.

SEEBECK EFFECT SHOWS PHOTON ENERGY CURRENT WITHIN CURRENT-CARRYING CONDUCTORS.

CHAN RASJID KAH CHEW

24 October 2023

Abstract. If a piece of conducting material has a temperature difference between its two ends, an electromotive force is observed between the ends with the hotter end being positive and the other negative. This is the Seebeck effect. The emf is dependent only on the temperature difference and the type of conductor material. Current physics only mentions the emf of the Seebeck effect, but has ignored another significant fact about the Seebeck effect. Besides the observed emf, the Seebeck effect causes a radiation energy current flow within the conductor from the hotter end towards the cooler end. The operation of a thermocouple electric cell relies on the Seebeck effect. An analysis the operation of such a cell shows that energy transmission by current-carrying conductors has nothing to do with the magnetic fields surrounding the conductor; the actual physical mechanism of energy transmission is by photon energy current within the body of the conductor.

1. Introduction.

(Note: The concept of an apulse comes from the author's earlier aether paper[2]. It is an aether wavelet of exactly one wavelength - a quantum of light similar to the photon. In this paper, an apulse is treated the same as a photon)

The aim of this paper is to examine the working of a thermoelectric cell based on the thermocouple. An analysis of how such a thermoelectric cell drives an external electrical load would show that energy transmission by current-carrying conductors has nothing to do with the magnetic fields surrounding the conductors. The actual physical mechanism of energy transmission of current-carrying conductors is by radiant(photon) energy current within the very conductor.

Key words and phrases.

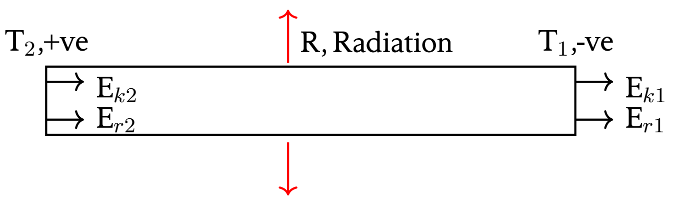

Figure 1. Seebeck Effect.T_2 is the hot junction, a heat source. T_1, a heat sink, is at room temperature

2. The Seebeck Effect

The Seebeck Effect was discovered by German physicist Thomas Johann Seebeck(1821). If a temperature gradient is established in a length of conductor, an electromotive potential is established between the ends of the conductor. This is termed the Seebeck Effect.

The effect could easily be explained with our current understanding of the nature of metals. A piece of solid metal has a cloud of free electrons within its body. A simplistic treatment may consider the free electrons as particles within a container obeying the kinetic theory of gases. The temperature gradient within the metal would result in the electron density increasing towards the cooler end. This would result an emf between the ends with the hotter end being electrically positive and the cooler end negative.

Figure 1 shows a piece of metal maintained with a steady state temperature gradient with the ends at temperature $T_2, T_1, T_2 > T_1$ and T_1 is at room temperature. To maintain the steady temperature gradient, there need to be a thermal heat flow from the hot end towards the cooler end supplied from an external heat source; without a heat source, the steady temperatures T_2, T_1 cannot be maintained. In the situation under our consideration, the thermal energy flow consists mainly of transfer of kinetic energy and radiant energy within the conductor. The two energy flow may be described as energy currents E_{k2}, E_{k1} and E_{r2}, E_{r1}.

The kinetic energy current E_{ki} is due to the molecular vibrations of the atoms of the solid. This is the main component of heat conduction. We may assume the hot end of the metal is heated with an open flame and the cooler end is a heat sink dissipating the heat flow. The kinetic component of heat is transferred from the flame to the metal through mechanical collision with the hot air molecules; this exchange of energy would propagate towards the cooler end. As the temperature gradient is at a steady state, there cannot be any accumulation of kinetic energy within the conductor. What kinetic energy that flows from the heat source must be fully dissipated at the heat sink with some heat loss dissipated to the air surrounding the conductor.

Classically, a solid body is almost 100% empty space; space is either "empty" or filled with the aether as with the author's aether SUT theory [2]. What is known is that the universe is a sea of radiation. The sun radiates energy. It is mainly radiations that energy reaches the earth and is absorbed by matter earth. All objects (temperatures above 0°K) radiates energy. The radiations within the body of a solid is no different from the radiations in the universe; the only difference may be said to be the origin. The suns energy comes from fusion and is dissipated mainly as radiations. Within the solid, electrons absorb or emit photons all the time. This is what is called thermal radiation of condensed matter. At ambient temperature, the radiations is mainly in the infrared spectrum.

In the situation as depicted in Figure 1, the conductor body is losing radiant energy to its surrounding as it is assumed the conductor temperature is above that of room temperature. It is also assumed that the temperature gradient of the

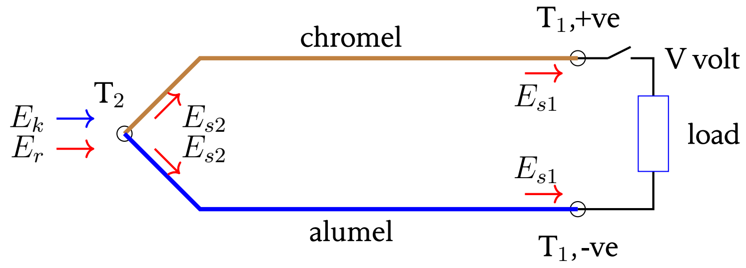

FIGURE 2. Chromel-alumel thermocouple. T_2 is the hot junction, T_1 is at room temperature. Energy currents E_k, E_r resulting from heat source. Radiant energy current $E_r = 2E_{s2}$.

conductor is at a steady state; this means there cannot be any average change in photon density within the conductor. As thermal radiant energy is dissipated fully across the conductor length: $R = E_{r2} - E_{r1}$. If T_1 is at room temperature, then $E_{r1} = 0$. This shows that the Seebeck emf is always accompanied by a radiant energy current of photons.

> *The Seebeck emf is always accompanied by a photon energy current within the conductor body.*

3. The Thermocouple As An Electric Cell.

The thermocouple may be used as a thermoelectric cell which converts heat energy into electrical energy that drives an external load. Figure 2 shows a schematic diagram of such a typical cell.

A thermocouple consists of two dissimilar metals joined at one common junction kept at a temperature T_2. The other open ends are kept at a reference temperature T_1. In its operation as a thermoelectric cell, T_1 may be considered at room and T_2 at an elevated temperature. The hot common junction T_2 is the source of heat that supplies energy to the cell. In order to maintain its emf, a heat source input is needed even if the cell is in open circuit.

The relation between the Seebeck emf of a conductor and its temperature difference may be expressed as:

$$E_a = \alpha_a \triangle T; \tag{1}$$

E_a being the Seebeck emf, α_a the Seebeck coefficient for the conductor A, $\triangle T$ the temperature difference. The Seebeck coefficient is a property of the conductor material.

The two metals of a thermocouple are chosen to have the greatest possible difference in their Seebeck coefficients. A common alloy pair is chromel (90% nickel, 10% chromium) and alumel (95% nickel, 2% manganese, 2% aluminium, 1% silicon). In Figure 2, for chromel with α_c, and alumel with α_a, The voltage difference V is :

$$V = E_a - E_c = (\alpha_a - \alpha_c)\triangle T; \tag{2}$$

3.1. **Thermocouple In Open Circuit.** When the thermocouple cell is in an open circuit, the energy currents E_k, E_r would be similar to what is explained in the Seebeck effect of Figure 1. E_k is the kinetic energy flow component needed to maintain the steady temperature gradient. The currents E_{s2} are the accompanying photon currents to the open circuit voltage V, $E_r = 2E_{s2}$. The current E_{s1} would be zero as the radiant energy would be fully dissipated through thermal radiation loss to the surrounding air.

3.2. **Thermocouple In Closed Circuit.** In a closed circuit, the heat source must be increased to supply the additional power needed to drive the external load. The current E_k would be the same whether the circuit is open or closed; this is so as the temperature gradient would be the same in both situations (ignoring any slight i^2r loss within the thermocouple). This would mean that the extra power need, P_l, may only be supplied through an increased radiant energy current E_r. As noted, $E_{s1} = 0$ in an open circuit. In a closed circuit, $E_{s1} = P_l/2$.

4. How Energy Is Transmitted Through Current-carrying Conductors.

In a closed circuit, the thermocouple is supplying electrical energy to drive an external load. As its source of energy is heat, it is converting heat energy to electrical energy and transmitting the energy through current-carrying conductors. The question that this article is trying to address is how electrical energy is transmitted through current-carrying conductors. The physical mechanism of transfer should be the same for all electrical cells, whether the cell is a thermocouple or a chemical cell. It should even be the same for alternating current generators.

With the thermocouple in operation supplying power P_l, the radiant energy current at T_2 is E_{s2}; at the the ends T_1, the radiant current is $E_{s1} = P_l/2$. E_{s1} is the amount of radiant energy photon leaving the thermocouple connectors connecting to the load. The energy that the load needs is directly carried in the photons of E_{s1}.

4.1. **Energy Transmitted Through Magnetic Fields.** The explanation of current electromagnetism is that electrical energy is transmitted through the magnetic fields surrounding current-carrying conductors. In our closed circuit thermocouple, it would mean the photons of E_{s1} would somehow be transformed into a form suitable to be transmitted by the magnetic fields. Current electromagnetism has no explanation how physical photon entities be converted and be carried through the magnetic fields surrounding the conductor wires. The photons of E_{s1} has only two pathways to go, either to be directed into the magnetic fields or be absorbed by matter; a photon may release its energy only when it relinquishes its existence - there is no third way. Current electromagnetism admits of neither.

4.2. **Energy Transmitted Through Photon Current Within Conductors.** The logical argument would be that the photon currents E_{s1} simply continue its path through metal conductors, leaving the conductors of the thermocouple and entering the conductors connecting to the load. There is no strong argument that radiation photons could traverse the thermocouple conductors and yet be stopped from entering the current-carrying conductors.

> *Current-carrying conductors transmit energy through photon energy currents within the conductors.*

The Seebeck effect shows this explanation in a rather explicit manner. To find any acceptable counter argument to it seems improbable.

This explanation, too, is consistent if the electric cell is a chemical cell. Chemical cells convert chemical energy into electrical energy. The chemical energy comes from the chemical binding energies of the relevant chemical interactions and these comes from changes in the electrons energy configuration when energy is released. Fundamentally, exothermic chemical reactions release energy as photons and these would leave the cell terminals as energy currents entering the current-carrying conductors.

It may seem that this explanation of photon energy current may face some difficulty when it comes to the AC alternator generating electrical power. A typical alternator in a power station has the rotor as the magnets and the armature windings as the stator. The current explanation of the alternator is through Faraday's law of electromagnetic induction. The rotation of the rotor magnets converts mechanical energy to electrical energy. The energy of mechanical work produces the electromotive force that causes currents to flow through the armature supplying electrical power to the external load.

If electrical energy is carried through photon currents, then the armature windings must be supplied with photons. If the photons originate in the armature winding itself, then there must be an external source of energy so that the atoms of the armature could absorb and re-emit photons continuously. The current theory is that all of this is taken care of through Faraday's law of electromagnetic induction.

An alternative explanation would be that the originating photons come from the rotating rotor magnets and jump the air gap (the aether) and enter into the armature windings providing the photon energy current. If indeed energy in conductors is through photon currents, then this phenomenon is found in the way a transformer works. All power stations need to step up the transmission voltage using step-up transformers. As the primary and secondary windings are separated, the photons from the primary windings could only leave it by jumping the air gap, traveling through the soft iron core and entering into the secondary windings. The photon current would then flow to its destination hundreds of kilometers away. That the originating photons comes from the rotating magnet is the more probable explanation. The mechanical work in moving the magnets is the source of energy producing the photon currents.

5. When The Magnetic Field Becomes Superfluous.

Before the development of the concept of the magnetic field based on the Biot-Savart Law, there were two competing experimentally derived force laws on the force interactions between two current elements. There was the Ampere's law (1823) and Grassmann's law (1845). In most situations, the two laws were in agreement except for the case of collinear current elements where the force was zero for Grassmann's and non-zero in Ampere's.

The Biot-Savart law for the magnetic field due to a single current element is based on the Grassmann's law. The Lorentz magnetic force law would then extend Grassmann's law by giving the force that a current element would experience in a magnetic field. There cannot be a similar field concept that could be derived from the Ampere's law. Because of the ease of analytical integration of fields with vector calculus, the current magnetic field approach was finally accepted. The Ampere's law has been largely relegated to the annals of history not because it has been discredited, but because Maxwell's theory based on the magnetic field has become universally accepted.

There is one more critical difference between Grassmann's law and Ampere's law. The Grassmann's law violates Newton's third law while Ampere's law is in agreement with the third law! Although some have argued that the violation of Grassmann's law with Newton's third law does not invalidate electromagnetism based on the magnetic field, the author takes a different view. It is because of this violation of Newton's laws of motion that Maxwell's equations is not Galilean invariant. A new Lorentz invariance has to be invoked to fit Maxwell's theory. The author's paper [3] shows clearly our physical reality does not compromise on Galilean invariance. A physical theory consistent with the reality that the human faculties can comprehend may only be be Galilean invariant. Maxwell's theory, though it has helped us to understand that light has a electric and magnetic origin, is not fundamentally a valid physical theory. A valid electric theory that is Galilean invariant needs to be urgently developed if our understanding of our physical world is to reach higher levels. Our current theoretical physics has indeed brought us to many levels further, but only in the realms of fantasies having no relation with the world of reality that the Good Lord has created us to comprehend and live in.

The introductory textbooks show how the force between two infinitely long parallel conductors with separation distance R could be computed by finding how one conductor acts on a length element dl in the other:

$$F_{dl} = \frac{\mu_0}{2\pi R} I_1 I_2 dl \tag{3}$$

It is done by computing the magnetic field of one conductor with current I_1 on the element dl in the other conductor and then applying the Lorentz magnetic force law: $\mathbf{F} = q(\mathbf{v} \times \mathbf{B})$.

The form of Ampere's law in modern notation is:

$$\mathbf{F_{12}} = -\frac{\mu_0}{4\pi}\frac{I_1 I_2}{r^2}\hat{\mathbf{r}}[2(d\mathbf{l_1} \cdot d\mathbf{l_2}) - 3(d\mathbf{l_1} \cdot \hat{\mathbf{r}})(d\mathbf{l_2} \cdot \hat{\mathbf{r}})] \tag{4}$$

It is only a force law between two current elements. By applying Ampere's law and doing a simple integration, the exact same formula (3) is derived. What is significant is that there is not a need for the concept of the magnetic field. The magnetic force is nothing other then the forces between charges when they have relative velocities. Such "magnetic" forces could be found in the more general Newtonian electrodynamic force law, the Webers force law [4].

It should not be surprising,too, that there is not a need to invoke the Poynting's theorem and the magnetic field to explain how energy is transmitted through current carrying conductors; the concept of the magnetic field is superfluous.

> *Energy is transmitted by current-carrying conductors through photon energy currents within the conductors and not carried in the magnetic fields surrounding the conductors.*

6. Conclusion.

Our analysis of how the thermocouple works as a thermoelectric cell shows rather explicitly that energy transmission by current-carrying conductors does not rely on the magnetic fields surrounding the conductors, but rather directly due to the flow of radiation photon currents within the conductors; the photons are absorbed and re-emitted along the path of the conductors. It is likely the magnetic field is just a superfluous mathematical construct that represent no physical reality in our natural physical world.

References

[1] A.K.T. Assis. Weber's Laws and Mass Variation. http://www.ifi.unicamp.br/~assis/Phys-Lett-A-V136-p277-280(1989).pdf

[2] Chan Rasjid. Coulomb Electric Gravity And A Simple Unified Theory (SUT). https://vixra.org/abs/1808.0211

[3] Chan Rasjid. The Lorentz Transformation Cannot Be Physical. https://vixra.org/abs/1501.0156

[4] Christof Baumgärtel and Simon Maher. Foundations of Electromagnetism: A Review of Wilhelm Weber's Electrodynamic Force Law. Foundations 2022, 2, 949–980. https://doi.org/10.3390/

Email address: `chanrasjid@gmail.com`
URL: `http://www.emc2fails.com`

Singapore