Basic Electricity And Photon Energy Current

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Abstract

There is great misconceptions and confusion about how energy is transmitted by electric currents.The electric current carries no energy. It is the photon energy current within current-carrying conductors that transmits electrical energy. The magnetic fields surrounding current-carrying conductors play no part in electrical energy transmission. A simple classical derivation of Ohm's law is given. The working of the Zn/Cu Galvanic cell is examined; it is shown to be a photon generator.

Glossary: photon. The term photon is here used to mean an apulse in the author's aether SUT theory [1]. All radiations are aether apulses; an apulse is a single electric polarization wave of the aether of exactly one wavelength. It may be treated as the quantum photon.

1 Introduction.

There is great misconceptions and confusion about how the electric current carries energy. This confusion is not confined only to the common folk, but happens even within the physics academia, with physicists and electrical engineers holding doctoral degrees. The common misconception is that electricity, specifically the electric current, carries electrical energy. This is wrong. Even thought the electric current involves physical electron drifts within a conductor, it transmits no energy. This indeed would be surprising given that our daily electrical appliances rely on the electric current that comes from our home power supply. This paper offers a rigorous argument as to why the electric current does not transmit energy. Though the electric current does not transmit energy, it accompanies every transformation of electrical energy to other forms or when *'electricity'* does work.

The author has two earlier papers [2, 3] which propose that current-carrying conductors transmit energy through photon energy currents within the conductor itself and not through the mediation of the magnetic fields surrounding the conductor as what is currently taught in schools. In a section below, an argument in greater detail would be given to refute the the mainstream explanation based on the magnetic field invoking the Poynting's theory. This paper also explains the working of a typical Galvanic cell which favors the argument for the photon energy current concept.

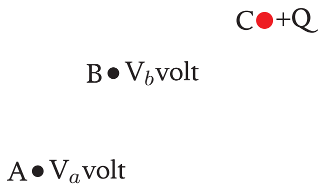

Figure 1: Coulomb electric potential at points A, B of charge C.

2 The Electric Current Transmits No Energy.

In the author's aether Simple Unified Theory(SUT)[1], our universe is fundamentally electric in nature. The only material of the universe is the electrical charge with states of either positive(+) and negative(-). The material of the aether may be considered to be a superposition of equal positive and negative charge densities. The basic SUT theory (currently) assumes matter is formed only from atoms that are composed of only protons and electrons. The neutron is just another state of hydrogen ^{1}H. There is only one universal force in nature and it is the Coulomb electric force. SUT dismisses the notions of the nuclear strong force and the electro-weak force.

There are only three forms of energy in nature, viz the Coulomb potential energy, kinetic energy and radiations(waves in the aether). What is commonly referred to as electrical energy is in fact the Coulomb electric potential energy. It will be shown that the way electrical energy is transmitted through conductors is that the energy source would transform the potential energy into photons which enters the conductor as an energy current flow. The photon is the actual physical carrier of electrical energy. More details would be shown in the later sections.

The electric potential is defined based on the Coulomb's law. The Coulomb potential V_e at a point distance r from a charge Q would be given by:

$$V_e = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}$$

where ϵ_0 is the permittivity of free space.

Figure 1 shows a typical case as to how changes in electric potential energy comes about. It shows two points A, B with potentials of V_a, V_b about a positive charge of Q at C. A charge of $-q$ at A has a greater potential energy then a charge of $-q$ at B. If a charge of $-q$ moves from point A to point B, traversing whatever paths, there is a loss of potential energy given by:

$$E_p = -q(V_b - V_a); \tag{1}$$

E_p being negative indicates a loss of energy in the change in position of the charge $-q$. As energy is conserved, the lost potential energy is either transformed to kinetic energy or dissipated as radiations or photons.

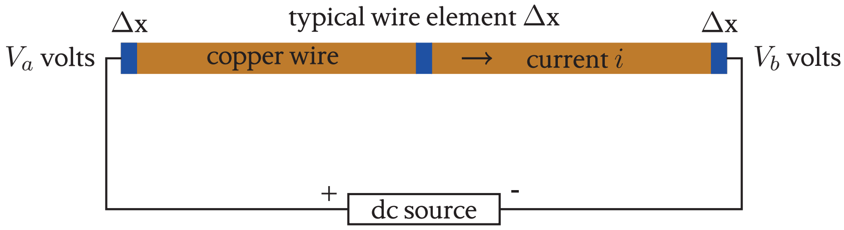

Figure 2: A constant voltage DC source across a long wire.

Figure 6 shows a typical case of a constant DC voltage source connected to a resistive load which is a long wire; the voltage may be that from a battery. The middle Δx is a typical element of the wire. With a constant voltage difference across the wire, the current i(assuming conventional current with positive free charges) is constant throughout the length of the wire. As the amount of charge entering the element Δx is the same as the amount of charge leaving the element, the amount of free charge q in the element Δx is a constant. As the electric potential ϕ at Δx is also a constant, the potential energy of q in Δx is given by:

$$E = q \times \phi \tag{2}$$

The equation (2) applies for any infinitesimal element Δx of the conductor. The integral sum: $\int (q \times \phi)\Delta x$ for the whole wire would give a constant amount of potential energy carried by the free charges within the wire. The conclusion here is that the electric current flow in the wire does not change the total potential energy of the free charges of the conductor wire.

It can easily be shown that the electric current flow also does not change the total kinetic energy of the conductor wire. Assuming that the wire is at a thermal equilibrium with the environment, the internal kinetic energy of the conductor due to the lattice vibrations is a constant. As the average drift velocity of the free electrons in the conductor is a constant, its contribution to the kinetic energy of the conductor, too, is a constant. The conclusion here is that the electric current flow in the wire does not change the total kinetic energy of the conductor wire.

In the circuit of Figure 6, it may be shown that the DC power source is supplying energy to the conductor wire as Coulomb potential energy as derived earlier with equation (1). The rate of charge flow into the left element Δx is $\frac{\Delta q}{\Delta t}$. The rate of charge flow out of the right element Δx is also $\frac{\Delta q}{\Delta t}$. As the potential energy of Δq at the left element is $\Delta q V_a$ and that at the right is $\Delta q V_b$, the rate at which the total potential energy changes due to the current flow is:

$$\frac{\Delta q}{\Delta t}(V_b - V_a); \tag{3}$$

With conventional currents, $\Delta q > 0$ and $(V_b - V_a) < 0$. This gives a negative rate change in potential energy due to the current flow. The equation (3) represents the rate at which the source is supplying power to the load. It is equation (3) which gives us the familiar power equation:

$$W = IV; \tag{4}$$

If the source is a battery, the voltage and current would be steady in the short term. This would mean that the source would be replenishing the energy loss as long as the current is flowing; the source supplies energy as what the load demands. A comparison may be made if the source is a charged capacitor; in this case the current will stop after the capacitor has fully discharged its stored potential energy. The battery, on the other hand, is a dynamic source of electrical energy; it converts energy stored in its chemical constituents to electrical potential energy *'on demand'*.

Figure (6) illustrates the typical situation where an energy source would supply energy to the load if it is connected to the source through electrical conductors. An electric current would then flow whose value would depend on the resistance of the load. The reason why electric current flows across a conductor which has a voltage difference is the principle of nature seeking a minimal - the minimal energy principle in this case. The free electrons would move from a higher potential energy seeking a lower energy states just as water flows downwards; thus the electric current.

As energy is conserved, the input energy must either be stored or dissipated. It has been shown that the conductor wire has no increase in kinetic energy. Also, the potential energy of the free electrons in the conductor remains steady. By energy conservation, the only way the supplied energy enters into the conductor without changing the kinetic energy of the conductor and the potential energy of the free electrons would be for the potential energy being transformed into photons entering the conductors as an energy current.

> *The physical mechanism of energy transmission by a current-carrying conductor is through photon energy flow within the conductor. The electrical energy source transforms Coulomb potential energy fully into photons that flows into the conductor. The energy conversion is triggered by the electric current flow in the conductor.*

As mentioned earlier, there is a great misconception as to how electric current transmits energy. Mainstream electric circuit theory rarely mentions that the energy implied in equation (4):$W = IV$ is Coulomb potential energy. Most texts in electromagnetism would introduce the idea that electrical energy is transmitted by current-carrying conductors through the magnetic fields surrounding the conductor, invoking the Poynting theorem. There is no clarification as to how electrical energy, specifically the Coulomb potential energy, could be transferred to the magnetic fields and transmitted hundreds of miles away by high voltage cables.

2.1 The Photon Current Within The Conductor

The idea that energy is carried by photons within current-carrying conductors should not come as a surprise. We know that all photons(ignoring gamma ray emission from nuclear interactions) are emitted by bound orbital electrons in atoms when they fall from higher energy states to lower states. The photons generated travel across empty space (the aether) until they meet with matter when they may be absorbed by the orbital electrons of atoms. This is how energy from the sun reaches the earth through radiations.

The bulk of solid matter is almost 100% empty space. Within a solid, the nucleus of atoms or molecules occupy the lattice nodes. The nucleus may classically be considered as point particles having almost no volume. The space within matter is no different from the space in outer space which is basically empty - empty of atoms. Although space is empty, it is never empty of photons. Photons fill all of space, whether it is outer space or the space within solid matter. Within matter, a photon may meet and be absorbed by an atom and then the atom may re-emit another photon. It is this absorption/re-emission of photons within matter that is the actual mechanism of energy transmission within current-carrying conductors.

> *The photons entering a current-carrying conductor may be viewed to traverse the conductor through the process of absorption/re-emission by the lattice atoms.*

All body above absolute zero emits radiations. This is because the atoms and molecules are never at absolute rest, but vibrates about their mean positions. This vibration constitutes the heat energy of the body; it is this thermal energy that causes the emission of radiations. The rate of radiation increases with the body's temperature. At room temperature, the radiation is mainly in the infrared range, 25 micron - 2.5 micron.

In general, as a free body emits energy through radiations, it is also absorbing radiations from its surrounding environment. If the body's temperature is uniform and steady over time, ignoring heat conduction and convection(as in a vacuum), the rate of radiation absorption is equal to its rate of radiation emission.

If a long wire is connected to a battery, the temperature of the wire would initially rise when atoms absorb energy. When its temperature reaches a steady state, all of the energy supplied to the wire would be fully dissipated as net infrared radiation loss and heat conduction and convection losses. It has been shown above that the energy supplied is all photons giving rise to an energy current entering the wire. It would be shown in a later section that an electrochemical cell is fundamentally a photon generator(this is actually true of all electrical power generators including AC alternators - they generate photons). In the case of a battery, the photons generated would fill the body of the battery and enters the conductor wires through both terminals. For simplicity, the energy current may be assumed to flow in at one end and its value is zero at the other end.

2.2 Rate Of Radiation Loss Along Conductor Length.

Within the conductor, a photon may leave the body without being absorbed or it may be absorbed by a lattice atom. It may be assume that, on average, a photon would be absorbed after traveling a distance of d. As the lattice spacing of solids is in the order of 1Å, we may make a wild guess of $d = 500\text{Å}$. If a photon is absorbed, the direction in which another photon would be emitted may be assumed to be random. If a photon is absorbed at the conductor surface, the probability that it would leave the conductor is about 0.5. For photons within a distance of d from the surface, the probability may be $\alpha < 0.5$. For a cylindrical wire of radius r, the probability that a photon is within the surface d layer is about $2d/r$. So the probability p that a photon would leave the conductor body is: $p = 2\alpha d/r$. For aluminum core steel-reinforced high power transmission line, the radius may be 5cm. Assuming $\alpha = 0.3$, $d = 500\text{Å}$, the probability is:$p = 2 * 0.3 * 500/10^{10}/0.05 = 6 \times 10^{-7}$. The observation is that most photons deeper within the conductor would be absorbed and re-emitted by the lattice atoms without leaving the conductor body.

If we trace the photon transmission path, the speed of transmission would be near light speed, but less, if it is assumed there is a delay in absorption/re-emission. If it is assumed the direction of re-emission is random, then the path of transmission takes on the typical characteristic of a random walk. The nodes of the path would have the greatest probability to be near the origin of transmission based on the normal distribution.

Initially when the source photons enters one end of the conductor, the photon density would be greatest at the source end and it decreases along the conductor length as some power is loss due to surface radiation loss; the energy current would thus lose intensity along the conductor length. If it is assumed that the conductor has achieved a steady uniform temperature, then the rate of power loss per unit length is uniform along the conductor's length as the rate of radiation is a function of its surface temperature. Thus, the radiation loss is uniform along the conductor's length. As the rate of radiation loss is equal to $\dfrac{\Delta v}{\Delta x} i$, the rate of voltage drop along the conductor's length is also uniform.

Assuming a steady uniform conductor temperature, there is now the following observations for a current-carrying conductor with a uniform cross-section and of homogeneous material:

1. *the radiation loss per unit length of conductor is constant.*

2. *The voltage drop is linear along the length of the conductor.*

2.3 Energy Transmission With Alternating Current.

The above analysis has been done based on direct currents, but there is no reason why the conclusions about photon energy current being the physical mechanism of electrical energy transmission should not apply for alternating currents.

For direct currents, the energy source is commonly the battery. For alternating currents, the source is the alternator that works based on electromagnetic induction. The alternator has two main parts: the stator and the rotor. For power station alternators, the stator - the stationary part - is usually the copper armature windings that connects to the primary windings of the step-up transformer. The rotor is the magnets that revolves around the stator.

The photons come from within the rotating magnets that jump across the air-gap entering the copper armature windings. This is the photon energy current source for alternating current generations. As usual, the transmission of energy by alternating currents is still through the photon energy current originating from the power station alternator that flows to a distant destination that may be hundreds of kilometers away. The fact of the voltage changing directions periodically does not affect the direction flow of the photon energy current.

3 Simple Classical Derivation Of Ohm's Law.

> *Ohm's law states that the constant voltage V across a conductor and the constant current I in the conductor obey the relation* $I = \frac{V}{R}$*; R being a constant, the resistance of the conductor.*

Although Ohm's law is not a precise statement, many conductors obey it through certain degree of accuracy and certain ranges of voltages, currents and temperature. It is still an important empirical law in circuit theory.

The derivation here is made simple by assuming a metal conductor of a uniform cross sectional area A, length l of a homogeneous metal element. Let's have the following parameters:

- V is the constant voltage across the conductor.
- I is the constant current in the conductor.
- A is the uniform cross-sectional area.
- l the length of the conductor.

- d is the number of free conduction electrons per unit volume.
- E is the electric field within the conductor.
- v is the average drift velocity of the conduction electrons.

It may be assumed that the free electrons move randomly following a random walk. On average, there is a drift velocity. Our model assumes every free electrons to be evenly distributed in the conductor and each moving with the same constant velocity v(v is very small in the range of millimeter per second).

We have proved earlier that the voltage drop in the conductor is linear so that the electric field E within the conductor is uniform: $E = \frac{V}{l}$. The electron drift v is a function of E as the force acting on each electron is $F_e = eE$; e being the electron charge. It is further assumed that there is a resistance to the drift of the electrons and that a constant drift velocity is reached when the force of action is equal to the friction reaction. It is assumed that the frictional reaction is proportional to the drift velocity v; thus:

$$e\frac{V}{l} = Kv \tag{5}$$

K being the constant of proportionality dependent on the conductor material. The current I is given by the formula:

$$I = dAve \tag{6}$$

Substituting v from equation(5) to equation (6), we have the following:

$$I = \frac{de^2}{K}\frac{AV}{l} \tag{7}$$

The value $\frac{de^2}{K}$ is termed the conductivity of the material and its inverse is termed its resistivity symbol ρ; $\rho = \frac{K}{de^2}$. ρ is dependent solely on the nature of the conductor metal. The resistance of the conductor R, a constant, is given by: $R = \rho\frac{l}{A}$. Substituting to equation(7) gives

$$I = \frac{V}{R} \tag{8}$$

This completes the proof of Ohm's law.

3.1 The Magnetic Field Not Fundamental.

Current electromagnetism invokes the Poynting theory to explain how current-carrying conductors transmit energy through the magnetic fields surrounding the conductor. It may easily be shown to be wrong. The main reason is that the theory relies on just the mathematical constructs of the electric and magnetic fields. The fields, especially the magnetic field, are not fundamental entities in physical nature. The truly fundamental entities in mechanics would be charge, space and time. The status of the fields in physics are just secondary to the fundamental physical dimensions of nature.

It should be noted that the definition of the magnetic field comes from the Biot-Savart's law which relies on current elements, i.e. charge in motion. The electric charge is a fundamental quantity, but not the magnetic field. In fact, it is optional in any physical theory to choose to either be blind to the magnetic field or to acknowledge it when convenient. The concept of the magnetic field is dispensable, but not so that of the electric charge.

The introductory textbooks would 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:

$$F_{dl} = \frac{\mu_0}{2\pi R} I_1 I_2 dl \tag{9}$$

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 same formula (9) may be derived from the form of Ampere's law which, in modern notation, is:

$$\mathbf{F_{12}} = -\frac{\mu_0}{4\pi} \frac{I_1 I_2}{r^2} \hat{\mathbf{r}} [2(d\mathbf{l_1} \cdot d\mathbf{l_2}) - 3(d\mathbf{l_1} \cdot \hat{\mathbf{r}})(d\mathbf{l_2} \cdot \hat{\mathbf{r}})] \tag{10}$$

It is only a force law between two current elements. By applying Ampere's law and doing a simple integration, the exact same formula (9) 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], [5].

This shows that in our explanation as to how current-carrying conductors transmit energy, the magnetic fields surrounding the conductors may just be ignored; the magnetic field is just a mathematical construct which may be considered to have no physical reality. The photon energy current explanation is based on the photon which is radiation and it is not just a pure mathematical construct; there is much empirical evidence to suggest it may be considered to have physical reality.

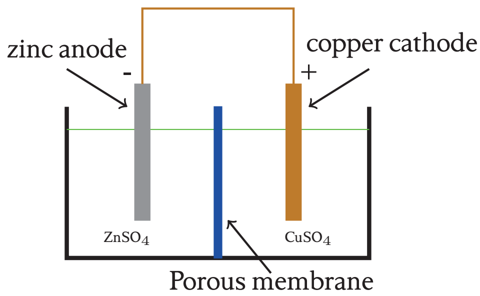

Figure 3: A zinc copper Galvanic cell with aqueous solutions of $ZnSO_4$ and $CuSO_4$ separated by a porous membrane. When active, sulfate anions SO_4^{2-} flow accross the membrane from the copper side to the zinc side.

4 An Electrochemical Battery Is A Photon Generator.

In the literature explaining the working of chemical batteries, nearly all would be about the electrochemical processes and how the chemical interactions transform chemical energy to electrical energy. Very rarely do they explain the actual physical mechanism of energy transformations happening within the batteries. Conventional explanation about the battery is simply just an all-encompassing statement that *'chemical energy is converted to electrical energy'*. There is seldom any mention of what constitutes chemical energy and what constitute electrical energy when the current flows and energy is supplied to an external load.

There are only three forms of energy in nature:
1) Coulomb electrical potential energy;
2) kinetic energy;
3) radiations; radiations are photons, or energy in transition.

Chemical and electrical energies are only generic terms. When atoms combine to form molecules, they combine to form bonds which make the compound more stable as they have a lower energy state; energy is given off(exothermic reaction). In order to break such bonds, energy need to be supplied(endothermic reaction). In more general chemical reactions, the atoms of the reactants would rearrange themselves to form new compounds with new bonds. The reactions would always be accompanied by energy changes.

Figure (3) is a typical Galvanic cell. When the terminals are closed by a connecting conductor, an electric current would flow from the cathode towards the anode. Within the cell, two half-reactions would take place:
1) Oxidation of zinc metal(anode):$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$.
2) Reduction of cupric ions(cathode): $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$.
The total reaction is represented by:
$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$; it is an exothermic reaction.

The energy released by the reactions are mostly Coulomb potential energy due to the rearrangements of the various positive nuclei and the negative electrons within the cell. Clearly, the released potential energy would be transformed to either kinetic energy or photons.

The conversion to kinetic energy could easily be ruled out as it would mean the cell would be releasing heat; this would only result in raising the temperature of the cell and there would not be significant energy released as energy supplied to any external load. This is bourne out by empirical evidence as there is no significant heat release within a Galvanic cell - or generally with other batteries - when it is active. So the only conclusion is that the Galvanic cell transforms electrical potential energy into photons within the cell. This transformation occurs as long as the cell is in a closed circuit with a conductor.

At the copper cathode, free electrons combine with the cupric ions Cu^{2+} to form copper atoms that deposit themselves onto the copper cathode electroplating it. It is known that free electrons within copper metal has higher energy than any electron energy states of copper. This means the free atoms would fall from a higher energy states to lower energy states when it become again as bonded electrons of copper atoms. As the electrons fall towards lower energy levels, photons would be released. As the photons are release in random directions, some would leave the cathode as an energy current; some would enter into the main body of the cell.

At the zinc anode, bonded electrons from the zinc atoms are ejected into the conductor as free conduction electrons. This requires energy; the energy comes from the zinc atom absorbing photons from the cell. Overall, there is still a surplus of photons released by the cell's electrochemical reactions. It is this surplus of photons that flow into both the terminals as photon energy currents supplying energy to the external load.

An electrochemical battery is a photon generator.

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