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Research Article

Electromagnetic waves work

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Abstract

In this paper electromagnetic waves and their work were studied. Discrete energy quantity, called quant, and substance state relation was defined assuming material is high density energy. Equation for electromagnetic work was derived. Equation for electromagnetic force was discussed. The quant energy and frequency in 5G and 6G were studied and rotating magnetic field was considered. The Earth's magnetic field and electrodynamic field were studied. In this paper the quant energy term was discussed.

Keywords: Electromagnetic waves, force, work, speed, length, frequency.

1. Introduction

In physics, electromagnetic radiation refers to the waves of the electromagnetic field, propagating through space, carrying electromagnetic radiant energy. It includes radio waves, microwaves, infrared, light, ultraviolet, X-rays, and gamma rays.

The electromagnetic (EM) spectrum is the range of all types of EM radiation. Radiation is energy that travels and spreads out as it goes – the visible light that comes from a lamp in your house and the radio waves that come from a radio station. In physics, *electromagnetic radiation* (*EM radiation* or EMR) refers to the waves (or their quanta, photons) of the electromagnetic field, propagating (radiating) are two types of electromagnetic radiation.

6G-sixth-generation wireless is the successor to 5G cellular technology. 6G networks will be able to use higher frequencies than 5G networks and provide substantially higher capacity and much lower latency. One of the goals of the 6G internet will be to support one micro-second latency communications, representing 1000 times faster or 1/1000th the latency than one millisecond throughput [1,2].

The 6G technology market is expected to facilitate large improvements in the areas of imaging, presence technology and location awareness. Working in conjunction with artificial intelligence, the computational infrastructure of 6G will be able to autonomously determine the best location for computing to occur; this includes decisions about data storage, processing and sharing 5G is the 5th generation mobile network. It is a new global wireless standard after 1G, 2G, 3G, and 4G networks. 5G enables a new kind of network that is designed to connect virtually everyone and everything together including machines, objects, and devices.

Some 5G pundits contend that the new network generates radiofrequency radiation that can damage DNA and lead to cancer; cause oxidative damage that can cause premature aging; disrupt cell metabolism; and potentially lead to other diseases through the generation of stress proteins.

At low frequencies, external electric and magnetic fields induce small circulating currents within the body. The main effect of radiofrequency electromagnetic fields is heating of body tissues. There is no doubt that short-term exposure to very high levels of electromagnetic fields can be harmful to health [3,4].

To protect against 6G and 5G and other electromagnetic fields in your home, the electromagnetic field home adaptor is recommended. The home adaptor will correct the 6G or 5G or 4G signal going to devices like a tablet in our home. It will not fully protect against fields originating out of your home (such as the neighboring routers and cell towers).

Some studies have found a link between electromagnetic field exposure and a higher risk of childhood leukemia, but other studies have not. Other studies have not found proof that electromagnetic field exposure causes other childhood cancers. Studies in adults did not prove that electromagnetic field exposure causes cancer.

In this paper electromagnetic waves and their work were examined.

2. Mobile networks

6G is expected to support 1 terabyte per second (Tbps) speeds. This level of capacity and latency will be unprecedented and will extend the performance of 5G applications along with expanding the scope of capabilities in support of increasingly new and innovative applications across the realms of wireless cognition, sensing and imaging. 6G's higher frequencies will enable much faster sampling rates in addition to providing significantly better throughput. The combination of sub-mmWave (e.g. wavelengths smaller than one millimeter) and the use of frequency selectivity to determine relative electromagnetic absorption rates is expected to lead to potentially significant advances in wireless sensing solutions.

Additionally, whereas the addition of mobile edge computing –MEC is a point of consideration as an addition to 5G networks, MEC will be built into all 6G networks. Edge and core computing will become much more seamlessly integrated as part of a combined communications/computation infrastructure framework by the time 6G networks are deployed. This will provide many potential advantages as 6G technology becomes operational, including improved access to artificial intelligence -AI capabilities.

6G is expected to launch commercially in 2030. 6G is being developed in response to the increasingly distributed radio access network -RAN and the desire to take advantage of the terahertz -THz spectrum to increase capacity and lower latency. While some early discussions have taken place to define 6G, research and development -R&D activities will start in earnest in 2020. Many of the problems associated with deploying millimeter wave radio for 5G new radio are expected to be solved in time for network designers to address the challenges of 6G. It's expected that 6G wireless sensing solutions will selectively use different frequencies to measure absorption and adjust frequencies accordingly. This is possible because atoms and molecules emit and absorb electromagnetic radiation at characteristic frequencies and the emission.

3. Electrodynamic field

The classical electromagnetic field incorporated into quantum mechanics forms what is known as the semi-classical theory of radiation. However, it is not able to make experimentally observed predictions such as spontaneous emission process or Lamb shift implying the need for quantization of fields. In modern physics, the electromagnetic field is understood to be not a *classical* field, but rather a quantum field; it is represented not as a vector of three numbers at each point, but as a vector of three quantum operators at each point. The most accurate modern description of the electromagnetic interaction (and much else) is *quantum electrodynamics* (QED), which is incorporated into a more complete theory known as the *Standard Model of particle physics*.

In QED, the magnitude of the electromagnetic interactions between charged particles (and their antiparticles) is computed using perturbation theory. These rather complex formulas produce a remarkable pictorial representation as Feynman diagrams in which virtual photons are exchanged.

Predictions of QED agree with experiments to an extremely high degree of accuracy: currently about 10^{-12} (and limited by experimental errors); for details see precision tests of QED. This makes QED one of the most accurate physical theories constructed thus far.

All equations in this article are in the classical approximation, which is less accurate than the quantum description mentioned here. However, under most everyday circumstances, the difference between the two theories is negligible.

4. Earth's magnetic field

A sketch of Earth's magnetic field representing the source of the field as a magnet. The south pole of the magnetic field is near the geographic north pole of the Earth.

The Earth's magnetic field is produced by convection of a liquid iron alloy in the outer core. In a dynamo process, the movements drive a feedback process in which electric currents create electric and magnetic fields that in turn act on the currents.

The field at the surface of the Earth is approximately the same as if a giant bar magnet were positioned at the center of the Earth and tilted at an angle of about 11° off the rotational axis of the Earth. The north pole of a magnetic compass needle points roughly north, toward the North Magnetic Pole. However, because a magnetic pole is attracted to its opposite, the North Magnetic Pole is actually the south pole of the geomagnetic field. This confusion in terminology arises because the pole of a magnet is defined by the geographical direction it points.

Earth's magnetic field is not constant—the strength of the field and the location of its poles vary. Moreover, the poles periodically reverse their orientation in a process called geomagnetic reversal. The most recent reversal occurred 780000 years ago.

5.Rotating magnetic fields

The *rotating magnetic field* is a key principle in the operation of alternating-current motors. A permanent magnet in such a field rotates so as to maintain its alignment with the external field. This effect was conceptualized by Nikola Tesla, and later utilized in his and others' early AC (alternating current) electric motors.

Magnetic torque is used to drive electric motors. In one simple motor design, a magnet is fixed to a freely rotating shaft and subjected to a magnetic field from an array of electromagnets. By continuously switching the electric current through each of the electromagnets, thereby flipping the polarity of their magnetic fields, like poles are kept next to the rotor; the resultant torque is transferred to the shaft.

A rotating magnetic field can be constructed using two orthogonal coils with 90 degrees phase difference in their AC. However, in practice such a system would be supplied through a three-wire arrangement with unequal currents.

This inequality would cause serious problems in standardization of the conductor size and so, to overcome it, three-phase systems are used where the three currents are equal in magnitude and have 120 degrees phase difference. Three similar coils having mutual geometrical angles of 120 degrees create the rotating magnetic field in this case. The ability of the three-phase system to create a rotating field, utilized in electric motors, is one of the main reasons why three-phase systems dominate the world's electrical power supply systems.

Synchronous motors use DC-voltage-fed rotor windings, which lets the excitation of the machine be controlled—and induction motors use short-circuited rotors (instead of a magnet) following the rotating magnetic field of a multicoated stator. The short-circuited turns of the rotor develop eddy currents in the rotating field of the stator, and these currents in turn move the rotor by the Lorentz force.

In 1882, Nikola Tesla identified the concept of the rotating magnetic field. In 1885, Galileo Ferraris independently researched the concept. In 1888, Tesla gained U.S. patent 381968 for his work.

6. Quantum energy

The word quantum derives from the Latin, meaning "how great" or "how much". The discovery that particles are discrete packets of energy with wave-like properties led to the branch of physics dealing with atomic and subatomic systems which is today called quantum mechanics. In physics, a quantum (plural quanta) is the minimum amount of any physical entity (physical property) involved in an interaction. The fundamental notion that a physical property can be "quantized" is referred to as "the hypothesis of quantization". This means that the magnitude of the physical property can take on only discrete values consisting of integer multiples of one quantum. For example, a photon is a single quantum of light or of any other form of electromagnetic radiation. Similarly, the energy of an electron bound within an atom is quantized and can exist only in certain discrete values. Indeed, atoms and matter in general are stable because electrons can exist only at discrete energy levels within an atom. Quantization is one of the foundations of the much broader physics of quantum mechanics. Quantization of energy and its influence on how energy and matter interact (quantum electrodynamics) is part of the fundamental framework for understanding and describing nature.

Basic problem in classic physics and chemistry was consideration that emission, transfer and absorption electromagnetic waves (radiation) performed continues.

Quant mechanical moving of electrons in atoms make magnetic field permanent ferromagnets. Electrical particles with spin also have magnetic moment. Some electrical neutral particles, for example neutron, which have spin, also have magnetic moment because of distribution electricity in their inner structure. Particles without spin never have magnetic moment.

The magnetic field of permanent magnets can be quite complicated, especially near the magnet. The magnetic field of a small straight magnet is proportional to the magnet's strength (called its magnetic dipole moment). The equations are non-trivial and also depend on the distance from the magnet and the orientation of the magnet. For simple magnets, m

points in the direction of a line drawn from the south to the north pole of the magnet. Flipping a bar magnet is equivalent to rotating its m by 180 degrees.

The magnetic field of larger magnets can be obtained by modelling them as a collection of a large number of small magnets called dipoles each having their own m. The magnetic field produced by the net magnetic field of identical (to a multiplicative constant) so that in many cases the distinction can be ignored. This is particularly true for magnetic fields, such as those due to electric currents, that are not generated by magnetic materials.

Equation of electron moving in magnetic field is:

$$m\frac{dv}{dt} = m(g + v_r) \qquad (1)$$

where v electrons velocity moving, m electron mass, g gravity acceleration, v_r friction acceleration, t, time.
Further, electromagnetic force can be defined [3,9].

$$F = m\frac{dv}{dt} - m(g + v_r) \qquad (2)$$

where F electromagnetic force in SI is newton (N).
In this way is defined magnetic force and magnetic moment. By equation (1) can control and seek out conditions for wished force of magnetic field. If more magnetic field fixed in set, then is obtained resulted magnetic force as shown in equation (3).

$$F = F_1 + F_2 + F_3 + \ldots\ldots\ldots F_n \qquad (3)$$

Magnetic force F is expressed in newton, N.
Electromagnetic waves work can be defined as:

$$w = F \times t \qquad (4)$$

where F, force, N, t , time, s and w, work, Ns.
Electromagnetic waves work first time defined in this paper.

In classical physics and chemistry is opinion that electromagnetic waves emission, transfer and absorption are performed continuous. Maks Plank introduce assumption that electromagnetic radiation emitted in discrete energy quantity called energy quant. It means energy emitted discontinuously, with break, in energy package. Energy of one quant proportional is frequency radiation f:

$$\varepsilon = hf = h\frac{c}{\lambda} \qquad (5)$$

where $h = 6.62\ 10^{-34} Js$ universal Plank's constant, c light velocity, f frequency and λ wave length of electromagnetic waves which emitted.

The photon energy formula $\varepsilon = hf$ is used to compute radiant energy in joules based on Planck's constant and a frequency of radiation in hertz [5,6].

Einstein is proved Plank's hypothesis on quant applying to describing photo effect. Einstein extended Plank's hypothesis that energy electromagnetic radiation transferring in quant to some obstacle which it absorbed. Instead, Plank's name quant (small pieces), Einstein suggested name photon (light pieces). Idea about photons (quant) means the following: electromagnetic waves energy has discontinuous structure. These small energy pieces are relying photons (quant) [6,8]. Plank's formula for energy one photon shows that different electromagnetic waves have photons non-equal energy [8,9]. Since photon's energy in opposition proportion with radiation waves length then minimal energy of photons have electromagnetic waves with maximum waves length, and such as radio waves, until maximum photons energy has path of specter which have minimal waves lengths and those are cosmic waves.

If electromagnetic waves emitted in the form of quant, with that energy each quant $\varepsilon = hf$, then all emitted energy:

$$E = nhf \qquad (6)$$

where $n = 1,2,3,4, \ldots.$

Acording this equation (5) follows that:

- The smallest energy which can emitted equal energy one quant (energy cannot be less from this energy but cannot be emitted).
- All amount emitted energy must be equal integer product of multi energy of one quant.

Equation (5) can be written in the following form:

If $\omega = 2\pi f \quad f = \frac{\omega}{2\pi}$

$$\varepsilon = h\frac{\omega}{2\pi} = \frac{h}{2\pi}\omega = h^{\bullet}\omega \qquad (7)$$

$$h^{*} = 1.05 \;\; 10^{-34}\, JS$$

where h^{*} also Plank's constant.

Electromagnetic waves emitted in the form of quant, with total emitted energy $\varepsilon = nhf$ to the final product. When these quant energies are high density then becomes substance. Thus, substance is high density energy.

The quant energy term can be derived according to following equation [7]:

$$\Delta p \Delta q = \varepsilon \Delta t \qquad (8)$$

where p probability of position, q is probability of time, ε is quant energy and t is time. This formula includes no determine principle. Vibration change can be defined as:

$$\Delta f = \frac{\varepsilon}{h} \qquad (9)$$

where f frequency.

7. How shield from electromagnetic waves

Some frequency of electromagnetic waves are harmful for biochemical processes in human body.

Typical materials used for electromagnetic shielding include sheet metal, metal screen, and metal foam. Any holes in the shield or mesh must be significantly smaller than the wavelength of the radiation. Electromagnetic shielding that blocks radio frequency. Electromagnetic radiation is also known as radio frequency shielding. The shielding can reduce the coupling of radio waves, electromagnetic fields, and electrostatic fields. A conductive enclosure used to block electrostatic fields is also known as a Faraday cage at is being kept out, or the enclosure will not effectively approximate an unbroken conducting surface.

Thin amounts of plastic wrap, wax paper, cotton and rubber are not likely to interfere with radio waves. However, aluminum foil, and other electrically conductive metals such as copper, can reflect and absorb the radio waves and consequently interferes with their transmission.

The polymer is 11 percent gold by weight, and the gold atoms in the substance efficiently scatter or absorb most forms of radiation, including X-rays. Chemically incorporated into a polymer, gold is less poisonous than other heavy metals that also block radiation.

The stop frequency is the end (highest) frequency of the frequency band to analyze. For information on other ways to set the start frequency. The maximum stop frequency can measure by the measurement hardware.

8.Conclusion

In this paper properties of the electromagnetic waves were examined. Equation for electromagnetic waves work was derived.

Quantum electrodynamics of energy and its influence on how energy and matter interact is part of the fundamental framework for understanding nature. The quant energy term was considered.

Equation for electromagnetic force was discussed.

Health shielding from electromagnetic waves was studied.

Notation

c - light velocity, m/s
g -gravity acceleration, m/s^2
F - electromagnetic force, N
f - frequency, s
$h = 6.62\ 10^{-34} Js$ -universal Plank's constant
m - electron mass, kg
p - probability of position
q - probability of time
t - time, s
v - electrons velocity moving, m/s
v_r- friction acceleration, m/s^2
w —work, Ns

*Greek symbol*s
ε -quant energy, J
λ wave length, m

Abbreviation

AC- alternating current
DC-digital current
EM- electromagnetic waves
EMR- electromagnetic radiation
MEC-mobile edge computing
QED-quantum electrodynamics
RAN- radio access network
R&D- research and development

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