Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 181 (2023) 18-31 EISSN 2392-2192

Planck's distribution and definition for temperature of electromagnetic waves

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ABSTRACT

Electromagnetic waves come with heat. Temperature at a particular point of a body at a particular time is considered as a defined concept, via entropy. A new concept of temperature of energy waves is discussed in this article, for waves having speed in vacuum as speed of light. Planck's distribution considers radiated waves of different wavelengths from a blackbody with a particular temperature. On considering the black body at two different temperatures, there is a need for a careful analysis in proposing definition for temperature of electromagnetic waves without confronting Planck's theory, which was established mathematically. This is done in this article with an application to cell phone waves. It is observed in this article that all electromagnetic waves heat all living beings.

***Keywords*:** Planck's distribution, Stefan-Boltzmann law, Planck equation, Electromagnetic waves

1. INTRODUCTION

Is there any light wave with wave length 10^{-1} m? Is there any radio wave with wave length 10^{-6} m? Many persons would say the answer "No" to these two questions with reasoning like: the wavelength ranges for light waves and radio waves are…; or with reasoning like: no such waves were found so far. But, logicians working on logical derivations hesitate to accept this answer until they find a derivation which establishes or proves non existence of such waves.

(Received 14 April 2023; Accepted 18 May 2023; Date of Publication 21 May 2023)

It was derived in [23] and [24] that any electric field wave in particular any light wave has wave length less than or equal to 1.063022744 × 10^{-3} m and it was derived that any magnetic field wave, in particular any radio wave has wave length greater than or equal to 1.063022744 × 10^{-3} m. For this purpose an electromagnetic wave was defined as an energy wave with light speed in vacuum, and it was observed that any electromagnetic wave for which wave length is less than 1.063022744 × 10^{-3} m (approximately) is an electric field wave and any electromagnetic wave for which wave length is greater than 1.063022744 × 10^{-3} m is a magnetic field wave. Logicians always need some logical derivations or logical reasons to accept answers for questions. What is the melting point of Zinc? What is the melting point of Gold? Many persons would accept a general conclusion: If temperature of a material is raised sufficiently, then it becomes a non solid material or energy at some particular temperature. But, logicians used to think about a possibility for finding a solid material in future, which never becomes a non solid material. Second order derivative of Planck's distribution for black body radiation with respect to wavelength of light rays emitted was considered in [20] to discuss temperature to make solids to non solids, so that a fixed temperature is applicable to all materials (known or unknown).

Let us consider the following constants in MKS system along with unit for temperature as Kelvin.

Planck's constant for light waves $h = 6.626 \times 10^{-34}$.
Planck's constant for radio waves ⓗ = 17.57889908.
Boltzmann constant $k = 1.38 \times 10^{-23}$.
Stefan-Boltzmann constant $\sigma = 5.672 \times 10^{-8}$.
Speed of light in vacuum $c = 2.9979 \times 10^{8}$.
Wien universal constant $b = 2.8978 \times 10^{-3}$.

Planck's distribution [25] for intensity $u(\lambda)$ corresponding to wavelength λ for a light wave emitted from a black body with temperature T will be considered in the form:

$$u(\lambda) = \frac{8\pi hc}{\lambda^5}\left(e^{\frac{hc}{\lambda kT}} - 1\right)^{-1}.$$

By considering real solutions of the equation $\frac{d^2u(\lambda)}{d\lambda^2} = 0$, the following major conclusions were derived in [20]. Every material in our universe should stop all radiations when its temperature is below 1.6 Kelvin. Every material in our universe radiates when its temperature is above 40541400000 Kelvin. Every material in our universe becomes non solid, when its temperature is above 405414 Kelvin. Here materials refer to both known and unknown materials.

All materials with temperature 40541400000 Kelvin should become energy. So, there is a natural question about definition of temperature of an energy wave, when definition of temperature of a black body is known through thermodynamics. The black body mentioned above has a specific temperature T. Does it mean that every energy wave with wavelength λ emitted from the black body has temperature T? It is absolutely meaningless, and moreover one gets waves with same wavelength even for different temperatures of the same black body.

A careful analysis is carried out in trying to define temperature for electromagnetic waves in this article.

2. ELECTROMAGNETIC WAVES

All scholars used to accept that radio waves are electromagnetic waves. Some scholars used to accept that light waves are electromagnetic waves. Some scholars used to say that light waves may be considered as electromagnetic waves by referring to some reasons. There are many persons to accept that gravitational waves are not electromagnetic waves. Some persons used to say that cavity magnetrons produce electromagnetic waves by calling them microwaves. Is an alpha ray an electromagnetic wave? Is a beta ray an electromagnetic wave? There are many questions and there are many answers. Answers may be accepted by some persons and may not be accepted by some persons.

Who can give precise correct answer? Who is the authority to verify the correctness of answers? What is procedure to find the authority to verify correctness of answers? All the things regarding electromagnetic waves begin from Maxwell equations. All persons used to interpret that the solutions of these equations provide simultaneous orthogonal oscillations of electric field and magnetic field. Both electric field and magnetic field oscillate simultaneously and thereby the waves which come from the source are assumed to contain both electric field wave component and magnetic field wave component, and such waves are understood as electromagnetic waves.

This is an understanding about the definition of an electromagnetic wave. That is, an electromagnetic wave is an energy wave that contains two same-wavelength-orthogonal component waves, namely, electric field component and magnetic field component. But, this is not a precise definition to identify electromagnetic waves. Moreover, it was mentioned in the previous section that an "electromagnetic wave" can contain either only electric field component or exclusively only magnetic field component depending on the wavelength of the "electromagnetic wave", around the value $1.063022744 \times 10^{-3}$ m. Before explaining this further, let us fix a definition for "electromagnetic wave", which will be applicable for this article. This definition for "electromagnetic waves" should not be compared with the existing "definitions". An energy wave is a wave that carries energy.

***Definition*:** An energy wave that can travel through vacuum with a speed c, the speed of light in vacuum, will be called an *electromagnetic wave*.

Light waves can travel in vacuum with speed c, and hence light waves are electromagnetic waves according to this definition. Radio waves can travel in vacuum with speed c, and hence radio waves are electromagnetic waves according to this definition. The energy waves produced by cavity magnetrons have speed not equal to c in vacuum, and hence they are not electromagnetic waves as per this definition. Alpha rays and beta rays do not have speed equal to c in vacuum, and hence they are not electromagnetic waves as per this definition. Gamma rays, X-Rays, ultraviolet rays, and infra red rays are electromagnetic waves according to this definition. Gravitational waves have speed c in vacuum [3, 10, 26, 29] so that they are also electromagnetic waves according to this definition. Let us next classify two categories of electromagnetic waves according to this definition.

Let us recall two imaginary situations. (a) A high voltage direct current passes through a resistor, and (b) A high current alternating current passes through a conducting wire coil. In the first case (a), two successive electrons in two successive molecules in serial try to become closer electrons, they repel each other by their electric fields, and the electric fields produce energy waves. One example is light waves produced from Thomas Alva Edison bulbs. In the second case (b), two nearby electrons in two nearby molecules in parallel try to become closer electrons, they repel each other by the magnetic fields induced from moving electric fields, and the magnetic fields produce energy waves. One example is radio waves. In both cases (a) and (b), both electric fields and magnetic fields may oscillate simultaneously and orthogonally, but only one can emerge as energy waves. One may expect energy waves from electric fields as well as energy waves from magnetic fields simultaneously from a source, but these two type waves cannot have same wavelength.

One example is waves obtained in Hertz experiment [2, 11], in which one may see light rays and experience radio waves simultaneously, but with different wavelengths. Maxwell equations guarantee orthogonal oscillations of electric fields and magnetic fields at a source, but never guarantee simultaneous wave propagation of both fields with *same* wavelength.

This fact can also be explained through theoretical formulae. It happens like this. An electromagnetic wave that has wavelength less than $1.063022744 \times 10^{-3}$ m (approximately) contains only electric field component and that one is produced from electric fields. An electromagnetic wave that has wavelength greater than $1.063022744 \times 10^{-3}$ m contains only magnetic field component and that one is produced from magnetic fields. These conclusions do not contradict Maxwell equations for electromagnetic wave. Moreover, there is no experimental evidence for observation of electromagnetic waves having both electric field component and magnetic field component with *same* wavelength. Let us call an electromagnetic wave that contains only electric field component as *electric field wave*, and an electromagnetic wave that contains only magnetic field component as *magnetic field wave*.

It is now possible to understand a black body, because heat conduction in a material is associated with movement of electrons in serial in all directions. A black body is an ideal physical matter that can absorb and emit all electric field waves with all possible wavelengths. A black body is considered as a body that emits "heat radiations". But heat radiations are electric field waves with "temperature", and electric field waves with temperature are heat radiations. This is an observation in view of movements of electrons along with the definition of "temperature of electromagnetic waves" to be stated later. All "heat radiations" are electric field waves and all electric field waves are heat radiations.

One more observation should be done based on this discussion. Stefan Boltzmann law can be applied for electric field waves. Temperature of electric field waves will be defined first and then temperature of magnetic field waves will be defined. An electric field wave with a particular wavelength may be radiated from a black body with temperature T_1, and a same wavelength electric field wave may also be radiated from a black body with a different temperature T_2. This means that it is not possible to associate the temperature of a black body with the definition of "temperature of an electric field wave". This fact will be taken into account while defining temperature of an electric field wave.

Let us now classify known electromagnetic waves. All visible light rays, non visible light rays, X-rays, gamma rays, ultra violet rays, and infra red rays are electric field waves. All radio waves, television waves for transmission, cell phone waves for transmission, and electromagnetic waves at the speakers of cell phones are magnetic field waves.

Electromagnetic waves at the speakers of cell phones may produce heat in our ears causing heat pollution (Figure 1).

One critical wave under classification is a gravitational wave. An energy wave with very long wavelength may be created when two mega size stars come closer to each other. There are teams which interpret that such a wave which travels with speed c in vacuum is created because of the gravitational forces between these two stars, by referring to a theory of Albert Einstein. So, the members call such waves as gravitational waves, even though there is no valid reason for involvement of gravitational forces, except the fact that gravitational forces are strong when the stars come closer to each other. But, one more reason is not even considered. The reason is that magnetic field forces of the stars may be strong when the stars come closer, and the energy waves may be produced by the magnetic fields.

Figure 1. Cell phone waves come with heat

That is, the energy waves should be magnetic field waves so that it should be an electromagnetic wave. There is a strong observational reason for this belief. When two stars are about to collide, magnetic fields should interact as a first incident, and then the matters of stars should have direct contact. So, magnetic field waves are expected at first, and then light waves or electric field waves are expected after a time period [1, 4, 12, 17, 18, 30, 31, 33].

This situation was observed in one event in 2017. Gravitational waves were observed at first in that event, and then a gamma ray burst was observed after a short time period. This event justifies that gravitational waves happened because of magnetic fields of stars. One more thing may also happen. Distance between two successive magnetic lines in a star increases with distance between the star and the magnetic lines.

That is, distance between two successive magnetic lines is very big when they are far away from the stars, and distance between two successive magnetic lines is small when they are near to the stars. Successive magnetic lines with very big distance should produce energy waves with very big wavelength, when two stars come closer. Successive magnetic lines with small distance should produce energy waves with small wavelength. T

hat is, successive magnetic lines with very big distance may produce gravitational waves when two stars come closer, and then successive lines with small distance may produce a fast radio burst [17, 18, 19, 30, 31, 33]. So, when two mega size stars come closer the following three things may happen one by one in the order: (a) gravitational waves production; (b) fast radio burst; (c) gamma ray burst. Only one thing among these three possibilities may happen; only two things may happen; all three things may happen; and same thing may happen again and again. The events (a) and (b) are production of magnetic field waves and (c) is a production of electric field waves. Ultimate conclusion is that gravitational waves are magnetic field waves so that they are electromagnetic waves, and well known electromagnetic waves have been categorized (Table 1).

Table 1. Classification of electromagnetic waves

Electric field waves	*Magnetic field waves*
Visible light rays	Radio waves
Non visible light rays	Cell phone waves
Ultra violet rays, Infra red rays, X-Rays	TV waves
Gamma rays	Gravitational waves

Heat radiations from a black body can be associated with electric field waves. Let us recall the intensity $u(\lambda)$ from the Planck's distribution law [6, 8, 25] given in the previous section:

$$u(\lambda) = \frac{8\pi hc}{\lambda^5}\left(e^{\frac{hc}{\lambda kT}} - 1\right)^{-1}.$$

This is an important distribution in theoretical physics. This is an exact distribution for which a mathematical derivation was given by Max Planck [25], without assuming theoretical assumptions (Like the assumption used for derivation of Lorentz transformation: No matter can exceed the speed c of light). It is possible to derive Wien's approximate distribution law from this Planck's distribution law. If $u(\lambda)$is also considered as a function of T along with λ, if a constant p is considered, and if a relation $\lambda T = p$ is considered, then the integral $\int_{p/T}^{\infty} u(\lambda)d\lambda$ is directly proportional to T^4 or to σT^4. Moreover, $\frac{d\,u(\lambda)}{d\,\lambda} = 0$ implies a relation $\lambda_{max}T = b$, known as Wien's displacement law.

These two things are interesting facts about the historical Planck's distribution. It was mentioned in the previous section about the application the second order derivative of $u(\lambda)$ in connection with temperature limits for non solidness and for energy forms. It was also mentioned that every material in our universe radiates when its temperature is above 40541400000 Kelvin. This is also a reason for a need to define temperature of electric field waves and to define temperature of all electromagnetic waves. Stefan-Boltzmann law [5, 16] derivable from Planck's distribution law plays a key role in defining temperature of electromagnetic waves. So, Planck's distribution law is important in this article in two aspects. One aspect is direct use in terms of Stefan-Boltzmann law, and another aspect is warning for clarity of the concept.

3. TEMPERATURE OF ELECTROMAGNETIC WAVES

Let us consider the following relations related with electromagnetic waves.

$$E = mc^2$$

$$E = h\nu$$

$$E = ⓗ\lambda$$

$$E = \sigma T^4$$

The first relation is not going to be used. A brief interpretation for this Einstein's energy mass relation is that if a matter with mass m becomes energy, then this energy is equal to mc^2. All the remaining three relations are needed in this article, and a common assumption for interpretations for the remaining three relations is that energy ray-wave comes from a point-source-object. The second relation is called Planck's equation. The energy released by a single-ray-electric field wave with frequency ν in one second is $h\nu$. This is the interpretation for Planck's equation for electric field waves. The third relation is called Planck equation for magnetic field waves.

The energy released by a single-ray-magnetic field wave with wavelength λ in one second is ⓗλ. The final fourth relation is called Stefan-Boltzmann law for thermal radiation, provided E is replaced by energy released per unit area per second in a black body radiation. So, this is applicable even for electric field waves which emerge from a point source, and in this case also let it be called as Stefan-Boltzmann law. So, let us have the following as an interpretation for this law. The energy released by a single-ray-electric field wave with "temperature" T in one second is σT^4. Thus, the temperature of an electric field wave has been defined indirectly.

Let us now define temperature of an electric field more directly. Let us consider an electric field wave with wavelength λ. Let T_λ denote the temperature of this electric field to define this concept. From the interpretations, it is possible to compare the second relation with the fourth relation.

$$h\nu = E = \sigma(T_\lambda)^4$$

$$(T_\lambda)^4 = \frac{hc}{\sigma\lambda}$$

$$T_\lambda = \frac{0.43259658615773 \times 10^{-4}}{\lambda^{\frac{1}{4}}}.$$

This one provides a formula for temperature T_λ of an electromagnetic wave with wavelength λ, when it is an electric field wave. For example, a gamma ray with wavelength 10^{-12} m has temperature $0.43259658615773 \times 10^{-1}$ Kelvin. An X-Ray with wavelength 10^{-10} m has temperature $0.43259658615773 \times 10^{-1.5}$ Kelvin. An infrared ray with wavelength 10^{-3} m has temperature $0.43259658615773 \times 10^{-3.25}$ Kelvin. These numerical calculations reveal that temperature of electric field waves are nearly equal to one Kelvin or less than one Kelvin. Usage of the unit "Kelvin" is meaningful in view of the assumption on radiation from point sources.

There is a need to discuss this temperature of electric field waves in comparison with temperature of a body which emits electric field waves at a particular point , say, P, in the body. Let T be the temperature at P at some time, and let $\lambda_1, \lambda_2, \ldots, \lambda_n$ be wavelengths of different light rays emitted from that point P.

Then T may be connected with $\lambda_1, \lambda_2, \ldots, \lambda_n$ and with $u(\lambda_1), u(\lambda_2), \ldots, u(\lambda_n)$ by means of a functional relation. One logical relation should be true. $T \geq T_{\lambda_i}$, for every $i = 1, 2, \ldots, n$. On the other hand, if different light rays with wavelengths $\lambda_1, \lambda_2, \ldots, \lambda_n$ reach a body at a point Q, then the temperature at this point should also depend on a functional relation which may connect $\lambda_1, \lambda_2, \ldots, \lambda_n, u(\lambda_1), u(\lambda_2), \ldots, u(\lambda_n)$, and the previous temperature at the point Q.

The definition for temperature of an electric field wave can also be given in terms of frequency of an electric field wave. For this purpose, let us consider an electric field wave with frequency ν. Let T_ν denote the temperature of this electric field wave to define this concept.

Then again

$$h\nu = E = \sigma(T_\nu)^4$$

$$(T_\nu)^4 = \frac{h\nu}{\sigma}$$

$$T_\nu = (1.03963 \times 10^{-6.5})\nu^{\frac{1}{4}}.$$

This one provides a formula for temperature of an electric field wave in terms its frequency ν. Both formulas give same temperature for an electric field wave under the consideration of the relation $\nu = \frac{c}{\lambda}$.

Let us now try to define temperature of a magnetic field wave. It is not possible to use the earlier arguments to define temperature of a magnetic field wave, because there is no formula for magnetic field waves corresponding to Stefan-Boltzmann formula meant for electric field waves.

An intermediate way to define temperature of a magnetic field wave is to begin with a comparison of the second relation with the third relation, as it was done in [21] to understand penetrating capacities. For this purpose, let us begin with an electric field wave with wavelength λ_e, and a magnetic field wave with wavelength λ_m. Suppose that these two waves have same energy so that λ_e depends on λ_m, and λ_m depends on λ_e. The dependence can be obtained from the relations

$$h\frac{c}{\lambda_e} = E = ⓗ\lambda_m$$

$$\lambda_m = \frac{hc}{ⓗ\lambda_e}$$

$$\lambda_e = \frac{hc}{ⓗ\lambda_m}$$

$$\lambda_e = \frac{1.129996 \times 10^{-26}}{\lambda_m}.$$

For a given magnetic field wave with wavelength λ_m, the relation $\lambda_e = \frac{1.129996\times10^{-26}}{\lambda_m}$ can be applied to find the wavelength λ_e of an electric field wave such that both waves have equal energy so that both waves have same penetrating capacity. On the other hand, for a given electric field wave with wavelength λ_e, the relation $\lambda_m = \frac{1.129996\times10^{-26}}{\lambda_e}$ can be applied to find the wavelength λ_m of a magnetic field wave such that both waves have equal energy so that both waves have same penetrating capacity. This argument was used in [21] to analyze penetrating capacities of magnetic field waves. Let us now extend this argument for finding temperature of a magnetic field wave.

Let us now consider a magnetic field wave with wavelength λ_m for this purpose. Let us find an electric field wave with wavelength λ_e by using the formula $\lambda_e = \frac{1.129996\times10^{-26}}{\lambda_m}$ so that both waves have equal energy. Since they have equal energy, they should have equal "temperature". Let us find the temperature T_{λ_e} of the electric field wave by using the formula $T_{\lambda_e} = \frac{0.43259658615773\times10^{-4}}{(\lambda_e)^{\frac{1}{4}}}$. Now the temperature T_{λ_m} of the given magnetic field wave with wavelength λ_m is defined as T_{λ_e} . Thus, for a given magnetic field wave with wavelength λ_m, for which its temperature has to be found, a corresponding electric field wave with wavelength λ_e is found in such a way that both waves have equal energy.

Then the temperature of the magnetic field wave with wavelength λ_m is defined as the temperature of the electric field wave with wavelength λ_e. Let us observe again that temperatures of magnetic field waves should be nearly equal to one Kelvin or less than one Kelvin, because temperatures of electric field waves should be nearly equal to one Kelvin or less than one Kelvin, in view of earlier numerical calculations.

4. FURTHER DISCUSSIONS

Let us use the notations used in the final part of the previous section. Then the following relations are true.

$$\lambda_m = \frac{\sigma}{ⓗ} \times T_m^4$$
$$\lambda_e = \frac{hc}{\sigma} \times \frac{1}{T_e^4}$$

For a given temperature of an electromagnetic wave, it is possible to find the wavelength of the electromagnetic wave, by using these relations. Moreover, for magnetic field waves, temperature increases with increase in wavelength, and wavelength increases with increase in temperature. For electric field waves, temperature decreases with increase in wavelength, and wavelength decreases with increase in temperature. For example, temperature of cell phone waves increases with increase in wavelength. Temperatures of X-Rays are greater than temperatures of infra red rays. To reduce the temperature of cell phone waves, frequencies of cell phone waves should be increased. Temperature of cell phone waves are less than one Kelvin. So, individual single-ray-cell phone wave may not harmful. But many rays of cell phone waves may release a huge amount of heat energy. Even for reduction of heat from many rays of cell phone waves, increase in frequency is necessary. For this purpose, alternating frequency of electricity used in production of cell phone waves should be increased. Increase in frequency of cell phone waves is necessary even to reduce the penetrating capacity. In addition to this one, many rays should be reduced to few rays to reduce heat energy. In view of discussions given in the second section, many rays of cell phone waves are produced by many simultaneous parallel electrons.

Thus, for reduction of many rays to few rays of cell phone waves, current used in production of cell phone waves should be reduced. Since rays are dispersed when they come from a cell phone tower, only few rays reach a man who is at a long distance from the cell phone tower. One more fact should also be taken into consideration. By using de Broglie law, it was established by the authors that the temperature measured by means of a thermocouple is directly proportional to the square root of the power produced or the square root of the product of current and voltage produced, in two book chapters, Mathematical analysis on power generation – Part I and II in a book Artificial intelligence for renewable energy and climate change. This implies that temperature increases as power used increases. So, there is a need to reduce voltage of electricity used to reduce temperature of cell phone waves. Regarding the cases of reduction of many rays to few rays of cell phone waves, one should not think about reduction of amplitude of cell phone waves. There is *no* actual concept of amplitudes for electromagnetic waves. Heat produced by radio waves cannot be compared with heat produced in electric induction stoves or with heat produced in a micro oven. This one needs an additional explanation. First observation is that the waves produced in a micro oven are not electromagnetic waves. Accelerated electrons in a micro oven hit objects or disturb electrons in objects to create heat. Oscillating magnetic field (not wave) produces eddy currents in vessels within the range-limit of an electric induction stove and thereby heat is generated.

What is a basic principle in production of heat by using magnetic field waves? Let us first begin with another question. What is a basic principle in production of heat by using electric field waves? Let a sunlight ray fall on a solar cell which is made up of mono crystalline silicon. This means that an electric field wave-ray falls on the solar cell. This electric field wave disturbs electric fields of electrons in silicon and makes electrons to move to get a potential difference. Let the sunlight ray fall on an iron plate. This electric field wave-ray disturbs electrons in the plate, and tries to move electrons with a failure, which leads to a heat generation. The same sun also produces magnetic field waves [14, 32]. How?

When there is a current flow in a metallic wire, there is a movement of electrons along a direction of the wire; and then the envelopes of moving electric fields of moving electrons create magnetic fields. When a material moves in a straight line with a high speed, then the electrons in molecules of the materials also move in a straight line and these movements of electrons create magnetic field. This is applicable for self rotating bodies [22] so that self rotating planets and stars do have magnetic fields [28]. This is applicable even for movements of magma in the interior of the earth so that there may be small variations in magnetic field of earth at some places. This is applicable even for gas-flows on the sun to produce non uniform magnetic fields on the sun [14, 32]. If there are two nearby gas-flows on the sun, two different magnetic fields may be created, and interaction of these two magnetic fields may create magnetic field waves which may reach our earth. This situation may happen on any gaseous stars and the stars may send magnetic field waves. That is, many fast radio bursts may happen on a gaseous star [19]. Let us consider magnetic field waves produced on the sun and sent to the earth.

These magnetic field waves may also create very small amount of heat on the bodies on the surface of our earth. To create heat on a body by means of an electric field wave, there is a need for electric field inside the body so that that electric field can be disturbed by the electric field wave. Similarly, to create heat on a body by means of a magnetic field wave, there is a need for magnetic field inside the body so that magnetic field can be disturbed by the magnetic field wave. Certainly if there is a free flow of electrons in a body, then there is a chance to have magnetic field inside the body. Certainly, body of a living human has magnetic field inside the body, and hence the magnetic field waves from the sun can cause a small amount of heat generation in the body.

So, magnetic fields on the sun may heat living beings on the earth. In particular, cell phone waves from receiver speaker along with variations in magnetic fields may heat ears. This is considered as heat pollution. Sunlight can be used to heat objects easily, because they all do have electric field inside. But there is a need for research for finding materials to draw heat from magnetic field waves of the sun, when materials are not connected with an alternating current source.

It should be noted that alternating current connected with an antenna has varying magnetic fields and these magnetic fields are affected by magnetic field waves. There should be electric power cable parallel to the two metal arms of a LIGO and there should be alternating current power supply in the cable. There should be a very small unpredictable amount of magnetic field in the metal arms because of the power cable. Gravitational waves (which are magnetic field waves) disturb this magnetic field of the arms to create heat and to change lengths of arms. That is, gravitational waves can change the lengths of the arms in a LIGO. LIGO technical teams have designed their instruments to provide graphical output for gravitational waves based on changes in length of arms [3].

So, a LIGO can observe gravitational waves, which are magnetic field waves with wavelengths about 2000 meters. Fortunately, gravitational waves last only for milliseconds, because they do have penetrating capacity. Magnetic field waves with high wavelength from sun are harmful to human beings, because there is a chance for penetrating skin. It is known to some extent about penetrating capacities of electric field waves like gamma rays, X-Rays etc, with small wavelengths [7, 9, 13, 15, 27]. If λ_m is a big wavelength of a magnetic field wave, then one can find an electric field wave with small wavelength λ_e by using the formula $\lambda_e = \frac{hc}{ⓗ\lambda_m}$. Then the magnetic field wave with wavelength λ_m has the penetrating capacity that is equal to the penetrating capacity of the electric field wave with wavelength λ_e. This is the reason to reduce wavelength of magnetic field waves to avoid harmfulness to human body. However, long wavelength magnetic field waves are required for underwater-medium communication, because the waves have to penetrate water. Somewhat long wavelength magnetic field waves are being used to communicate submarines from ground level. Moreover short electric field waves and long magnetic field waves can be used to kill unwanted germs and bacteria.

5. CONCLUSIONS

There are exactly two types of electromagnetic waves. One type is electric field waves which are generated from electric fields, and another one type is magnetic field waves which are generated from magnetic fields. All light rays are electric field waves so that they are electromagnetic waves. Gravitational waves are magnetic field waves so that they are also electromagnetic waves. It is possible to define temperature for these two types of electromagnetic waves. These temperatures are nearly equal to one Kelvin or less than one Kelvin. For electric field waves, temperature increases with decrease in wavelengths. For magnetic field waves, temperature increases with increase in wavelengths. Short electric field waves and long magnetic field waves are harmful to all living beings. To reduce heat pollution from cell phone waves, the following three controls may be considered. First priority should be given to increase frequency for alternating electricity being used for production of cell phone waves. Second priority should be given to reduce current in electricity being used for production of cell phone waves. Third priority should be given to reduce voltage in electricity being used for production of cell phone waves. There is a need for research in finding materials that can be used to generate heat from magnetic field waves. All electromagnetic waves generate heat in bodies of all living beings. This should always be considered while generating electromagnetic waves.

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