Indian J.Sci.Res. 13 (1): 255-256, 2017

ISSN: 0976-2876 (Print)
ISSN: 2250-0138 (Online)

WHAT IS THE POLARITY OF AN ELECTROMAGNETIC WAVE?

C. GANESA MOORTHY[a1], G. UDHAYA SANKAR[b] AND G. RAJ KUMAR[c]

[a]Department of Mathematics, Alagappa University, Karaikudi, India
[b]Department of Physics, Alagappa University, Karaikudi, India
[c]Department of EEE, Nehru College of Engineering and Research Centre, Pampady, India

ABSTRACT

There is no precise answer to the question: What is the polarity of an electromagnetic wave? Electromagnetic waves are identified as electric field waves or as magnetic field waves, but not both. This exclusive identification provided in this article fixes polarities of electromagnetic waves.

KEYWORDS: Maxwell Equations, Wave Equation, Electromagnetic Waves.

All things begin from Maxwell equations for electromagnetic theory. Both electric field and magnetic field satisfy a common wave (differential) equation, when these two fields vary simultaneously. This common differential equation is derived from Maxwell equations (see section 9.2.1 in (Griffths; 1999)). Since these two varying fields satisfy same wave equation, it was assumed in history that both of them lead to electric field waves (EF waves) and magnetic field waves (MF waves) with common wave lengths. The electric field is perpendicular to the magnetic field, but these two waves travel in the same direction, which is perpendicular to both electric field and magnetic field. A wave called electromagnetic wave (EM wave) travels in the common direction of EF wave and MF wave. An anomalous property of EM waves is that they travel transversely, when their corresponding EF waves and MF waves do so. So, the "definition" for EM waves needs clarifications in connection with polarity. This problem of fixing polarity in giving the definition has to be solved. For this purpose, solutions of common wave equations for EF waves and MF waves have to be discussed.

SOLUTIONS OF WAVE EQUATIONS

Let us first consider a string vibration problem. Suppose a string of uniform linear velocity is stretched to a uniform tension and it is fixed at two ends. If the string is pulled aside and released from rest, then it vibrates transversely. The displacement with respect to time obeys a one dimensional wave equation (see chapter 5 in (Sneddon; 1957)). Its solution represents a wave motion. Initial conditions can be fixed for string problems, and 'wave solutions' may be obtained. Let us use the phrase 'wave solution' for a solution of a wave equation that represents a wave in nature. Some wave solutions may be obtained for wave equations satisfying initial conditions. But all solutions of a wave equation need not be wave solutions. The wave nature of solutions depends on initial conditions. One can fix a position of the string with zero velocity at initial time, and one may obtain a wave nature for displacement. But, when the problem of producing EM waves is considered, there is no way (at present) to fix initial conditions for varying electric field as well as for varying magnetic field. So, it is not guaranteed for production of EF waves as well as for production of MF waves through any arbitrary procedure which follows the principle for production, because there is no method to fix suitable initial conditions leading to waves. Some unknown suitable initial conditions were satisfied in the first experiment of Hertz, and Hertz was successful in producing his EM waves. The waves obtained by Hertz are classified as 'microwaves'. Some initial conditions may lead to production of radio waves. Some initial conditions may also lead to production of light waves. To explain this statement let us discuss EF waves and MF waves.

EF WAVES AND MF WAVES

EF waves are the waves produced from variations in electric charges and variations in electric fields. If EF waves strike a conductor of electric charges, then the first reaction is movement of electric charges, more specifically, movement of electrons. As a second reaction, magnetic field may be varied. EF waves are transversal waves. For an example of EF waves, let us consider an invention of Thomas Edison. An electric current lamp with a resisting filament to produce light was experimented for his invention. The movements of electrons are restricted in the filament, when a current passes through the filament. So, there are variations in the electric field and in the magnetic field. Hence the Maxwell equations are satisfied, and hence a three

[1]Corresponding author

dimensional wave equation is satisfied by the electric field and the magnetic field. The photoelectric effect gives the conclusion that EF waves are produced from the electric current lamp, and they are light waves. There is no assurance that an electric current lamp produces MF waves; visible as well as non visible; as EM waves.

MF waves are the waves produced from variations in magnetic field. If MF waves strike a conductor of electric charges, then the first reaction is a variation in the magnetic field around the conductor. As a second reaction, movements in electric charges may happen. All radio waves are MF waves.

DISCUSSION FROM HERTZ'S EXPERIMENT

In the classical experiment of Hertz, a loop/circuit for alternating current is broken with two ends which are closely placed. The current produces sparks and EM waves between the ends. From the observation method used in this experiment, it can be concluded that MF waves are considered as EM waves. Light waves may also be produced in this experiment. But, they cannot be correlated with MF waves in view of uniqueness of polarity for an EM wave. By the same polarity reason, it can be concluded that every EM wave is either an EF wave or a MF wave, but not both. All light waves are EF waves and all radio waves are MF waves. If there is an imaginary instrument that produces all EM waves, then there should be a gap in the spectrum of microwaves; which is placed between classical light waves and classical radio waves.

This break happens, because electric field is perpendicular to magnetic field and so because there is a ninety degree difference in polarity between EF waves and MF waves. So, a classification is required for microwaves. Let us end this discussion with an observation. All waves from the sky and the earth are observed with the help of electric fields and magnetic fields created by these waves, when these waves have velocities equal to the velocity of light. So, these waves are either EF waves or MF waves.

CONCLUSION

1. Every EM wave is an EF wave or a MF wave, but not both.
2. Light waves are EF waves.
3. Radio waves are MF waves.
4. There is a break in the spectrum of microwaves such that one side consists of EF waves and the other side consists of MF waves. This statement needs a mathematical justification, apart from a physical justification given above.
5. An EM wave does not contain an EF wave and a MF wave with same frequency, simultaneously.

REFERENCES

Griffths D.J., 1999. Introduction to electrodynamics, Third edition, Prentice Hall, New Jersey.

Sneddon I., 1957. Elements of partial differential equations, McGraw-Hill, London.