The Essential Guide to the Electric Universe

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The Essential Guide. A new introductory resource is (or shortly will be) up and running on the thunderbolts.info web site, to prepare visitors for the subjects and subject matter they would like to have before researching further and participating in the site's Forum to discuss subjects regarding the Electric Universe. The Essential Guide is designed to expose the first-time as well as repeat visitor to some of the qualitative and technical aspects of plasma and electrodynamics, and to demonstrate the importance of the perspective that charge separation is maintained by cosmic plasmas, resulting in large scale energy flows in the Universe that, in most cases, can far supersede the force of gravity.

Some observations on the Electric Universe paradigm. What precisely does the Electric Universe cover? How do some of its assumptions and interpretations of observations and data differ from those in astronomy and astrophysics, and other areas of science? What areas of science may be affected if the predicted effects of large electric discharges are correct?

Electrical circuits, and how energy is transmitted in space. A brief historical description of electrical energy transmission in electrical circuits, with some thoughts on how that singular phenomenon translates to the cosmic scale, where the "wiring" consists of plasma filaments connecting stars, planets, and galaxies.

1. Introduction

There (is) (will shortly be) a new section on the website www.thunderbolts.info, called "The Essential Guide to the Electric Universe".

In 2009 Dave Talbott, co-author with Wal Thornhill of **The Electric Universe** [1], asked Bob Johnson to write a summary which could serve as a basis of understanding for readers relatively new or confused about Electric Universe (EU) concepts.

Bob Johnson's summary [unpublished,©], which derives in large part from the works of the masters of plasma behaviour, namely Kristian Birkeland, Irving Langmuir, Hannes Alfvén and most especially Anthony Peratt and his comprehensive analysis of plasma behaviour in **Physics of the Plasma Universe**, underpins this new site.

The aim of Bob's summary was to lay the foundations for a basic understanding of plasma behaviour, without which the concepts advocated by the proponents of the Electric Universe might seem far-fetched. The new website seeks to incorporate and build on those foundations with examples of the underlying plasma behaviour drawn from the observed Universe.

1.1. Structure of the Essential Guide

The EG starts with familiar territory such as how far away stars and galaxies are, and discusses the historical antecedents and figures of classical science who have contributed to the electromagnetic sciences in particular. Local effects of an electric origin in phenomena such as the auroras and the magnetospheres of planets and some moons, as well as evidence observed about the workings of the Sun, lend familiarity to a rather large arena.

The EG goes on to discuss plasma phenomena, which leads into a slightly technical discussion of how plasma works and why it is such a difficult subject to master and model with accuracy. There are 3 appendices, and a glossary is under construction for inclusion later.

In addition to still images and written references, there are links to videos, and more are planned. We also will include links to relevant Thunderbolts Picture of the Day, much of whose content is informative of ideas and diverse subjects under the broad heading of the Electric Universe. This is the Web; we plan to take advantage of its many resources.

1.2. Intended Audience

We want to reach an interested, intelligent audience who are willing to take a little time to consider these ideas. In this way, we hope to make people open up to seeing and interpreting what they see in the critical context of "could there be a plausible electrical cause or link involved here, that might offer a clearer or more accurate or simpler explanation of this?"

As an aside, I might add that it is my personal hope that this association between the NPA and the EU folks will be a stimulating, fruitful and highly motivated 2-way dialog. While most of us in the EU do not have access to raw data from NASA or ESA or university research studies, even fewer, like me, know what to do with it. It's still early days, and I know I have to be a perpetual student. Many scientists and mathematicians are NPA members. Your participation and help are sorely needed, in my view.

[Sample pages from the EG to be presented at the conference]

2. Observations on the Electric Universe Paradigm

The label *paradigm* is used in this title rather than "theory", because the ideas, as presented by the leading thinkers in this domain are less than full-blown theory and are still in a very *qualitative* state of patterns and examples .

Underlying mathematics is not yet the EU's long suit, although a large classical groundwork of mathematics describing widely understood physics and electromagnetic interactions is in place and widely used.

Plasma physics and quantitative reasoning must underlie any Electric Universe theory; it is a cornerstone to a set of linked ideas that branch off into many other avenues of research which make EU not just an astrophysics and cosmology domain.

2.1 Causal Reasoning and Qualitative Physics

Causal reasoning and qualitative physics should not be dismissed lightly, particularly at an early stage in the development of a set of ideas that may lead to a theory. Quantitative physics follows, in well-reasoned cases, which may evolve into adjustments to existing theory, or a new theory.

Johan De Kleer, researcher in The Intelligent Systems Laboratory at the Xerox PARC campus in Palo Alto, California, wrote a paper in 1984 that appeared in *Artificial Intelligence* titled "How Circuits Work" [2].

He describes a process for analyzing how the "functions" of [electronic, in his application] circuits can be derived through forms of analysis and reasoning. In his introduction he notes:

"This theory explains how the function of a circuit (*i.e.*, its purpose) is related to its structure (*i.e.*, its schematic). This issue is explored by showing how the function of a circuit is derived from its structure. The intermediate point between structure and function is behavior. Structure is what a device is, and function is what the device is for, but behavior is what the device does. Causal reasoning analyzes how disturbances from an operating point propagate through a circuit. It thereby determines the qualitative behavior of a circuit from its structure. In addition, unlike quantitative predictions it produces intuitive, causal explanations for the behavioral predictions. These behavioral predictions, combined with their explanation, form the basis for reasoning which explains how the purposes of the circuit are achieved by that behavior."

That appears to be a useful construct that could help the reasoning out of how a circuit-driven electric universe model might be evaluated and described, starting with the qualitative physics side. In his paper, he references three papers on the subject of qualitative physics itself. This, then, is a legitimate, researched and published area of enquiry in the realm of physical reasoning.

De Kleer says this about qualitative physics (paraphrasing three of his six points):

1. His analytic work is **based on earlier work** on qualitative physics. Those papers were concerned with broad issues and do not explore any domain in particular. His paper uses a detailed qualitative physics in his domain: electronics. It could be applied to any pursuit of science; qualitative physics is *domain independent*.
2. *Qualitative vs. quantitative*. One of the central driving intuitions behind qualitative physics is the idea that in reasoning about an artifact, one first obtains a deep intuitive understanding of how the artifact works and **then uses this deep understanding to guide further, perhaps quantitative analysis**. Most of the potential applications of qualitative reasoning to electronics discussed in [his] conclusion are based on this idea.
3. *Architecture*. The **computation** which uses the qualitative physics to produce *accounts for behavior* is **surprisingly complex**.

We need not be put off by the EU model's being in a stage of qualitative physics today; it is still necessary at this point. We should be concerned with refining the model, e.g., observing or describing its circuits and defining their behavior better, and deepening it with quantitative physics directed toward an electrical and plasma physics interpretation to better integrate the basic forces at work in the cosmos. The EU model implicitly includes gravitational and other forces; it does not exclude or dismiss them.

There may be simpler or more direct descriptions of a broad class of larger-scale phenomena in the Universe, if the developments in classical electro-magnetics from the 18th through 20th century, coupled with modern developments in physics and mathematics concerning plasma physics and electrodynamics, were to be utilized to their fullest extent in interpreting the rich flow of scientific observations we are reaping today. Were that to come to pass, a large revision of many concepts and underlying assumptions might be required.

The ideas of an Electric Universe are founded on the proposition that the energy that powers cosmic phenomena is rooted in the electromagnetic phenomena which arise in the plasma state of matter. Indeed, almost all observable matter in the Universe is in the plasma state.

Charge separation in cosmic plasmas provides the electric fields that accelerate charged particles to high velocities, and leads to the creation of large current flows at various scales that connect among bodies and formations in space. To date, *no one* knows precisely where lie the generators of collimated jets and filamentary currents spanning thousands of parsecs and more.

If there are electric currents in space, they must form closed circuits, with a motive force to initiate and maintain motion of their charged particles. Donald Scott, Ph.D., diagrammed primary and secondary circuits of electrical current in his diagram of the Sun in 2006 [3], based in part on Hannes Alfvén's heliospheric and galactic circuitry in 1981, [4], foreshadowing the virtually identical solar diagrams in 2011 papers by NASA researchers [5].

3. Cosmic Energy Transmission

3.1. Electric Fields

Electric fields are a critical part of a working theory of how large energy flows are transmitted great distances via cosmic circuits. For most of the modern era, it was thought that electric fields were impossible in space, as it was thought to be empty and non-conductive. When plasma conditions were found to exist widely in space, another reason was given: that plasma is infinitely conductive, or superconducting, and thus its magnetic fields were "frozen in", and the plasma was uniform, without significant charge separation. Hence, weak or no electric fields.

The discovery of large field aligned currents in 1979 by TRIAD spacecraft above the auroras of Earth [6] substantiated Norwegian researcher Kristian Birkeland's experiments, measurements and conclusions at the opening of the 20th century [7]; such currents are now called Birkeland currents. Directly detecting and observing such fields, although possible through inference from ion and electron measurements by satellites, is very difficult, and broad scale detection takes a lot of time or spacecraft or both. The distribution of such electric fields in space re-

mains largely unmapped as a result, although radio astronomy offers false color imaging at radio wavelengths which purportedly implies filamentary current-carrying plasma structures in space. [8]

The EU paradigm has it that there are cosmic scale, field aligned currents connecting as circuit structures ranging from stellar systems to galactic clusters, carrying current flows and transmitting energy across great distances to power stars and galaxies and other observed, but poorly explained, phenomena.

Our opinion is that there exist rational explanations, put forward by scientists and researchers and thinkers from the dawn of the knowledge of electricity through the present day, as to how these phenomena are to be described in more quantitative terms. Classic electromagnetic laws dating from Maxwell and Heaviside and forward, are the basis of today's university courses and research programs in electrodynamics and plasma physics.

3.2. Electrical Current

Electrical current can be defined as a flow of charged particles. This flow is often relatively slow, and not as fast as energy is measured to propagate in a circuit. We call the axial speed of charges along a conducting medium the drift velocity.

The charge-conducting medium can be a material with a highly mobile charged-particle population. Metals are one example; a plasma is another.

Electrical interactions between moving charged particles in the conducting medium give rise to resistance. So, to maintain a current, there must be something pushing the charged particles along against the resistance of the medium.

The most direct way to explain this is to note that where charge separation occurs, electric fields are set up, within which charged particles are influenced to move. Avoiding simple electrostatic situations, charge can be made to separate in a battery by electrochemical means, which gives rise to the electric field in the attached wires of a complete (continuous) circuit.

Another method is to mechanically rotate a loop or coil of wire within a magnetic field. This is the arrangement we call a generator; it converts the input energy of motion of charged particles (which "see" a changing magnetic field as they move from parallel to perpendicular to the field direction, and back again, in each half rotation) in the coil an into an alternating "electromotive force" or EMF in a connected circuit. So, again, work on moving the electrons is done by an electric field.

Yet another method is the charge separation that manifests in structures in plasma called double layers, discovered by Irving Langmuir, who termed them "double sheathes". As these operate at large scales, extremely strong electric fields can be set up. Evidence for a single source of charge separation in cosmic plasma is inferential (we observe and measure ion and electron energies and velocities and counts in circumsolar space with our scientific instruments, but not "voltage" *per se*, which needs a reference value for comparison), but it should operate under the same electromagnetic laws as electric fields and circuits do here on Earth.

Author and researcher Anthony Peratt, in his textbook **Physics of the Plasma Universe** [9], devotes Chapter 4 to *Electric Fields in Cosmic Plasma* and Chapter 5 to the subject of *Double Layers in Astrophysics*, including relevant equations, circuit models, computer simulations and diagrams of electric discharge. He notes in 5.5.3, Exploding Double Layers, "In most cosmic plasma situations the individual circuit elements must be replaced with elements that are distributed over cosmic distances. Thus, even the conducting "wire" itself, connecting the circuit elements, must be replaced by a transmission line representation of the current-carrying, field aligned, pinched plasma filament conductors." Example of double layer based phenomena include the Auroral Circuit, solar flares, double radio galaxies and quasars, and high-energy cosmic particle radiation.

Peratt gives an example in 5.6.2 finding that a solar filament carrying a current of 3 x 10^{11} A can sustain a maximum double layer potential drop of about 9 x 10^{10} V. Such a double layer is capable of accelerating particles to energies that correspond to the highest solar cosmic ray energies ever observed.

3.3. The Electromagnetic Field

Australian physics teacher Ian Sefton at the University of Sydney, Australia, presented a paper [10] that is in the *Proceedings of the 10th Biennial Science Workshop*. In it he clearly explains how the flow of electric energy is via the electromagnetic field set up by the charge separation that powers the circuit. The flow of energy can be indicated by calculating the direction and scalar value of *Poynting vectors* based on the direction and value of the electric and magnetic field value at any point around the circuit. (See 3.4 below.)

Sefton's paper referenced two papers by John Poynting [11], [12] dating from the late 19th century. This is therefore not new knowledge, but it seldom appears in physics textbooks. I owe Sefton a debt of gratitude for publicizing this, and for supplying me with a much larger list of references on this topic. Much of what follows regarding circuit functions and Poynting vectors is directly attributable to his valuable inputs.

Given an electric field which exerts force on charged particles, and a circuit around which particles can flow, there is a presence of excess charged particles on the surfaces of the "wires" comprising the circuit. If the circuit is not "complete" — a switch is open a or a wire is broken, say — the situation is electrostatic; the like charges will repel or exert forces on each other and try to rearrange themselves so as to be as far from all the other charges as possible. Practically speaking, magnetic field is not generated if there is no current.

In a metal wire the ions are bound into a lattice and so are less mobile than the electrons. In a plasma, the ions and electrons can all move fairly freely, even if there is a significant fraction of neutral atoms, molecules, dust, etc present in the plasma.

Gauss's Law states that the *direction* of the electric field created by a long straight conductor with a uniform charge distribution is radially away from the axis of the wire, and it is cylindrically symmetrical, that is the field strength **E** decreases away from the surface of the wire as if it were a series of weaker and weaker concentric cylinders. For conductors which are curved or have bends or carry differing amounts of charge along their surface, the computations are more complex, but still obey Gaussian Law concerning the field direction and intensity at points in space outside the wire. As long as the electrons are not flowing along the wire, there is no electric field inside the wire, nor an electromagnetic field outside the wire.

If the circuit is completed, the electric field created by the source of charge separation (battery, generator, double layer or plasma sheath) also exists inside the wire and the charged particles undergo an acceleration (the "push" by the E field) and move against the resistance offered by the conductor. Further, the current flow generates a magnetic field around the conductors. Together these two fields are the electromagnetic field of the circuit. Sefton, in 2002, quotes Arnold Sommerfeld, 50 years earlier: "Metals conduct current but space conducts energy and the best conductor of electromagnetic energy is the vacuum!" I would add that matter in the plasma state conducts even better than metals.

In addition to their use in electrical energy flux analysis, Poynting vectors are also widely used in lens design for elements in fiber-optical circuits, as well as in microwave transmission design using coaxial cables.

Why not use this technique in simulations of Birkeland currents and stellar jets and solar filaments to visualize where the actual electrical energy flows are taking place and how they vary with time and other variables?

3.4. Electromagnetic Field and Energy

From Obituary Notices for John H. Poynting [13], a letter from Sir John Larmor noted, "Nobody before Poynting seems to have thought of tracing the flux of energy in a medium elastically transmitting it, and where the whole process is therefore exposed to view."

John Poynting showed mathematically that the electric and magnetic fields are associated with energy in two important ways:

- They **store energy**
- Together they are responsible for the **transmission of energy**

Poynting's theory states that there will be a flow of energy through any place where the **electric and magnetic fields both exist** and **are not parallel to one another**.

In a short length of current carrying wire, the electric field in the space around the conductor will be normal to the wire and the magnetic field direction is around a circular plane normal to the wire. So long as there is a current, both an electric and a magnetic field will exist, and the first requirement above is met.

There is a second electric field inside the wire when current is present, whose direction is parallel to the axis of the wire. Just at the surface of the wire, the interface between conductor and the adjacent space, the axial electric field exists in conjunction with the radial electrical field. Near the surface of the conductor, then, the electric field vector may point at an angle to the surface of the wire, but it is still in a plane that contains the axis of the wire. Since the magnetic vectors lie in planes perpendicular to the wire's axis, and electric field vectors are co-planar with the wire axis, they meet the second requirement above, that they not be parallel.

Through any point, two straight lines determine a plane which contains them both. Consider the magnetic and electric field vectors at such a point, with some angle in the plane between them (the *lesser* of the two possible angles is used).

If the space around these vectors is "empty" or is made of non-magnetic material, Pointing showed that the energy flux density **S** (energy per unit time, such as Joules/s) equals

$$\mathbf{S} = \frac{\mathbf{E} \times \mathbf{B}}{\mu_0}$$

The direction of **S**, the Poynting vector, is perpendicular to the imaginary plane of the two EM vectors **E** and **B**, using the right hand rule from the first vector to the second. Its scalar magnitude is EB sin ϕ, where ϕ is the lesser angular difference between the **B** and **E** vectors.

Sefton notes that, "In a wire with very low resistance, the axial electric field needed to move the charge carriers is relatively small, and the total electrical field outside the wire must be nearly perpendicular to the surface." Plasmas exhibit very low resistance, but not super-conductivity, so this condition likely describes the external electric field outside a plasma filament.

3.5. An Example Circuit

In Sefton's illustration of a simple circuit, he has only a source of charge separation (a battery), with a conductor attached to each end (+ and -), said conductors being attached to a simple electric light globe with a high-resistance conductor (filament) completing the circuit. He indicates the magnetic field lines encircling the conductor at various positions, and denotes the electric field lines which are normal to the conductors. The direction of the Poynting vectors is also shown. These vectors illustrate that the energy flux goes from the battery to the part of the circuit containing the light, as well as to the entire circuit since the electric and magnetic fields have no limit on their extent, but simply get weaker with distance from the current.

This is a 2-dimension illustration, but a cosmic circuit with energy distribution would be a 3-dimensional flux of Poynting vectors, possibly complicated by other field contributions of nearby bodies, plasma flows, etc.

3.6. Jupiter and Saturn

From observing that Io "generates" an electric current of some 3 million amperes [14, 15] astronomers had predicted that they would find something similar at Saturn. Both of these gas giants have numerous moons and rings. Each has a moon orbiting in a plasma torus or ring that is composed of ions and electrons from atoms discharged from the moon's surface, in a process typically termed volcanoes or geysers; i.e. heat is generated and matter is ejected from the surface, some of it at greater than escape velocity.

The NASA/JPL/Cassini team announcement [16] in April, 2011, reported finding a "very large" electron-ion current connecting Enceladus to Saturn's auroral oval around its north pole, aligned with the planets magnetic field. Unlike Io, a similar footprint has not yet been identified in Saturn's south polar regions, although there appears to be evidence of the high current flow near Enceladus's south polar regions, where the so-called "cryovolcanic geysers" along the rille-like, so-called "tiger stripes" eject a plasma of charged particles into the collocated E-ring, *i.e.*, Saturn's plasma torus. These "tiger stripes" are measured to be almost 100K warmer than surrounding terrain. Here are at least two cases of *direct in situ measured evidence* of electrical circuitry in

space. It is at least plausible to imagine that similar phenomena could occur at different places and at different scales elsewhere in the Universe.

Scientists continue to publish [17], [18] that tidal or shear heating due to the gravitational attraction between planet and moons is the source of such phenomena, causing thermal venting by "cryovolcanic geysers", when electric fields and charged (ionized) particles are present as part of the available forensic evidence. Similar events are observed at moons of Jupiter and Neptune. The possibility of Joule heating of underground water ice (not explored in the literature) may be more plausible than tidal heating if telluric currents exist within Enceladus and other bodies. Another hypothesis, megawatt electrical current flows machining away and accelerating surface and sub-surface material into space, is not even evaluated, despite the fact that electrical discharge machining (EDM) is not a just theory in factories on Earth, it is an engineering reality

Peratt has noted the difficulties in detecting and measuring current flows in space directly. In the case of the gas giants, and elsewhere, it is still unclear as to the precise source of these currents in the complex motions of differential moon and planetary rotation and orbital periods, the magnetic field aligned current between moon and planet, and the coplanar plasma toruses containing signatures of electrically discharged surface materials. There are, electromagnetically speaking, a lot of moving parts, electric currents in different planes, and magnetic and electric fields. Is the driver the gas giant planet, with a metallic hydrogen core rotating and acting as a dynamo to create the voltage potentials that drive the currents, or are the moons and their plasma ionospheres slicing through the differentially rotating planetary magnetic fields and generating those currents and auroral footprints? Or from the solar system scale, is it the Sun and its heliospheric current sheet to be considered the dynamo behind *all* the currents throughout the heliosphere?

4. Conclusion

Many contemporary theories of the Universe are being introduced to the public as fact by popular magazine and book publications. The basic qualitative ideas of the Electric Universe, from the Thunderbolts web site and its publications, may challenge readers critical of the status quo to investigate more closely some of their basic premises and observations.

The EU group hope to help persuade others better suited by training, attitude, scientific knowledge and rigor than I possess, to help pursue some of these ideas and to assist in bringing them to the attention of scientists and the lay public alike. I appeal to members of the NPA to consider these things, and to interest themselves in looking into the plausibility of the model. Your sincere, constructive criticism and scientific and mathematical assistance are heartily solicited in evaluating and furthering these unconventional but plausible ideas.

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