Proceeding of the 2015 International Conference on Space Science and Communication (IconSpace), 10-12 August 2015, Langkawi, Malaysia

A Mathematical Model for Improving the Mechanism of Satellite Antenna

M.E. Emetere[1], D.K. De[1], T.V. Omotosho[1] and M. Bakeko[2]
[1]Department of Physics, Covenant University, Ota, Nigeria
[2]Science and Technology Unit, Federal Polytechnic, Bida, Nigeria
moses.emetere@covenantuniversity.edu.ng, dilip.de@covenantuniversity.edu.ng, omotosho@covenantuniversity.edu.ng, mdanasabe@yahoo.com

***Abstract*—The functionality of any type of antenna could be traced to the Maxwell's electromagnetic field equations. However, salient operational problems of antennas are traced back to the Maxwell's. The inclusion of the effects of particulate to either transmission or reception unit of antenna is paramount. The Schrodinger was used to model a now reformed Maxwell's equation which explains in details the electrostatic and induced magnetic field of either transmitting or receiving antenna. This theory applies to only to stationary satellite antennas.**

***Keywords*—Antenna; Maxwell's; Schrodinger's equations.**

I. INTRODUCTION

The beauty of the Maxwell's equation is its long time application to diverse fields of antenna application. Though recently, many scientist and engineers have improved on the Maxwell's equation to solve practical problems relating propagation of radio wave signals, the omission of the role of particulate either in space or near earth surface is still a challenge that must not be ignored. Therefore we introduced the particulate influence to the Maxwell' equation by introducing the Schrodinger equation. The Schrodinger equation is another concept which has enjoyed wide application to diverse areas like the Maxwell's equation. Many of its solutions i.e. in 1D, 2D and 3D are being propounded using diverse method. In this paper, we shall be using the Schrodinger equation to explain the particulate involvement in the Maxwell's equation. This theory applies to both transmitting and receiving antennas.

II. THEORETICAL BACKGROUND

This ideas calls for the restructuring of the Maxwell's (shown below) to properly understand the mystery of its application to the antenna technology.

$$\nabla . E = \frac{\rho}{\varepsilon_0} \quad (1)$$

$$\nabla \times E = -\frac{\partial B}{\partial t} \quad (2)$$

$$\nabla \times B = \mu_0 J + \mu_0 \varepsilon_0 \frac{\partial E}{\partial t} \quad (3)$$

$$\nabla . B = 0 \quad (4)$$

Equation (1) represents the Coulomb's law where E is the electric field, ρ is the charge density, ε_0 is the permittivity of free space. Permittivity describes the ability of materials to transmit an electric field. Equation (2) represents the Faraday's law where B is the magnetic induction. The negative sign can be justified using the Lenz law. Equation (3) is the Ampere's law where μ_0 is the permeability of free space. Permeability is the ability of a material to support the formation of a magnetic field within itself in response to an applied magnetic field. J is the current density. Equation (4) represents the Gauss's law.

III. MATHEMATICAL EXPERIMENT

The charged particulates in space or near earth surface are believed to spin. We propose that the nature of excited particulate spin initiates other concepts in propagation like signal attenuation e.t.c. We therefore introduce the time-independent Schrödinger equation to account for its spins as [1,2]

$$i\hbar \frac{\partial}{\partial t}\psi - \frac{\hbar^2}{2m}\nabla\psi + V\psi = 0 \quad (5)$$

The langrangian density related to equation (5) is given as

$$\mathcal{L}_1 = \frac{1}{2}\left[\left|\frac{\partial\psi}{\partial t}\right|^2 - \frac{\hbar^2}{2m}|\nabla\psi|^2 - V|\psi|^2\right] \quad (6)$$

We apply the minimum coupling rule to describe the interaction of ψ with the electrostatic field i.e. $\frac{\partial}{\partial t} \mapsto \frac{\partial}{\partial t} + ieV, \nabla \mapsto \nabla - ieA$ where $V = V_o + E_o(\frac{a^2}{x} - x)$. Here V is the total potential in space or near earth surface, V_o is a constant on the surface of the charged air, E_o is the electric field and $(\frac{a^2}{x} - x)$ is the antenna potential, x is the Dybe length. Equation [6] transforms

$$\mathcal{L}_1 = \frac{1}{2}\left[\left|\frac{\partial\psi}{\partial t} + ie\psi\phi\right|^2 - \frac{\hbar^2}{2m}|\nabla\psi - ieA\psi|^2 - V|\psi|^2\right] \quad (7)$$

$$\mathcal{L}_1 = \frac{1}{2}\left[\left|\frac{\partial\psi}{\partial t} + ie\psi V_o + iE_o e\psi\left(\frac{a^2}{x} - x\right)\cos\omega t\right|^2 - \frac{\hbar^2}{2m}|\nabla\psi - ieA\psi|^2 - V|\psi|^2\right] \quad (8)$$

We Apply the solution of the standing wave $\psi(x,t) = e^{iS(x,t)}T(x,t)$ in equation [8]. $\mathbb{R}^3 X\ \mathbb{R} \rightarrow \mathbb{R}$, the lagrangian density takes the form

$$\mathcal{L}_1 = \frac{1}{2}\left\{E_{rt}^2 - |\mathrm{E_z}|^2 + \left[\frac{\hbar^2}{2m}|eA|^2 + |V_o e|^2 - \left(\left|E_o e\left(\frac{a^2}{x} - x\right)\right|^2\right) + 2E_o V_o e^2\right] {E_r}^2\right\} \quad (9)$$

Considering the langrangian density of the particle in an electrostatic fields $\mathrm{E_1}$-$\mathrm{E_2}$ fields

$$\mathcal{L}_o = \frac{1}{8\pi}(|E_1|^2 - |E_2|^2)(10)$$

Where the value of electric and magnetic was adapted from Glenn [3] and can be restructured into any geometry of antenna.

$$E_1(a,z) = (\beta E_r(a,z)e_r + E_z(a,z)e_z)e^{-j\beta r}sin\theta \quad (11)$$

$$E_2(a,z) = (\beta E_r(a,z)e_{r1} + E_z(a,z)e_{z1})e^{-j\beta r}cos\theta(12)$$

where $e_r = e_{r1} = \frac{\xi m}{4\pi r}$ and $e_z = e_{z1} = \frac{\xi mj}{4\pi z^2}$ are the parameters which describes the nature and dynamics of the particulate spins between the dish and its controlling device (see figure 1).

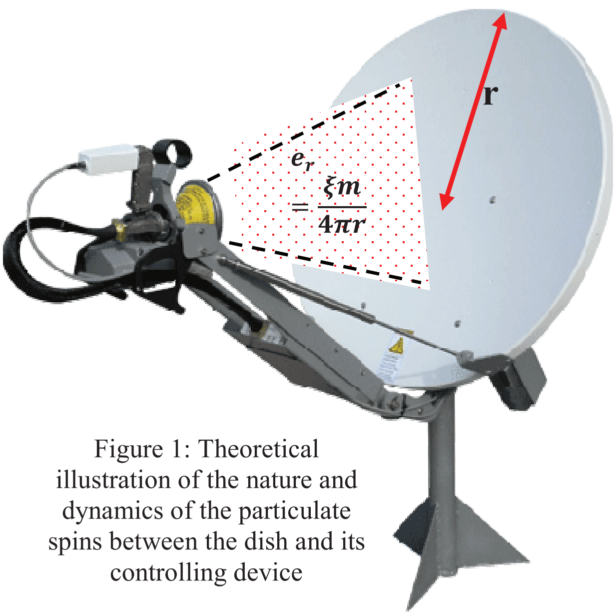

Figure 1: Theoretical illustration of the nature and dynamics of the particulate spins between the dish and its controlling device

The generalized boundary conditions for equation (11) are

$$\begin{cases} E_1(a,0) = E_\alpha(z) \\ E_1(\infty,z) = 0 \\ E_1(a,x) = E_\alpha(z).\alpha \\ E_1(a,\infty) = 0 \end{cases} \quad (13)$$

The boundary conditions for equation (12) are

$$\begin{cases} E_2(a,0) = E_\gamma(z) \\ E_2(\infty,z) = 0 \\ E_2(a,x) = E_\gamma(z).\gamma \\ E_2(a,\infty) = 0 \end{cases} \quad (14)$$

where α and γ are the attenuation factor of the electrical fields; $E_\gamma(z)$ and $E_\alpha(z)$ are the electric fields generated by the polar difference; β is the frequency of excited power; j is the antenna current; r represents the radius or horizontal component of the antenna; z represents the vertical component of the antenna; m represents the magnitude of the particulates; ξ represents the electrical permeability; μ_o represents the magnetic permeability; e_r is the spin factor which determines the electron spin along the horizontal component; e_z is the spin factor which determines the electron spin along the vertical component. Therefore the total action of lagrangian density is given by

$$D = \iint \mathcal{L}_1 + \mathcal{L}_o \quad (15)$$

Then the Euler-Lagrange equation [4] associated to the function $S = S(E_r, E_z, \mathrm{B_r}, B_z, r, \theta, z)$ gives rise to the following governing systems of equation

$$E_{rt} + \left[\frac{\hbar^2}{2m}|\mathrm{B_r} - eA|^2 + |B_z + V_o e|^2 - \left(\left|B_z - E_o e\left(\frac{a^2}{r} - r\right)\right|^2 - |B_z|\right) + 2E_o V_o e^2 + \beta e_r\right] E_r = \beta E_r e_r e^{-j\beta r}(sin\theta + cos\theta) \quad (16)$$

$$\frac{\partial}{\partial t}[(B_z + V_o e){E_r}^2] - \frac{\partial}{\partial t}\left[\left(B_z + E_o e\left(\frac{a^2}{x} - x\right)\right){E_r}^2\right] - \frac{1}{2}\frac{\partial B_z}{\partial t} = 0 \quad (17)$$

$$\frac{\hbar^2}{2m}{E_r}^2\frac{\partial}{\partial t}(\mathrm{B_r} - eA) = \beta B_r f_r e^{-j\beta r}(sin\theta + cos\theta) \quad (18)$$

$$\frac{\partial}{\partial t}E_z = \frac{\partial}{\partial t}E_z e_z e^{-j\beta r}(sin\theta + cos\theta) \quad (19)$$

$$2\left|B_z - E_o e\left(\frac{a^2}{r} - r\right)\right| E_r E_o e\left(\frac{a^2}{r^2} - 1\right) = \frac{j\beta}{8\pi}\left[\frac{E_r e_r}{r}(sin\theta + cos\theta) + \frac{2B_r f_r}{r}(sin\theta + cos\theta)\right]\beta e^{-j\beta r} \quad (20)$$

$$\frac{1}{8\pi}[\beta E_r(a,z)e_r + \beta B_r(a,z)f_r + E_z(a,z)e_z + B_z(a,z)f_z][cos\theta - sin\theta] = 0 \quad (21)$$

$$\frac{1}{8\pi}[-\frac{2}{z}e^{-j\beta r}sin\theta(B_z(a,z)f_z + E_z(a,z)e_z) - \frac{2}{z}e^{-j\beta r}cos\theta(B_z(a,z)f_z + E_z(a,z)e_z)] = 0 \quad (22)$$

Basically, equations (20-22) can be used to explain the various problems associated with the uplink or downlink budgeting as shown in Figure 2.

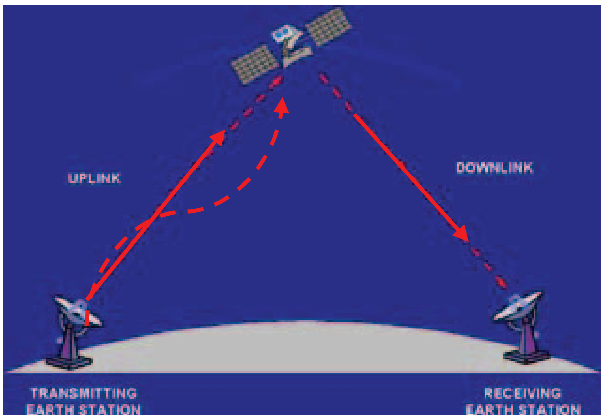

Figure 2: Mathematically interpretation of common problems in uplink or downlink budgeting (re-modified diagram from http://transition.fcc.gov)

IV. VALIDITY OF THE MODEL

The model has been used to solve salient problems in antenna technology. For example equation (16-19) has been used to resolve the efficiency, bandwidth and size –challenges of the transmitting loop antenna [4]. The results showed that the loop antenna could be remodeled to accommodate its shortcomings by adopting the angular displacement principles. The polynomial theories e.g. Boubaker, Bessel or Chebyshev polynomial expansion scheme can be used to optimize the various desired parameter. In Ref [4], the Hermite polynomial was used to resolve the current within the loop. Equation (16) was used to resolve the magnetic field effects on the sheath of the plasma antenna [5]. Aside, the explanation given in [5], this equation can be applied as a modulator in virtual instrumentation. The authors have not applied equation (16) to virtual instrumentation at the time this research. Equation (18) was used to resolve fading in multipath propagation in ultra wideband application [1]. This concept solves a major communication problem in satellite technology. Equation (20) was used to improve the respond time in detecting natural lightning using any electromagnetic device [2]. The major success was the theoretical possibility of using the natural lightning as a source of renewable energy. The specification for the energy trapping device was explained theoretically. Though the research is still on going and not got to the validity stage at the time of writing this research work. Recently, the application of equation (19) is applied to the MRI antenna. It was reported that equation (19) can be used to aid the Bloch NMR flow equations to improve the possibilities of detecting more accurately complex problems in neurological examination. The signal loss due to fluctuating velocity as it transmits through compartmental molecular boundaries was resolved via the application of equation (19). One of the advantages of equation (19) is the higher diagnostic selection to determine the degree of cognitive impairment in patient. This concept may be used in satellite technology to determine the diagnostic selection of uplink or downlink challenges relating to the transmitting or receiving antennas. The numerical simulations of some of the problems can be seen in the literatures highlighted in this text.

V. CONCLUSION

The main issues of satellite technology can be solved using a model which is comprehensive to feature salient challenges in the uplink or downlink budgeting. The validity of the model propounded in the text has been highlighted. However, its application is not limited to the specific problems that were solved in the main text. Basically, equations (20-22) explain the combination ratios of different conditions of electrostatic and induced magnetic fields of the satellite antenna. Its functionality to either the transmitting or receiving satellite antenna can be simplified using extensive super-fast computers to investigate the radio transmission in turbulent atmospheric medium e.g. the planetary boundary layer. Also, this model can be used to affirm Schreiner et al. [6] investigation of the noise level and receiver stability of Global Positioning Systems (GPS) using data collected from two independently developed Radio Occultation (RO) instruments flying in orbit on the FORMOSAT-3/COSMIC (F3C) and Metop/GRAS (GNSS Receiver for Atmospheric Sounding) missions. The two data sources were investigated using the former post-processed at a frequency of 50 Hz using single difference excess atmospheric phase algorithm. The perfection of this algorithm has not been ascertained as valid in satellite communication. However, if equation (20-22) is adequately incorporated into the Schreiner algorithm, a major satellite application problem would be solved.

ACKNOWLEDGEMENT

This paper is sponsored by Covenant University

REFERENCES

[1] Moses E Emetere “Theoretical Modeling of a Magnetic Loop Antenna for Ultra wideband (UWB) Application”. TELKOMNIKA Indonesian Journal of Electrical Engineering, 12(10), 7076 – 7081.2014

[2] M.E. Emetere, M.L. Akinyemi, U.E. Uno, A. O. Boyo "Lightning Threat Forecast Simulation Using the Schrodinger-Electrostatic Algorithm". IERI Elsevier Procedia, vol9, pp53 – 58, 2014
[3] Glenn S. S.,"Radiation Efficiency of Electrically Small Multiturn Loop Antennas" IEEE Trans Antennas Propagation, 20(5), pp 656-657, 1972
[4] Uno E. Uno and Moses E Emetere **"**The Physics Of Remodeling The Transmitting Loop Antenna Using The Schrodinger-Maxwell Equation" Journal for Asian scientific research, 2(1), 14-24, 2011
[5] M.E. Emetere, "Investigations of the Sheath Effect on the Resultant Magnetic Field of a Cylindrical Monopole Plasma Antenna", Plasma Science and Technology, 17(2), 153-158, 2015
[6] Schreiner, W., Sokolovskiy, S., Hunt, D., Rocken, C., and Kuo, Y.H., "Analysis of GPS radio occultation data from theFORMOSAT-3/COSMIC and Metop/GRAS missions at CDAAC". Journal of Atmos. Meas. Tech. 4: 2255–2272, 2011.