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ENERGY CURRENT AND PHOTOELECTRICITY THEORY

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Abstract. This paper continues with the development of the author's aether Simple Unified Theory (SUT) [1] and the wave-pulse theory of light[2]. The theory may be called photoelectricity, a replacement for electromagnetism based on Maxwell's equations. In contemporary electromagnetism, energy transmission in current carrying conductors is explained based on the Poynting theory; that it is the surrounding magnetic fields of the conductor which is responsible for energy transmission. This paper argues that such an explanation is not convincing. It is hypothesized that the actual mechanism of energy transmission is through apulses(aether wave pulses, almost photon-like), being absorbed and remitted within the conductors. This is the basis of the novel concept of the energy current in electrical circuit. This paper also touches on various related aspects of physics including the Ampere's force law. An integration method for Ampere's forces is explained. Various experiments involving the Ampere's longitudinal forces have been re-examined. Faraday's law of electromagnetic induction for the AC alternators is explained as aether apulses being emitted within the magnets that jump the air gap entering into the armature winding of the alternator; this is the energy current source for the conversion from mechanical to electrical energy in AC alternators.

1. Introduction

This paper continues with the development of the author's aether Simple Unified Theory (SUT) [1] and the wave-pulse theory of light[2]. The theory may be called photoelectricity, a replacement for electromagnetism based on Maxwell's equations. Our universe is wholly electric as the sole material of the universe is the electric charge. The material of the universe together with space and time forms the basis of everything that are observable to the endowed human faculties.

The term photoelectricity is coined as all electromagnetic phenomena comes from interaction of electric charge and light. In SUT, all radiations are waves in the aether. Aether waves exist only as discrete apulses. An **apulse** is a wave of exactly one wavelength. A continuous train of waves as depicted in textbooks does not exist in reality. There is no concept of magnetism. Magnetism is now relegated to only as an analytical tool in the teaching of elementary physics. Photoelectricity is capable of explaining

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almost all of electromagnetic phenomena - and more - without the need of the concept of the magnetic field. Without the magnetic field, there is no need of the Biot-Savart law, Lorentz force law, Maxwell's equations and the Poynting theorem.

The only force that exists in nature is the universal Coulomb electrical force. The magnetic force is due to the forces between charges when they have relative motion. The gravitational force is due to the slight excess of Coulomb attraction over repulsion [1]. As a start of a new theory, it may be assumed that the only matter particles that exist are protons and electrons; the neutron within the nucleus of atoms is just another state of the hydrogen atom, a proton and a nuclear electron. A material body may have classical kinetic energy. All charge distributions have electric potential energy. So matter may possess only kinetic and electric potential energy and no other (the energy within the nucleus of atoms, too, is wholly electric). The only other form of energy in nature is waves in the aether - energy in transit. An ***apulse*** (a quanta of light similar to the photon) is a single pulse of wave in the aether of one wavelength. It is the result of polarization of the aether charge into positive and negative electrical. Light radiations consist only of apulses.

2. Work And Energy

This paper introduces the concept of energy current within conductors, a totally new concept to contemporary physics. As such, it is necessary to be have a discussion about what energy is. At the time of Newton, the modern concepts of work and energy did not exist. In Newton's *Principia* (1687), there was only the concept of *quantity of motion*, our modern momentum mv. The principle in classical mechanics that energy was proportional to mv^2 was first developed by Gottfried Leibniz and Johann Bernoulli, who described kinetic energy as the living force, *vis viva*.

Work and energy are inseparably tied together. The term work was introduced in 1826 by the French mathematician Gaspard-Gustave Coriolis as *'weight lifted through a height'*. In classical mechanics, work has a definite meaning and is now defined as the line integral of a force acting along a path over a distance: $W = \int \mathbf{F} \cdot \mathbf{ds}$. It is the work done by the force and has the same unit as energy.

In the early days of Newtonian mechanics, the basic three qualities of physical nature are characterized by mass, space and time; they are represented by the corresponding physical dimensions of [M],[L] and [T]. We need to add the temperature dimension [K] when the physics of thermodynamics requires it. The discovery of the electric charge requires a new dimension of [Q]. the dimension of energy is $[M][L]^2/[T]^2$. It can be seen that the concept of energy involves only the properties of mass, space and time only. It should not be a surprise that temperature is not a dimension in energy as the concept of temperature in itself is a representation of the amount of internal energy possess by the particles of a body. In SUT, mass

has been replaced by electric mass which is magnitude of charge x volume. So the dimension of energy in SUT is $[Q][L]^5/[T]^2$. What this means is that energy reflects on the relation between matter and space and time. So the concept of energy is created so that this relation could be dealt with quantitatively with our mathematics. Indeed, the development of classical mechanics is almost inseparable from the concept of energy.

Decent physics should never be involved with fanciful speculation. As a science, physics should fundamentally be based on the well recognized scientific method as espoused by pioneers such as Francis Bacon. [5]

> *Baconian method, methodical observation of facts as a means of studying and interpreting natural phenomena. This essentially empirical method was formulated early in the 17th century by Francis Bacon, an English philosopher, as a scientific substitute for the prevailing systems of thought, which, to his mind, relied all to often on fanciful guessing and the mere citing of authorities to establish truths of science.*

Other cardinal criteria of the scientific method includes logical consistency and verifiability. Scientific theory such as the Big Bang is never a scientific theory proper as it is never verifiable. Just as it is pointless to speculate on the beginning of the universe, it is pointless to speculate on how energy in the universe come about. The law of conservation of energy has been well accepted as a cardinal principle for a long period prior to Einstein's special relativity. It is revived in SUT free of relativistic mass-energy equivalence.

> ***The Law Of Conservation Of Energy*** *- Energy can neither be created nor destroyed.*

We may be tempted to propose that the total energy in the universe is a constant. This would be incorrect as it would lead to a logical contradiction. As the universe is infinite, it would then have a constant yet infinite amount of energy; a constant number cannot at the same time be infinite.

The author in his other papers have shown why mass-energy equivalence of $E=mc^2$ cannot be valid [3][4]. Here, we will present an argument based on what has been said to be the meaning of energy. We have said that energy represents a state of the relation between matter, space and time. If mass-energy equivalence is to be valid, it would mean that mass may be created or destroyed. In SUT, this would mean a violation of the law of conservation of charge. It is known that the law of conservation of charge is one of the strongest law in the physical world. Since our knowledge of electricity to the discovery of the proton and electron to be the fundamental charged particles of matter, never has there been the any empirical evidence that charge could be created or destroyed. Although contemporary physics would like to point to the annihilation of a positron and electron to be evidence supporting mass-energy equivalence, this is rather weak and the experiment in itself is highly questionable [4]. Experimental proof of mass destruction should not be just some observation of charge pairs *disappearing*, it should cover actual

destruction of charged particles themselves without the need of any charge pairing; such evidence has never been found. So, in order to support the principle of mass-energy equivalence, we need to dismiss another primary principle of nature which is much stronger in all other respect, whether from the theoretical aspect or from empirical evidence. So the prospect of mass-conservation of $E=mc^2$ to remain as a cardinal pillar of physics does not seem to be encouraging.

There are only three forms of energy in nature. Associated with matter would be the kinetic and electrical potential energy of matter. The other is radiation waves in the aether - energy in transit.

> *There are only three forms of energy in nature: the kinetic energy of matter, the electrical potential energy of matter and aether wave radiations.*

It may be said there is another more fundamental form of energy, that of the aether. In SUT, it is postulated that the substance of the aether is composed of a superpose of equal positive and negative electric charge densities. As any system consisting of electric charge has energy, the aether may be the fundamental pool of primal energy in the universe. As we have no empirical evidence yet of this aether energy, it would be ignored in this paper.

The early pioneers who considered the quantity proportional to mv^2 being the living force *vis viva* seems not far off from the truth. Energy can never be dissociated with motion as what is *"living"* has motion. There is energy in the universe as we have inherited energy in the universe by not asking *"whence come energy?*. A static universe does not possess any energy.

All three forms of energy are indeed just as different aspects of energy. No amount of any one form of energy could be increased or decreased without quantitative changes in the other two forms. Kinetic energy is frame dependent, yet it cannot be independently increased or decreased. The total electric potential energy of a system of charges is dependent only in its spatial configuration (and possibly on relative motion of the charges); it is Galilean invariant. The energy of light as an apulse is given by the well known $E = h\nu$ and it is Galilean invariant.

The definition of work in classical mechanics has the same unit of energy, but work is not energy. Work is an action that will give rise to changes in energy. There is a fundamental principle relating work and energy:

> ***Work Energy Theorem*** *- All changes in energy, which may involve transformation of the form of energy, may come only from work.*

In photoelectricity, changes in energy must involve electrical forces doing work.

2.1. **Conservation Of Kinetic And Potential Energy.** The transfer of kinetic energy between two bodies is best illustrated by the elastic collision in the typical textbook problem between two billiard balls. It would completely be solved just through the application of conservation of momentum

and energy. Yet, there is no mention at all about forces and work done in the changes in kinetic energy - nor in potential energy. It is a fundamental assumption in photoelectricity that there is only one universal force and it is electric. So how does the electric force come into the picture of elastic collision.

At the microscopic level, a solid body is mainly *"empty space"* if we accept the model of the atom as having the nucleus and the orbital electrons as point particles. All mechanical forces have an electrical origin. A body is held together as a solid body because there are electric forces that keep the solid lattice positive nucleus at optimal distances from each other. We may visualize the bonds between the nucleus being held together by springs. Compressive forces on the solid would be countered by reactions from the bonding forces becoming more repulsive. Tensile forces on the solid too would be resisted by tensile forces from the stretching of the bonds.

When two different solid bodies are pressed together, there is a contact interface separating the two bodies that prevent the two merging as one solid body across the interface. This is because the positive nucleus of atoms always keep a distance apart due to Coulomb repulsion. These forces between colliding bodies are internal forces and does no work in changing the total energy of the system consisting of the two bodies, but they cause a redistribution of kinetic energy between the two bodies through the work done by the internal electrical forces elicited through *"collision"*.

In a planet's orbit around the sun, the planet's distance from the sun is changing which means the total gravitational potential energy of the sun-planet system is changing. From SUT, we know that gravitational potential energy is electrical potential energy as gravitational attraction is from the Coulomb forces. So throughout the orbit of the planet, the kinetic and potential energy of the system are changing from one to the other. Here again, there is work done by the attractive forces between the sun and the planet.

2.2. **Emission And Absorption Of Light Energy.** When an orbital electron falls from an energy level and emits an apulse, the electron exerts a force on the aether. The force does work on the aether and creates an apulse wave in the aether carrying away the work done. The reactionary force does work reducing the total energy of the electron. The reverse happens when an orbital electron absorbs an apulse. In such cases, there is conversion of light energy to and from kinetic and potential energy. Again work done is involved.

3. Energy Current In Current Carrying Conductor

There is only one universal mechanism of energy transmission over space distance. It is through the emission and absorption of apulses in matter. The destiny of an apulse is its creation and emission through the universal Bohr mechanism, its transmission in a straight line and its final fate of

being absorbed by an electron of an atom (ignoring in this paper nuclear interactions).

The emission and absorption of apulses involve forces of interaction between matter and the aether. As explained in SUT theory, aether has mass. When an orbital electron falls to a lower energy orbital, it creates a wave pulse in the aether. The atom exerts a force on the aether. If we assume the force acts for one full cycle creating a single pulse of one wavelength λ, and if the average force is F, the work done by F is Fλ; thus, the energy of the apulse is $E = F\lambda$. If the frequency of the apulse is ν and assuming $E = h\nu$, then the momentum of the apulse is $p = F \times wave\_period = E/(\lambda\nu) = E/c$; or $E = pc$. It is coincidental that the energy-momentum relation for the apulse is the same as that of the relativistic photon, yet there is no assumption of any mass-energy equivalence in SUT.

Before the discovery of electricity, man could only generate energy and use it locally at the place of generation. There is no way to tap the power of sunlight, fire or hydroelectric power at one place and transmit and use the energy at a remote location. It is only after the discovery of electricity that we could generate energy at one place, transmit it hundreds of kilometers away through electric cables to do various useful work. Today, almost all electrical power usage is transmitted through conducting electrical cables and distributed to users through electrical grid systems.

Current electromagnetism explains power transmission of current carrying conductors based on the Poynting theorem. It assumes energy to flow outside of the conductor through the magnetic fields surrounding the conductor. In the steady state, the conducting wires are electrically neutral. It is difficult to identify any electric field outside the conductor to complete the Poynting vector of $\mathbf{S} = 1/\mu_0(\mathbf{E} \times \mathbf{B})$. If there is any electric field, it exists only within the conductor in parallel with the direction of the current and which drives the current; in no way could this electric field participate in the Poynting vector equation to even indicate a flow of energy from source to load. Furthermore, the Poynting theorem does not give us the actual physical mechanism of energy flow, but only the direction of energy flow. Even though electromagnetic energy may be considered to be photons, the Poynting theorem in itself has no direct relation with light as particles.

The SUT photoelectricity explanation for energy transfer through current carrying conductor is that energy is carried by apulses within the conductor, absorbing and re-emitting apulses along the length of the conductor towards the load. If we assume that the apulse radiation wavelength follows blackbody radiation, then at normal room temperature the wavelength for maximum radiation intensity is 10μm, in the microwave range. This is completely at odds with the Poynting approach which relies on the magnetic field. One is an aether theory without magnetism and the other is based on Maxwell's equations. Not only does photoelectricity show that energy current flows within conducting wires, but it also gives the actual physical energy carrier as apulses in the lattice space of the conducting material

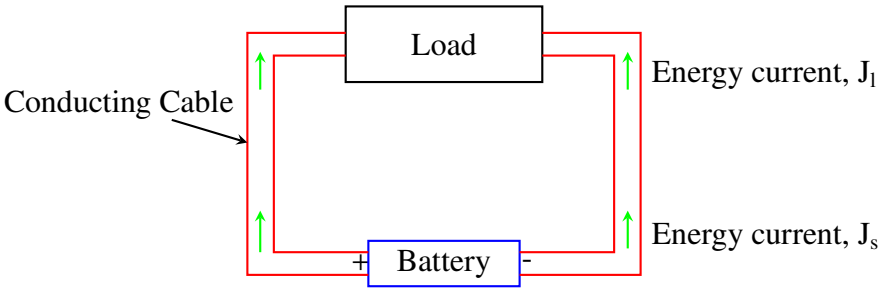

Figure 1. Battery supplying power; energy current flows within the conductor from both battery terminals. Current J_s leaves source, J_l enters load. Energy current direction is independent of electric current direction.

(matter is mainly empty space if electrons and the nucleus are considered as point particles). It is difficult to experimentally verify if energy flow really is due to apulses flowing through the conductors. The acceptance of photoelectricity may only come if it is successful in explaining electromagnetic phenomena. In this respect, energy current in conductors can explain all that current electromagnetism could explain - and more. There are various electromagnetic phenomena that current electromagnetism could not explain or could only be explained with reservations; e.g. exploding wire, Ampere's hairpin experiment, Graneau's liquid mercury fountain experiment and others. Such could easily and directly be explained with photoelectricity as shown in sections below.

> Definition: **Energy current**. *The energy current flowing across a section in a current carrying conductor is the amount of energy the apulses carry across the section in one second.*

An apulse carries energy as well as momentum. Energy current has the same unit as power; it is the watt (W) in SI unit. The momentum of the apulses is in the longitudinal direction tangential to the current density vector, but away from the energy source and towards the load.

A typical example would be a battery supplying power to an external load (Fig 1). In the steady state, the power supplied is $VI = 2J_s$ watt. The power available to the load is $2J_l$ as there are ohmic loss of $J_s - J_l$ in the conducting wires. As energy supply comes only from the battery and energy comes only in the form of apulses, the energy flow would generally be equal flow of energy out of the positive terminal and the negative terminal (based on symmetry consideration). If the load is just a resistor, then the input energy would be dissipated as ohmic energy loss or I^2R loss. If the resistor is a plain copper wire with cylindrical cross-section, then the power input would be equal to the radial outflow of all apulses carrying away the ohmic energy.

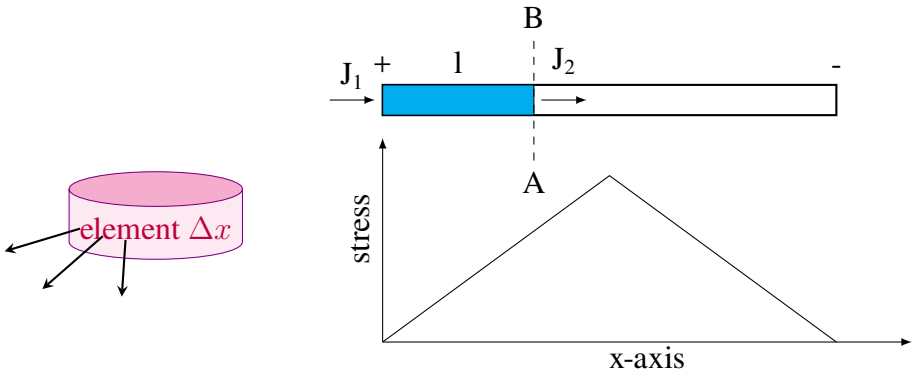

Figure 2. Left: A typical Δx element of a conductor wire of circular cross section; the radiation intensity is symmetrical and points in the normal direction to the surface. Right: A long conductor with electric current I; a section of length l from left terminal, resistance R. The graph shows the variation of compressive stress on an element of length dl of the conductor at various distances within the conductor.

3.1. **Forces And Momentum Due To Energy Current Flow.** In photoelectricity, the universal mechanism of energy transmission in conductors is the absorption and re-emission of radiation by matter of the conductor. If an atom absorbs an apulse, its energy and momentum gain would be that of the apulse. If we assume there is a finite time Δt for the absorption of the energy, there will be an average force F that acts on the atom. This force may be calculated based on the rate of momentum transfer: $F = \frac{h\nu}{c\Delta t}$. The force F is a force of action of the aether on the atom. As energy transfer is within a conductor, the force is an external force acting on the conductor, the atom being at a node of the solid lattice structure of the conductor. The total momentum gain by the atom - thus also the conductor - is the momentum of the impinging apulse.

The reverse happens when an atom emits an apulse. The creation of the apulse will cause a recoil force from the aether on the atom. This would cause the atom to lose energy as well as momentum. This recoil force is an external force acting on conductor, the atom being a node of the solid lattice of the conductor. The force is given by the same equation as in absorption: $F = \frac{h\nu}{c\Delta t}$.

As explained above, the flow of energy current across a conductor always elicit forces of action and reaction between the aether and the solid lattice of the conductor. Such forces would cause stress within the conductor. A simplified model would enable us to calculate such stress forces. Our simplified model assumes that there are only two typical apulse absorption and re-emission within the conductor:

(1) total energy relay onward - A lattice atom absorbs an apulse. In a small time interval later, relays a similar apulse of the same amount of energy and momentum forward in the longitudinal direction.
(2) ohmic dissipation - A lattice atom absorbs an apulse. In a small time interval later, it emits an apulse of the same energy, but in the transverse direction. Thus, all the absorbed energy would leave the conductor dissipated as thermal radiation. The atom would retain the longitudinal momentum of the impinging apulse.

In reality, atoms may relay only a portion of energy and momentum of an apulse or it may re-emit energy only after absorbing multiple number of apulses. What is important is the net effect.

Let us examine the ohmic loss for a typical element l of a long straight conducting wire transmitting energy as in Fig 2. Assuming a steady state, all the ohmic loss is dissipated as thermal radiation from the surface of the conductor wire. Fig 2 left shows a typical cross-section element Δx in l. From symmetrical consideration, we can conclude that there is no reason for a preferred longitudinal direction for radiation dissipation; the radiation intensity is directed outward and normal to the surface of the conductor. Thus, there would not be any net recoil force in the longitudinal direction due to ohmic radiation dissipation. The integral sum of the radiation intensity about the cylindrical surface would represent the ohmic loss by the element. Assuming circular symmetry in the radiation intensity, there would be zero net recoil force on the element in the transverse direction.

Fig 2 right shows a section of the conductor length l from the left end with resistance R. The difference between energy current $J_1 - J_2$ is the rate of ohmic radiation loss in R. J_2 is the rate of energy transmission onward across R. With our simplified model, the rate of net momentum absorbed by element l is $\frac{dP}{dt} = (J_1 - J_2)/c$, the momentum being in the longitudinal direction. $\mathbf{F} = \frac{d\mathbf{P}}{dt}$ is the net external force of action by the aether on the element l of the conductor.

A solid body is held rigidly in shape due to the lattice bonds of the atoms at the nodes of the crystal structure. It could be visualized that the nodes of the lattice attract one another, but they keep apart at an optimal distance between them. With our assumption of steady state, there is no motion of the element l. The element l pushes with a force of F on the interface AB of the conductor solid. This results in the lattice nodes at AB being forced closer together, their distances apart in the longitudinal direction being lesser than the neutral optimum. It is this compression of the solid lattice bonds that elicits a reaction at the interface AB balancing the force F pushing against the interface. In Fig 2, for every small element Δl of the conductor, there is a compressive stress on it that increases from the terminal and peaking at a maximum at the center of the conductor where the energy current is zero, i.e. the null energy region.

For every small element Δl of a long current carrying conductor, there is a compressive stress force in Δl due to the energy current that flows through it. The stress increases linearly towards the direction of the null energy current region.

For the above element l, the compressive force is: $F = (J_1 - J_2)/c = I^2R/c$. As F has a factor of 1/c which is extremely small in nearly all situations, such compressive stress has almost no practical significance. Even in the rails of railguns that operate at a million ampere, the estimated stress is in the order of only tens of kilogram-weight, practically insignificant for the sturdy steel rails (but there are other very strong Ampere recoil forces at work). Such compressive stress forces due to energy current flows are independent of any Ampere forces that may be present.

3.2. **Temperature Variation Within A Long Current-carrying Conductor.** Contemporary electrical circuit theory provides only a simplified model. For example, the resistivity in a uniform long metal conductor is taken to be constant and the rate of ohmic loss under steady state is taken to be I^2R. This may be a good approximation for small currents, but the prediction based on energy current of photoelectricity shows that such a simplified model could be very far off from reality for high currents, say in the order of hundreds of ampere.

Referring again to the long conductor in Fig 2, the energy current entering the conductor at the left is J_1 and the energy current at the middle is zero. Let's take a small Δl element of the conductor near the left end. Within a small time interval Δt, some atoms of Δl would absorb apulses entering it. The total absorbed energy of such atoms may end up in three manners:

(1) a fixed I^2R amount dissipated as thermal radiation.
(2) a small proportion retained as internal kinetic energy.
(3) the larger proportion relayed onward leaving the element.

If it is assumed that there is a small non-zero time interval between the absorption and re-emission of an apulse, then the amount in (2) above is not zero unless a certain steady temperature of the element Δl is reached. In general for metal conductors, the retained energy in (2) above would cause a rise in temperature of Δl. The rise in temperature continues until a steady state is reached when no energy is retained as internal kinetic energy. As the amount of retained energy is proportional to the energy current of Δl, the rise in temperature is greater near the energy source and would be at a minimum at the middle of the conductor where the energy current is zero. This analysis shows that, in the steady state, there would be a temperature gradient along the conductor with a maximum at the ends and falling to a minimum at the center. In general, the proportion of retained energy increases with the power supplied to the long conductor. The higher the power, the greater would be the temperature gradient. This is in contrast to the contemporary simplified electrical circuit model that does not treat

of any variation of temperature in a current-carrying conductor. With large powers and currents, the temperature gradient may be significant.

> *In the steady state of a solid long current carrying conductor, the temperature has a gradient that decreases from the source end towards the null energy current region.*

In the case fluid conductors like mercury or molten metals, the atoms are free to move but such a temperature gradient would still exists though no steady state temperature may be achieved. To date, it seems no one has ever mention of such a phenomenon.

Let's consider the effect of a temperature gradient on a long narrow trough of mercury carrying a large enough electric current. When the temperature of mercury rises, its density decreases. In order that the hydrostatic pressure of the mercury at the same horizontal level to be the same through the body of mercury, the height of the mercury must rise to offset the decrease in density. This means the level of the mercury would be at a maximum at the two ends of the trough and gradually falling to a minimum at the center region with zero energy current. The surface of the mercury would acquire a concave curvature. This concavity is a prediction of the new concept of energy current in photoelectricity. Such a surface concavity in mercury could be experimentally verified by reflecting light off the mercury surface.

> *The new photoelectricity theory predicts that when an electric current flows through a long narrow trough of mercury, there is a temperature and surface level gradient along its length with the temperature and level being at a maximum at both ends and falling gradually towards the center, the region of zero energy current. The mercury surface concavity could be be verified experimentally by reflecting light off the mercury surface. Such an experiment may be taken to be a verification for the concept of energy current within current-carrying conductors.*

In this same example, the temperature gradient would give rise to mercury metal flow. At the ends where the mercury height is a maximum, there would be a surface mercury flow downwards towards the center. This would be accompanied by an undercurrent of mercury flow from the center towards the ends of the trough, the current source.

In general, electric currents - whether direct or alternating currents - flowing through liquid metals would give rise to metal flows within the liquid body due to the temperature gradients established by energy current with the liquid body.

> *A high enough electric current in a liquid metal conductor will cause a metal flow on the surface following the direction of the energy current from the current source towards the null energy current regions. There would be accompanying*

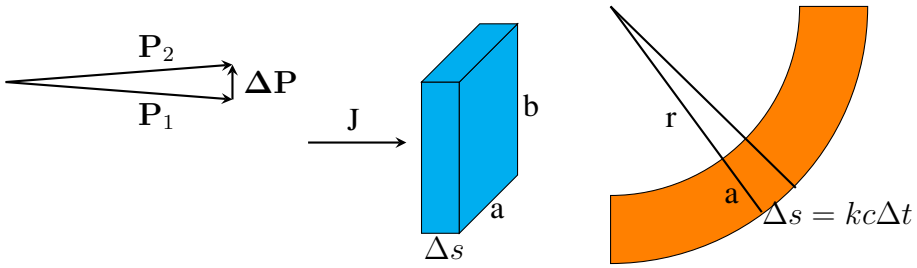

Figure 3. Circular bar connector radius r. Typical element of thickness Δs, rectangular cross-section a $\times$ b . Energy current J.

undercurrents from the null energy current region towards the energy source.

3.3. **Radial Stress Forces In Conductor Bends.** When an energy current changes direction, the momentum of the apulses carrying energy will change in direction causing reactionary forces on the bends in the conductor. This issue is seldom addressed in contemporary undergraduate electromagnetism as the physics is not clear. Such forces are very weak and would probably be of theoretical interest only. They can easily be computed through energy current theory; a typical example is shown here.

A power station with a 300MW 3-phase AC generator has three lines supplying a maximum power of 100MW for each line. The lines would be connected to the primary coils of a step-up transformer. Let's assume a generator line needs to make a 90deg turn through a solid copper connector as shown in Figure 3. It is well known that electrical signals in copper wires travel at a fraction of the light speed c, say kc; k may be between 0.5 to 1.0. Also, in steady state transmission, the volume energy density within the conductor is assumed uniform. At any one moment, the amount of energy within the typical conductor element would be $E_{ds} = \dfrac{J\Delta s}{kc}$. The vector triangle has $\mathbf{P_1}$ as the momentum of E_{ds} after the energy absorption and $\mathbf{P_2}$ as the momentum on leaving the element with $\mathbf{\Delta P} = \mathbf{P_2} - \mathbf{P_1}$. The radial recoil force on the element is -F where $\mathbf{F} = \dfrac{\mathbf{\Delta P}}{\mathbf{\Delta t}}$. As $\dfrac{\Delta P}{P_1} = \dfrac{\Delta s}{r}$ and $P_1 = E_{ds}/c$, we have $F = \dfrac{\Delta P}{\Delta t} = \dfrac{P_1 \Delta s}{r\Delta t} = \dfrac{P_1 kc}{r} = \dfrac{E_{ds}k}{r} = \dfrac{J\Delta s}{cr}$. The recoil force acting on the conductor element is a total force on the surface area $\Delta s \times b$, of magnitude F and directed radially outwards. The radial stress S on the conductor connector is:

$$S = \frac{J}{crb} N.m^{-2} \tag{1}$$

If J=100MW, r=1m, a=b=5cm, the force acting on a 5cm length of the conductor is 0.017N or 1.7 gram-weight, an insignificant force.

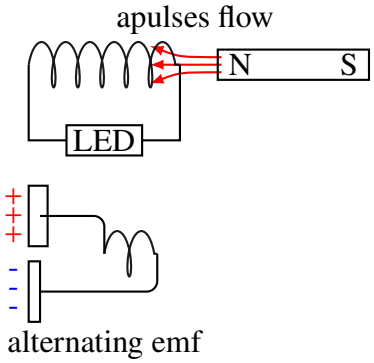

Figure 4. Upper: solenoid and moving magnet. With the magnet moving left and right, apulses would be generated within the magnet which travel across the air gap into the solenoid. A small AC emf would be induced lighting up a small LED. Lower: equivalent alternating emf due changing electric field direction.

4. Faraday's Law And Electromagnetic Induction In Photoelectricity

A large proportion of the energy consumed by the world today comes from electricity generated by turbine-driven electrical generators in power stations. From whatever energy sources, the turbine converts the energy into rotational kinetic energy which turns the rotor of the generator. The generator works on the principle of electromagnetic induction of Faraday's law producing the electromotive force(emf) in the armature winding which is what is termed electrical energy. So the summary effect of the generator is to convert mechanical energy to electrical energy which may then be transmitted over long distances through electrical cables to far-away destinations.

Faraday's law may be stated as:

> *When the magnetic flux linking a closed path changes, an electromotive force(emf) would be induced along the path equal to the negative of the time rate of change of the magnetic flux.*

Mathematically, $E = -\dfrac{d\Phi}{dt}$ where Φ is the magnetic flux linking the closed path. In general, an emf would be generated in a closed conducting circuit if there is a change in magnetic flux linking the circuit. Most often, as with AC generators, the change in magnetic flux is due to the relative motion of magnets and the armature winding. With a conductor being the closed path, an alternating emf would be generated which supplies power. Fig 4 (upper) shows the typical textbook case of a magnet moving relative to the solenoid. As long as the magnet keeps moving, an AC current would flow in the circuit.

Fig 4 (lower) shows an equivalent circuit. The alternating emf is due to an induced electric field that changes direction as the magnet oscillates along

the horizontal direction. This may be explained through the Weber's force law. There are electrical forces interacting between the electric charges in the magnet and those charges in the external conducting circuit which depend on relative motion between the charges. Relative motion in itself is insufficient to invoke the electrical forces through the Weber's forces. If the moving iron bar is not magnetized, no electromagnetic induction would occur. This could be explained as magnetization within a permanent magnet has the magnetic dipoles of the iron atoms aligned giving a net magnetic moment in the horizontal direction. Without this magnetic dipoles' permanent alignment, the net result of the Weber's interaction would not cause a net field that moves the electrons between the two plates; there would be no induced net alternating emf. This is only a *prima facie* explanation of Faraday's law invoking the Weber's force law.

Current electromagnetism does not have any explanation for the Faraday's law; it is an experimental law just as when Michael Faraday discovered years back. Current electromagnetism also has no explanation as to the physical mechanism for the conversion of mechanical energy to electromotive force that can do work. The mathematical expression of the law simply states the relation between the generated emf and the rate of change in the magnetic flux; nothing is said about conversion of forms of energy.

Though photoelectricity has yet to fully explain Faraday's law, it has a definite explanation for the mechanism of energy conversion between mechanical energy to electrical energy. In cases where Faraday's electromagnetic induction apply, apulses would be generated in the ferromagnetic iron with a magnetic field within and when the magnetic flux linking the conducting circuit is changing. Fig 4 shows a simple textbook case where the magnetic flux of the permanent magnet is changing due to its relative motion to the solenoid. Apulses would be emitted by the magnet which has the ability to travel across the air gap to enter into the solenoid providing the energy of the induced AC emf.

In the operation of a power alternator, apulses would be emitted by the magnets and jump the air gap into the armature winding; this is the source of energy currents which flows into the primary winding of the step-up transformer. The apulses would again jump the air gap into the iron core traveling towards the secondary; they would again jump the air gap entering into the secondary winding. This would be the input energy current to the transmission lines as in Fig 5.

For power transmission across conductor coils through electromagnetic induction, the path of the energy current does not need to be accompanied by electrical field driving currents through the transformer core. Using the idea of permeability of matter, iron can allow high induction energy transfer in the transformer. If there is no core material with a high permeability (as soft iron) but only air, the amount of power that a transformer could transfer would be reduced by a huge factor. The typical efficiency of power

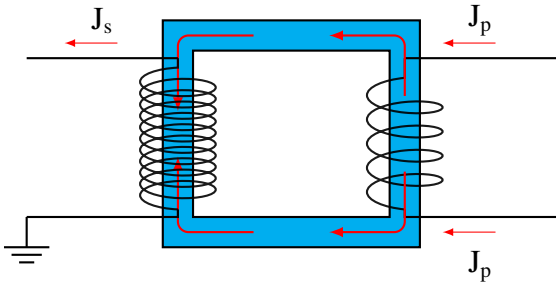

Figure 5. Delta-wye (Δ-Y) step-up transformer action. The right primary winding is connected to the armature winding through a 3-phase delta connection. The left secondary winding connects to the transmission cables through a wye connection. Energy current J_p jumps the air gap entering the iron towards the secondary and jumps the air gap into the winding giving the secondary energy current J_s.

transformer is in the range of 97 - 99%. The gains through using high voltage in long distance power transmission far outweigh the little transformer losses.

5. Ampere Longitudinal Force

In 1822, Andre-Marie Ampere proposed his force law between current elements. Hermann Grassmann proposed a competing force law, also between current elements. It was from Grassmann's law that the current Lorentz magnetic force law was derived. There is one critical difference between the two competing laws; only Ampere's force law predicts a repulsion between two collinear current elements. This repulsion gives rise to what is now referred to as Ampere tension within a long straight current-carrying conductor. The form of Ampere's law in modern notation is:

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

The force is the action of a directed current element $d\mathbf{l_1}$ with current I_1 on a directed current element $d\mathbf{l_2}$ with current I_2; r is the distance between the elements and $\hat{\mathbf{r}}$ is the unit vector from $d\mathbf{l_1}$ to $d\mathbf{l_2}$.

From the time of Ampere right up till the 1990's, numerous experiments have been performed by various physicists to verify if the controversial Ampere tension does exist [6, 9, 10, 11]. Although controversies still remain today, the evidence supporting Ampere tension seems rather strong. Any evidence of Ampere tension would not be favorable to the Lorentz magnetic force which is based on the Grassmann's law. To examine experiments involving Ampere tension, it would be useful to derive a formula that shows how an electric current would cause tensile stress variations within it.

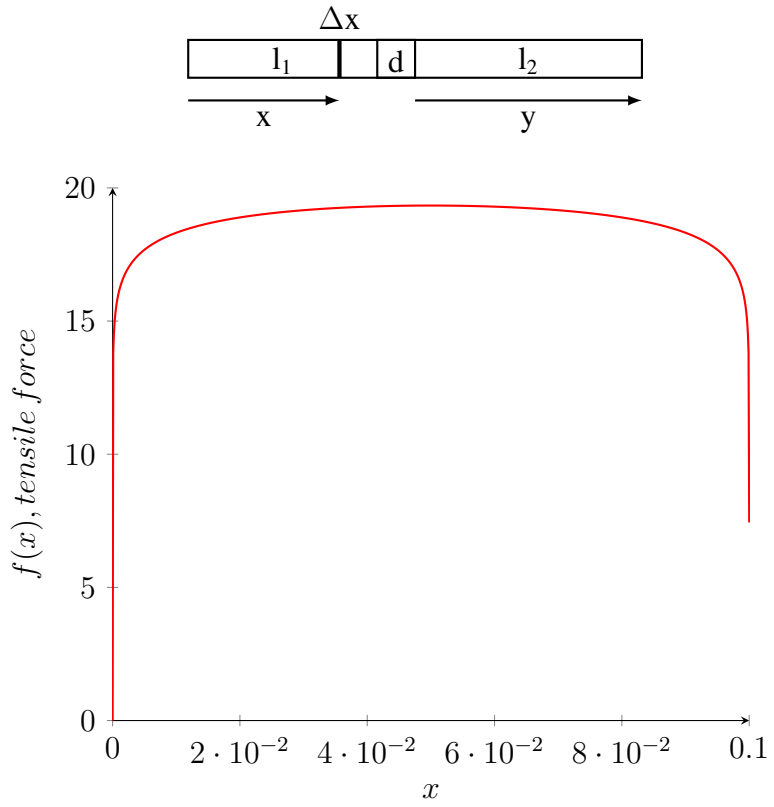

Figure 6. Graph showing variation of Ampere tensile force in a long conductor with current I. f(x)=ln(0.1-x)-ln(0.1×1e-10)+ln(x+1e-10). For I=1000A, l=0.1m, d=1x10$_{-10}$m, the maximum force at the middle is 1.93N.

5.1. **Integration Of Collinear Elements.** For two collinear elements dl_1, dl_2, the force is repulsive and is given by: $F = \frac{\mu_0}{4\pi}\frac{I^2}{r^2}dl_1 dl_2$. The following shows the method of integration for the forces between two sections l_1, l_2 separated by a small element d in a long straight conductor as in Fig 6. The integration is to compute the forces between the elements of the sections divided into infinitesimal collinear elements Δx. It seems that such an integration may face a singularity for the force of interaction between two adjacent elements dl_1, dl_2 as $1/r^2$ diverges to infinity. But this singularity does not exist if it is taken that the Δx are all of the same size so that $(dl_1 \times dl_2)/r^2 = (\Delta x \times \Delta x)/(\Delta x)^2 = 1$ as $r = \Delta x$.

The integral required to compute the force between sections l_1 and l_1 is:

$$\int_0^{l_1}\int_0^{l_2}\frac{1}{(y+d+l_1-x)^2}\,dy\,dx=\int_0^{l_1}\Big[\frac{-1}{y+d+l_1-x}\Big]_0^{l_2}dx$$
$$=\int_0^{l_1}\Big(\frac{-1}{l_2+d+l_1-x}+\frac{1}{d+l_1-x}\Big)\,dx \tag{3}$$
$$=\Big[log(l_2+d+l_1-x)-log(d+l_1-x)\Big]_0^{l_1}$$
$$=log(l_2+d)-log(d)-log(l_2+d+l_1)+log(d+l_1);$$

Substituting $l=l_1+l_2+d$ and eliminating l_2, the integral in equation (3) is : $log(l-l_1)-log(ld)+log(l_1+d)$.

In practice, the computed force between sections l_1, l_2 for a separation d in the order of one Angstrom (10^{-10}) may be taken to be that between two adjacent sections as one Angstrom is the order of lattice spacing in solid crystals. See Fig 6

The method of integration above should also be applicable to compute the force between two sections l_1, l_2 where they are at a right angle; the angle should be positioned at the center of the element d separating l_1, l_2.

6. Liquid Metal Flow Due To Electric Current

There are various electromagnetic experiments that current electromagnetic theory cannot explain. These generally involve observations of motion in liquid metal like mercury or molten metals when high currents are applied to the metal. Peter Graneau in Ampere-Neumann Electrodynamics [6] cited how Carl Hering (1923) heated liquid metals by passing large currents through molten pools and observed the liquids moving. The Graneaus' concluded that such metal flow could be explained by the existence of Ampere longitudinal forces in conductor currents. The author here holds a different opinion that Ampere longitudinal forces may not be the correct explanation for such metal flow.

There should be some hydrodynamical explanation involving all liquid flows, whether it is for water currents in the ocean and the above metal flows due to electric currents. It is well known that the main three factors giving rise to ocean currents are temperature, density of water and hydrostatic pressure due to tides (ignoring wind for surface currents and Coriolis forces due to the earth's rotation). So ocean currents would flow due to differences in these three factors at different parts of the ocean. In the case of experiments involving high electric currents in mercury or molten metal and where metal flows are observed, then it is very likely that the cause of the flow should also be found in the same three factors of temperature, density and hydrostatic pressure, though much in a minuscule scale. Ampere tension may not be a cause for the metal flows.

In Fig 6, the graph shows how the internal tensile force varies along the conductor, being almost zero at the ends and rising almost vertically to a

value close to the maximum. The manner of variation of the force has a similarity with a solid metal rod being subjected to a tensile stress by forces applied at the ends, each a little from the rod's ends. Here the tensile stress is uniform throughout the rod. In the case of Ampere tension, the slight difference is that there is a small force gradient rising to a maximum at the center.

A solid is a body held rigidly together as a lattice structure by solid bonds of attraction between the atoms or molecules. Such lattice bonds are electromagnetic in nature and may be viewed as holding the lattice nodes together at an optimal distance - rigidly. Tensile stress on the solid would stretch the bonds and cause the lattice spacing to increase. The lattice bonds now is analogous to that of an extended spring which reacts with an opposing force equal to that of the applied force. If the applied force is compressive, the lattice spacing would decrease giving rise to the same opposing reactionary force from the lattice bonds.

At the microscopic level, the effect of the Ampere tension on a solid conductor may be visualized in this manner. Let's consider any section interface dividing the conductor into two sections. The interface may be visualized as cutting into the lattice bonds pulling at the two sections opposing the tendency of the two sections from moving apart due to Ampere collinear repulsion. If two bodies in empty space were to repel each other, the bodies would have motion away from each other. In the case of the conductor, it is the lattice bonds at the interface that prevent the two sections from moving apart or breaking apart (Indeed, it is the Ampere force that is the cause of exploding wire when the Ampere tension is much stronger that the lattice bonds). This shows how it is the reactions of the solid lattice bonds that balances the Ampere longitudinal forces so that the body of the conductor seems to be subjected to a *'zero net external force'*.

There may be an assumption that Ampere tension may cause metal flow in liquids as the atoms of liquids are free to move unlike as in solids. But even in liquids, there are electromagnetic cohesive forces that hold the liquid together. Just as the solid bonds react to and oppose the Ampere repulsion, the cohesive forces too may act in the same manner to prevent bulk motion in the body of the liquid subjected to electric currents. The cause of metal flow may lie in factors other than in the Ampere longitudinal forces.

There is another reason why Ampere longitudinal force may not be able to explain metal flow. Any metal flow involves a circulation of liquid in the metal body and this involve work done which needs a continuous energy input. It is clear that Ampere tension in itself is only an internal stress force which does no work. As it does not cause any direct energy input into the liquid body, it is not likely that it is the cause of any metal flow.

Let's examine two of Graneaus' experiments involving passing high currents in liquid mercury:

- **Mercury In Trough Experiment** Fig 7 (1994) - Currents of 300 - 1000A (could be AC or DC currents) were passed through the

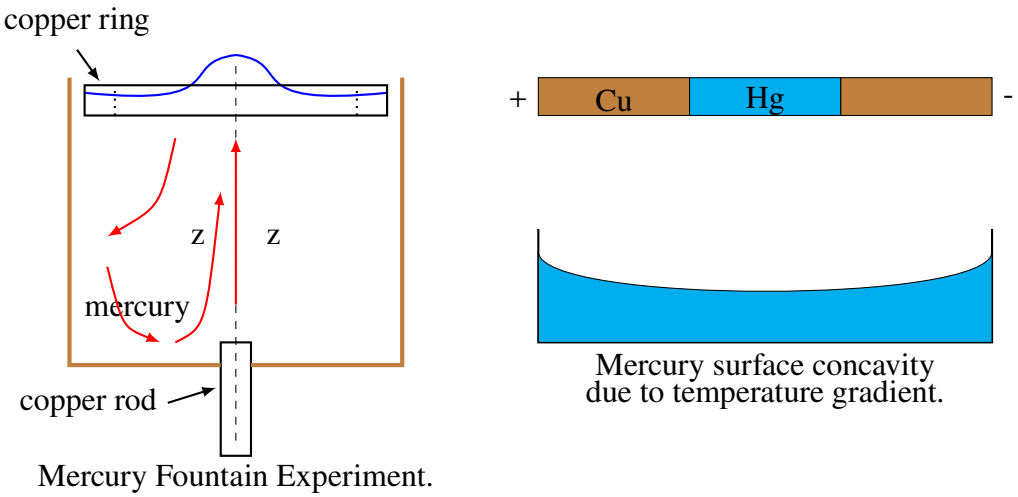

Figure 7. Graneau's experiments. Left: cup depth 4.5 cm, diameter 6.4 cm; red arrows show mercury flow. Right: mercury in trough, cross section 1/2"x1/2", currents 300-1000A.

mercury. It was observed that the mercury near the copper electrode face seemed to produce waves towards the center, but only for a short distance of a few centimeter. It was said there seemed to be some mercury flow from the copper ends towards the trough center.

This experiment has been examined in the earlier section on temperature gradient due to energy current flow within a current carrying conductor. It predicts that the surface of the mercury would acquire a concave curvature. It also predicts that there would be surface mercury flow from the electrode ends towards the mercury center and accompanying undercurrents bringing mercury from the center back towards the electrode ends. It is expected that simple visual observations may not be able to confirm any such mercury flow or the concavity of the mercury surface.

The experiment may be examined from the perspective of Ampere's tension. Fig 6 shows the variation of Ampere's tensile force along the length of the narrow trough of mercury. It could be seen that the variation is rather gradual throughout the length. The tensile force in the mercury works against the cohesive forces of the mercury that tends to hold the liquid body together. Thus the presence of Ampere's tension reduces the hydrostatic fluid pressure in the mercury. This reduction is greatest at the center and lesser towards the copper electrode face. This hydrostatic pressure difference should cause the mercury surface to acquire a convex curvature but this was not observed. The very probable reason is that the temperature gradient is the more prominent of the factors as compared to that of Ampere's tension.

But the effect of Ampere's tension seemed to be more prominent when the length of the mercury length was made short as compared to its cross section of 1/2" x 1/2". It was observed that sparks may form at the copper-mercury interface separating the mercury from the copper; the separation may happen at either ends. This could easily be explained. It is known that the cohesive forces in mercury is greater than the copper-mercury adhesive forces. The Ampere tensile forces works against the adhesive forces and if the tensile forces are stronger than the adhesive forces, it would cause the mercury to separate from the copper.

When the trough length was reduced further to below 1/2cm, the mercury would bulge upwards and may finally be forcefully expelled. This may be due to the thermal expansion of the mercury alone.

- **Mercury Fountain Experiment** Fig 7 (1994) - The upper electrode is a copper ring and the lower is a copper rod. The setup is contained in an insulating dielectric container which is filled with mercury to the level of the copper ring. A current of about 500 - 1000A (AC or DC) was passed through the mercury. It was observed that the mercury at the center of the ring would rise forming a conical fountain head with mercury flowing down the sides of the cone. As explained earlier, any mercury flow in a body of mercury carrying electric currents may not be due to Ampere's tension. The temperature gradient due to energy current in conductors may offer an explanation for this experiment.

  With temperature gradients established by energy current flow, the temperatures of the mercury near the copper ring and the bottom rod electrode are higher then at the regions z-z, the region of zero energy current. The cause of the mercury fountain comes only from the higher temperature near the bottom rod electrode and not the higher temperature near the upper ring. A higher temperature would cause the mercury to expand resulting in a lower density. This would give rise to convection mercury currents upwards along the central axis heating up the mercury along it.

  In the body of a liquid, there is the natural tendency for the hydrostatic pressure at a certain horizontal level to be the same. As the mercury density along the axis has fallen, its surface level at the central axis has to rise in an attempt to maintain its original hydrostatic pressure. This raising of the mercury level at the central axis is what causes the mercury fountain cone to form. The fountain flow would continue as long as the temperature gradient in the mercury is maintained.

The experiments above are independent of current direction. The currents may be AC or DC.

7. Phenomenon Of Exploding Wire

"For nearly two centuries it has been known that a fine wire will explode when suddenly subjected to a large flow of electrical current." [8]. It was discovered in 1964 that a current pulse would break a straight copper wire into many fragments without visible melting. A metallurgical examination of the pieces confirmed that the metal parted in the solid state. Peter Graneau [6] suggested that the phenomenon could be explained by the Ampere longitudinal force at work. If there is sufficient evidence that Ampere's force law is correct, then this explanation is surely acceptable. The author here suggests another possible explanation.

When a current pulse is applied to a fine wire, energy currents enter the wire at both ends. Some atoms of the wire would absorbed the energy apulses and would retain the energy for a small time interval as increased internal energy. If the rate of energy absorbed is small, the atoms would eventually dissipate all the energy and reached a stable steady state. But if the energy currents are high as compared to the cross section of the wire, then the wire would explode the very moment the current is applied - instantaneously! This is because the apulses move at the speed of light. In an infinitesimally small time interval Δt, the amount of retained internal energy for any small element Δl of the wire may be large enough to cause the increase in kinetic energy of the atoms to overcome the solid bonds holding the the wire together. In such a small time interval Δt, it is reasonable that one cannot talk about any phase change from the solid to the liquid state. The explosions would happen without giving any time for any *'phase change'*. To explain exploding wire based on a sudden increase in absorbed energy by the wire would be less convincing if it is assumed energy in conducting wire is carried by the magnetic field outside of the conductor.

8. Conclusion

This paper shows that Maxwell's theory based on the concept of the magnetic field should be replaced by a modern theory of electricity. The concept of the magnetic field is an anachronism from the days when the permanent magnet was examined and the idea of magnetic poles were formed. We now know that all magnetic phenomena are due to electrical interactions between electric charges when they have motion, an extension of Coulomb's law beyond electrostatics. Contemporary physics still insists on preserving the *status quo* of electromagnetism because the concept of the magnetic field has pervaded all of *'modern physics'* so much so that removing magnetism from electromagnetism proves to be a most daunting challenge. In fact, it is much easier to invent new exotic physical hypothesis and concepts - as in the Standard Model, string theory - than to create a proper modern electricity theory without magnetism. This paper is a first step in replacing the Poynting theory which attempts to explain - but not too convincingly - how energy transmission along current carrying conductor is due to the magnetic fields

surrounding the conductor. This papers show that the actual mechanism of transmission of electrical energy within conductors is not very different from how energy of the sun reaches the earth, .i.e. by radiations across *'empty space'*. Within current carrying conductors, it is through aether apulses being absorbed and remitted along the conductor passing the radiant energy onward. This should not be surprising as solids are nothing much more than empty space as almost a 100% of their volume is empty.

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