Director of the Computer Services and Information Technology (COMSIT) of the University

He is married to Barrister Ruth Abiola Adimula and blessed with children.

Acknowledgments

1. I am here only because the Lord has been my strength. He has taught my fingers to fight and my hands to war, to the extent that the bow of the enemy is broken by my hands. I thank the Lord God Almighty through my Lord and Saviour Jesus Christ for making this day a reality.
2. I thank the University of Ilorin, under the able leadership of Prof. Abdul Ganiyu Ambali and the immediate past Vice-Chancellor, Prof. I. O. Oloyede for giving me opportunities to serve in various capacities, which opportunities and challenges have equipped me in pursuance of my mandate.
3. I thank all of you who are here for this lecture, without all of you, there is no lecture. Thanks for coming.
4. I thank the First Lady, Kwara-State, Her Excellency, Deaconess Omolewa Ahmed for her support and love to the family.
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Dear Sir/Ma,

INVITATION TO THE 129th INAUGURAL LECTURE

This is to cordially invite you to the 129th Inaugural Lecture of the University of Ilorin, scheduled to hold as follows:

TITLE OF LECTURE:	**The Mandate: Radio as an Instrument of Dominion**
INAUGURAL LECTURER:	**Professor Isaac Abiodun ADIMULA** **B.Sc. (Ilorin), M.Sc. (Ife), Ph.D. (Ilorin), Professor of Physics**
VENUE:	**The University Auditorium, University of Ilorin Permanent Site**
DATE:	**Thursday, 18th April, 2013**
TIME:	**4.30 p.m. Prompt.**
CHAIRMAN:	**Vice-Chancellor, University of Ilorin**

(*Note: All Guests are to be on sit by 4.30p.m as the venue will be closed*)

Thank you

Prof. I. A. Adimula

I started my primary education at the St. Mark's Anglican Primary School, Offa, Kwara-State, thereafter I proceeded to Mount Carmel College, Ilorin.
At the expiration of the secondary education, I had a one year working experience at Radio Kwara, where by fate; I was posted to work at the Outside Broadcast Unit of the corporation where I actually began my adventure with Radio.
In 1983 I graduated from the department of Physics of this great University and served at the then Fed. School of Arts and Science, Ondo and then proceeded to the University of Ife for a Master degree in Electronic and Electrical Engineering in 1984. At the completion of the M.Sc. Electronic and Electrical Engineering in 1986, I had admissions for Ph.D. in Electrical Engineering and Physics, but I opted for Physics after realising that at this level there is no difference between the two disciplines.
By Fate again, I was offered a post graduate research work at the Dip. Di Electronica e Informazione Politecnico di Milano, Italy, where I had 15 months of research work with top scientists in the field of Radio propagation.

In 1986, I joined the services of the University of Ilorin as an Asst. Lecturer and moved through the ranks to be appointed a Professor of Physics in Sept, 2011. I thank God and the University for the journey thus far, cumulating in the delivery of this 129th Inaugural lecture of the University.