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Magnetodynamic waves in the air

Alexander I. Korolev

Department of General Physics I, Faculty of Physics, St. Petersburg State University, 7/9 Universitetskaya nab., 199034, Saint Petersburg, Russian Federation

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ABSTRACT

The paper describes experiments to search for a variable magnetic field close to a rechargeable conductive flat plate and a ball in the air, as well as an experiment looking for a variable electric field near a rotating permanent magnet. It has been found that variable electric and magnetic fields do not induce each other within the measurement error. It means that rotary Maxwell's equations are not applicable in the near-field zone and the classical concept of displacement current in vacuum (air) has no physical meaning. A conclusion is made on the existence of transverse magnetodynamic waves. Statics and dynamics of the magnetic field near the permanent magnet rod are investigated experimentally. The methods to compute magnetodynamic waves from any source are presented. Four types of polarization of these waves are identified: linear, circular, toroidal and mixed. Concentration and deflection of magnetodynamic waves are observed on introducing inhomogeneity in the form of a ferrite rod into their propagation way, which is similar to diffraction in optics. Secondary magnetodynamic waves from the induced magnetic moments in atoms of ferrite are registered near its surface, which is like reflection in optics. Some ideas for observation of effects similar to dispersion and interference are presented for magnetodynamic waves. The structure and properties of electrodynamic, magnetodynamic and electromagnetic waves are discussed. The ideas of experiments to search for their unknown properties are described. In conclusion, technical applications of magnetodynamic waves such as magnetography, magnetic tomography and other are considered.

1. Introduction

Classical electrodynamics states that a variable electric field generates a variable magnetic field and vice versa. The relation between them is given by Maxwell's equations [1,2]. This assertion is based on the hypothesis of existence of a magnetic field from displacement currents. However, this hypothesis has no experimental verification. Faraday found no generation of one field by another [3]. Maxwell theoretically linked electric and magnetic fields in the media, using the concept of electromagnetic momentum [4]. In the demonstration experiment aimed at observation of displacement currents, the circular magnetic field observed between plates of a flat capacitor is excited by radial conduction currents flowing through the plates, as alleged in, for example [5]. The paper gives a theoretical description of solitary dynamic magnetic field using the modified Maxwell's equations.

Time-variable magnetic fields with low frequencies are considered in a number of publications, but they contain no information about induced rotary electric fields predicted by Maxwell's equations, see, e.g. [6,7].

To find a variable magnetic field in a variable electric field, two experiments have been conducted. In the first one, measurements of the magnetic field were made close to a copper plate under a variable potential; in the second one, near a steel ball.

2. Magnetic field in the area of a variable electric field

2.1. Theory

Let us estimate the normal component of intensity of electric field E near the center of a rechargeable plate. We use the well-known formula of classical electrostatics:

$$E = |\mathrm{grad}(\varphi)| \sim \varphi/d \quad (1)$$

where φ is the potential of the plate relative to the ground, d is the distance from the point of measurement to the plate. The maximum possible pulse amplitude from the pulse generator is 50 V. The electric field intensity at a distance of 1 mm from the plate at that time is $E \sim 5 \times 10^3$ V/m. In accordance with Maxwell's fourth equation, around the area of the variable electric field there must be a variable magnetic field, with the intensity in the air given by

$$rot(\mathbf{B}) = \partial \mathbf{E}/\partial t \quad (2)$$

Let's divide this area into some slices. Around each, according to Eq. (2), there must arise ring magnetic fields, see Fig. 1. Then, summing up the magnetic fields of the adjacent slices, we get zero.

E-mail address: alex-korolev@ya.ru

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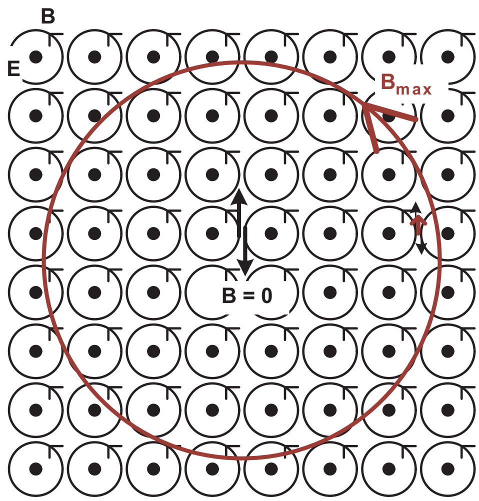

Fig. 1. Area of a variable electric field. Lines **E** are directed forward. Field **E** is homogeneous in the central part of the area, decreasing to **0** closer to the edges of variable electric field.

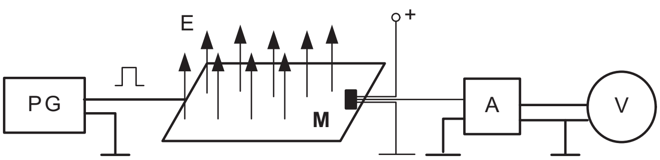

Fig. 2. Scheme of the experimental setup for observation of a variable electric field in the area of a variable magnetic field. PG—pulse generator, M—Hall's probe, A—broadband amplifier, V—oscilloscope.

Thus, a magnetic field cannot be observed in a homogeneous variable electric field. However, in real conditions it is necessary to take the boundary effect into account. The region of the maximum magnetic field over a flat plate must have a form of a closed contour, where the electric field gradient is maximum, see Fig. 1. Theoretically, there could also occur an attenuation of the magnetic field over the plate due to overlapping of displacement currents flowing from the reverse side of the plate. To account for this, the magnetic field is also measured near the ends of the plate.

On the other hand, it is well known from electrodynamics [8,9] that an electromagnetic wave in the near-field zone is not yet formed, and the electric and magnetic fields there, if measured with split-hair accuracy, vary independently. Thus, Maxwell's equations for this zone should not be applicable. It is noticed that displacement currents can be used to "fast" alternating *E* field. Slow alternating field is called "quasi-stationary" and do not induce magnetic field. But definition of the edge between "fast" and slow oscillation is not given. Because of e/m waves on very low frequencies exist the theory is not convincing. So, the concept of displacement currents loses its physical meaning. To resolve this problem, the experiments described below have been conducted.

2.2. Measurements

Fig. 2 shows a functional diagram of the experimental setup. Using Pulse Generator G5-82, rectangular pulses of positive polarity (RPPP) are directed onto a copper plate measuring $115 \times 150 \times 1\ mm^3$, resulting in a variable electric field around the plate. Observations of the magnetic field near the plate are performed in the near-field zone using the Hall probe. This probe is *Honeywell* 840 G capable of detecting magnetic fields up to 840 G in one coordinate. The response time is 3 ms; the average sensitivity under normal climatic conditions is 2.4 mV/G. The signal is then amplified by a broadband amplifier UZ-29 and fed into the oscilloscope S1-73. RPPP are formed with durations of 1 mcs, 1 ms, 10 ms, 100 ms and delays of 6 mcs, 6 ms, 60 ms, 600 ms, respectively.

Measurements of the magnetic field above various parts of the plate are made in three coordinates. For measuring the longitudinal components of the magnetic field, the minimum distance to the sensor is 1 mm, and up to 0.2 mm when measuring the transverse dimension. According to the results of all measurements $B=0\pm1$ G. Thus the energy density of the magnetic field is no more than $\sim10^{-10}$ of that of the electric field.

In the second experiment, a steel ball 22 mm in diameter is used instead of a copper plate. The pulse durations are 1 ms and 10 ms. The results of the measurements of the magnetic field are the same. We apply Maxwell's fourth equation to estimate the magnetic field near the surface of the ball. Due to the spherical symmetry, the magnetic fields of the regions above the surface of the rechargeable ball are all entirely subtracted, with the exception of the area of the lead-in of the current supply. Thus, in the framework of classical electrodynamics, the magnetic field around the displacement currents around the ball should be zero. The magnetic field of the real currents flowing over the ball is not observed because of its smallness: the total value of the conduction currents flowing from the pulse generator onto the plate or the ball does not exceed 0.05 A.

The experiment with the ball is not as revealing as that with the plate. However, it suggests that in space, in addition to electromagnetic waves, there could propagate waves of an electric field, the so-called electrodynamic waves. These waves are longitudinal in nature, since the electric field is scalar. Their decay is clearly inversely proportional to the square of the distance, and the rate of variation in the electric field in this wave is limited by the inertia of the propagation medium. Such waves were observed experimentally in [10].

3. Measurements of the electric field in the area of a variable magnetic field

Fig. 3 shows a diagram of the experimental setup. To create a variable magnetic field, a rotating permanent magnet was chosen. It is a bar magnet, with a diameter of 10 mm, 15 mm long. The maximum magnetic field at the end is 0.3 T. To rotate it, a QX Motor 5-24 V is used. A rectangular flat aerial made of copper, measuring $105 \times 12 \times 1\ mm^3$, is used to measure the electric field.

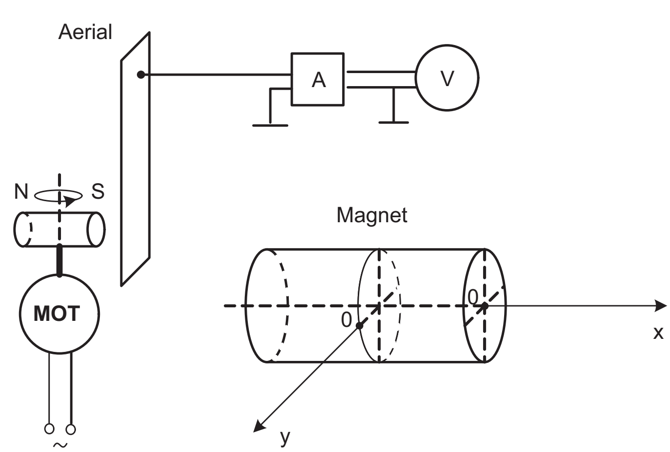

Fig. 3. Scheme of the experimental setup for observation of a variable electric field in the area of a variable magnetic field. Registration of magnetodynamic waves is carried out using Hall's probe instead of an aerial.