The Positive Side of Electrons, Electric Current and Electromagnetism

by

David L Johnson

(Email: David.Johnson.Pivot@gmail.com)

September 2024

Abstract

The electron represents one of the most exciting and important particles in atomic science. Electrons are very small and mobile fundamental (or elementary) particles that engage in orbitals around atomic nuclei, or can move as an electric current through a conductor, or can spectacularly jump en masse through dielectric material in the form of lightning or an electric arc. They are also important in atomic bonding and chemical reactions.

Electric current is usually understood to be caused by the movement of electrons, but electric charge carriers aren't always electrons, and they aren't always negative. In animals (including humans), electric charge carriers are primarily sodium, potassium, calcium, and magnesium ions, which are all positively charged, and when a nerve passes an electric signal, it consists of positive charge movement. For semiconductors, electric current cannot be fully explained simply in terms of the movement of electrons (the negative charge carrier), and a positive charge carrier is required.

With like-charges repelling and opposite-charges attracting, we treat negative electric charge as being distinctly different to positive electric charge, or at least that the electric fields associated with each type of charge to be different. This paper considers what ***electric charge*** *and associated* ***electric fields*** *might consist of, and attempts to explain the reasons why the positive and negative fields of electric charges interact with each other as they do.*

In terms of like-pole repulsion and opposite pole attraction, ***magnetic fields*** *are quite similar to electric fields, and are inter-related as implicit in the term '****electromagnetic****'. This paper looks at several models for the electron and its role in electric currents, and explores the nature of and differences between electric and magnetic fields with reference to the STEM electron model.*

Note. This paper is a slightly modified version of the first five introductory chapters of the position paper titled 'Electricity and the Duplicit Electron', updated and newly released by the STEM Development Group (SDG) in September 2024. This paper has been prepared and published with permission of SDG.

The chapters omitted from the full position paper are: Chemical Battery Power Sources; Electromagnetic Induction; Electromagnetic (Motor) Force; Eddy Currents and the Hall Effect; Static Electricity (Electrostatic Charge); Capacitors and Inductors; Micro and Radio Waves; Semiconductors and the P-N Junction; Photovoltaic Cells; Photodiodes and LEDs; and NPN and PNP Transistors. The appendices on the development of the electron model and a derivation of electron's g-Factor have also been omitted.

The full SDG paper is freely available via this link: Electricity and the Duplicit Electron.

Electron Models

In textbooks, electrons are usually portrayed as small monopole spherical particles. However, when fed into the **Dirac** and **Schrödinger** wave equations, spherical particle stats generate unwanted and unmanageable singularities. To avoid such problems, the spherical electron model is reduced to a dimensionless dot, referred to as a **point-form definition**. A consequence of this mathematical expediency is that all the electron's energy and mass is considered to be concentrated at a dimensionless dot, which has no radial width. This means that the point-form defined electron cannot have conventional angular momentum due to a physical spin and, consequently, an electron's observable/measurable angular momentum is considered to be **intrinsic spin** (i.e. an inherent property that defies explanation), with a **spin-up electron** having a quantum number $m_s = +1/2$, and a **spin-down electron** a spin quantum number $m_s = -1/2$. Despite having a point-form definition, electrons and their intrinsic spin are typically represented as shown in figure 1.

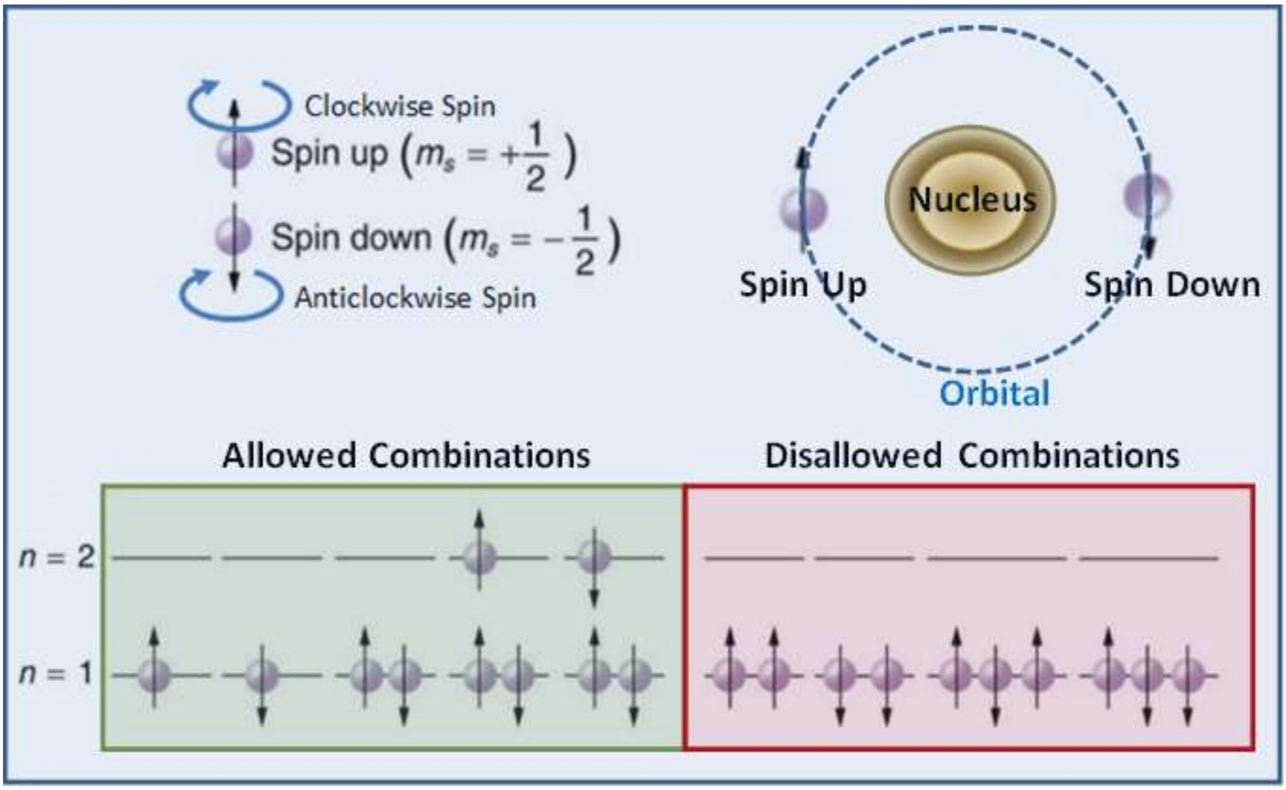


Figure 1: Electron Spin and Atomic Orbitals

According to the QM-based **Standard Model**, a **fermion** is a fundamental (or elementary) type of particle that has **half spin**. An electron is a **lepton**, which is a sub-class the fermion category, that is used to define the base electric charge -1e, and a **positron** is an **anti-particle** of an electron with a charge of +1e. The Pauli Exclusion Principle (PEP) was first identified by the Austrian physicist Wolfgang Pauli in 1925, and by 1940 PEP had been generalised and extended to include all fermions. Couched in QM terminology, the generalised form of PEP states that two or more **identical fermions** cannot occupy the same quantum state within a quantum system simultaneously. Thus, for electrons, PEP means that two electrons with the same '**up**' or '**down**' spin cannot occupy the same atomic orbital.

From a purely theoretical point of view, QM electrons and positrons are both structureless point-form particles. The QM model is thus essentially a mathematical model of the electron and positron designed to work well with the theoretical mathematical models that piggy-back onto the wave equations, but it is far removed from being a **physical model** for the electron. However, logically, something cannot come from nothing, and thus electrons and positrons must, at very least, consist of an infinitesimally small jot of **fundamental electromagnetic material** that has inherent charge characteristics (negative for electrons and positive for positrons), spin ('intrinsic' or physical) and mass.

Although the point-form definition of the electron and positron might have proven useful for the development of QM concepts, it unfortunately stifles incentive to explore potential structures for fundamental particles such as the electron and positron, and the potential development of a realistic physical model that might better explain their properties and behaviour. And certainly there is no funding available to encourage and support any such research.

A well-documented alternative model to QM-based point-form model is the **Toroidal Solenoidal Electron** (**TSE**) model, which considers an electron to consist of a spinning electric charge that moves at high speeds in a **solenoidal** pattern around a torus-shaped pathway: based upon references [1] to [6], figure 2 shows examples of variations of the TSE model.

An advantage of a toroidal model over a spherical model is that it can validly be represented by the point at the centre of mass of the torus because no electromagnetic material physically exists at that point. The main electromagnetic properties (mass, charge and spin) are associated with, and can be thus considered to be concentrated at, the centre of mass without having to shrink the physical size of the particle as for the point-form QM model. TSE models are physical models that, mathematically, can be validly treated as a point-form particle to satisfy the QM wave equations. Several authors (references [7] to [10]) claim that TSE models are more realistic and potentially provide an equal, if not better, fit to the observed properties and electromagnetic characteristics of electrons than the QM-based monopole point-charge model does.

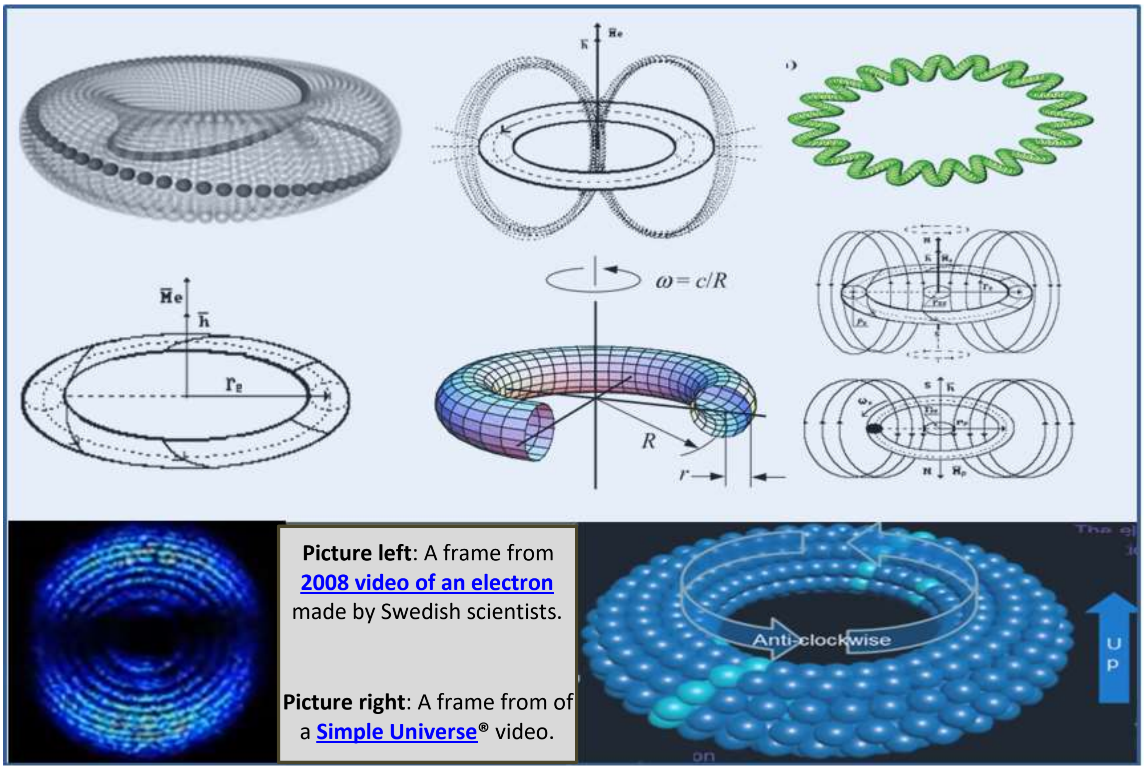


Figure 2: Examples of Torus-Based Electron/Positron Models

More recently, in 2015/2016, D Bowen and R Mulkern (references [12] and [13]) developed the toroidal-based **Charged-Electromagnetic-Wave-Loop** (**CEWL**) model that, unlike the TSE model, does not have a solenoidal spin of charge around the torus. CEWL considers that an **electron** consists of a negative sinusoidal **electromagnetic wave** moving at the speed of light around a toroidal path so as to generate the electron's charge and magnetic field. For a **positron**, a positive electromagnetic wave is considered to move around the toroid in the opposite direction to that of the electron: the figure 3 composite shows how the magnetic field (green) generated by the CEWL positron (the red wave-form) and the CEWL electron (blue wave-form) has the same circular direction around and through the torus.

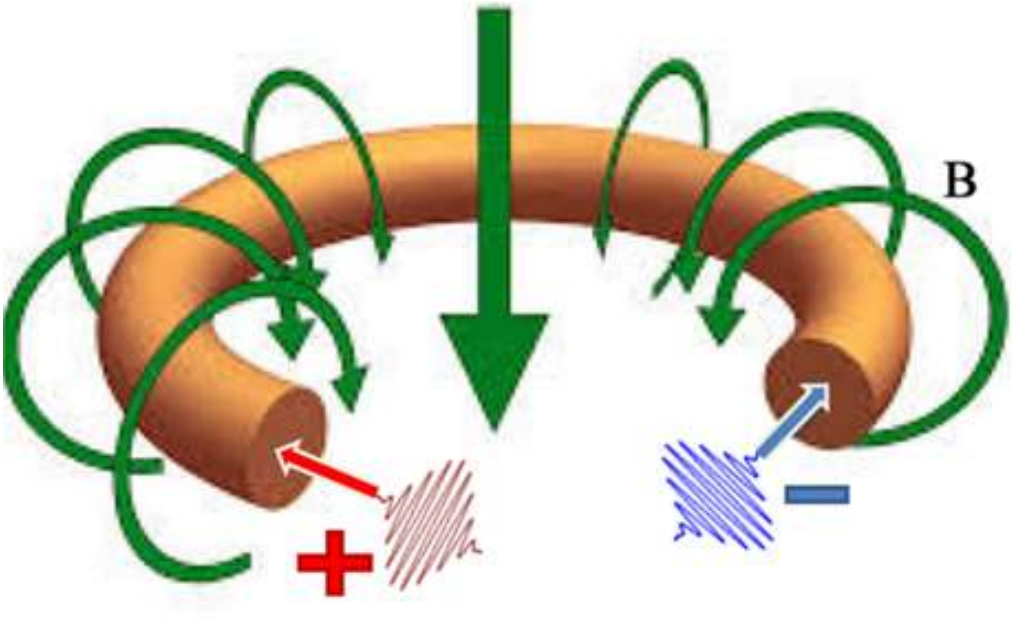
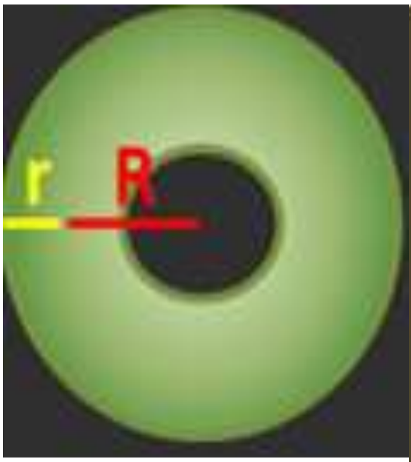


Figure 3: The CEWL Electron/Positron Model

[The CODATA radius of the electron](), which represents "[classical electron radius]()", is 2.82 $\times 10^{-15}$ m. Earlier estimates by M MacGregor (reference [16]) placed the radius of an electron in the range 4 x 10^{-13} to 7 x 10^{-13} m, which is compatible with the 2015 Bowen and Mulkern (reference [13], with a copy of the calculation shown as figure 4 estimate the radius to be 3.86 x 10^{-13} m. These two estimates are about 100 times larger than the classical CODATA estimate for an electron radius, and thus it is reasonable to assume that the actual size of an electron remains unknown.



Energy-Core of STEM Electron

Note. A discussion about **electron size** and the derivation of the **electron g-factor** is provided in the [Appendix]() of this paper.

Known values and definitions:

Q_e (charge of electron) = 1.602176565(35) × 10^{-19} Coulombs [4];

μ_e (bare magnetic moment electron) = 9.27400968(20) × 10^{-24} Amp·m² [5];

g (g factor correction) = 1.00115965218073 [6];

Note: see Postulate 4) below for when and why to apply g factor correction.

C (speed of light) = 2.99792458 × 10^8 m/s;

T (transit time at speed C around loop of diameter d) = $\pi d/C$;

μ_l (magnetic moment of current around any circle) = Amperes × $\pi d^2/4$.

For a charge of a single electron going in a circular loop at the speed of light:

$$Amp_e\,(\text{Ampere around loop}) = \text{Coulomb/s} = (Q_e/T) = Q_e \Big/ \left(\frac{\pi d}{C}\right)$$

$$\mu_l = Amp_e \times \left(\frac{\pi d^2}{4}\right) = Q_e dC/4$$

Solving for the "d" that satisfies the known bare magnetic moment μ_e:

$$d_e\,(\text{diameter of electron loop}) = 4\mu_e/(Q_e C) = 7.72318492 \times 10^{-13}\ \text{m}$$

$$\text{Length around loop} = \pi \times 7.72318536 \times 10^{-13}\ \text{m} = 2.426310 \times 10^{-12}\ \text{m}$$

Figure 4: CEWL Calculation of Electron Diameter and Circumference

The energy-centric [**S**pin **T**orus **E**nergy **M**odel]() (**STEM**), as proposed by the STEM Development Group (**SDG**), is another toroidal model quite similar to the CEWL model. Both these models have half-spin and satisfy the QM wave equations. However, the STEM and CEWL models are fundamentally different from the QM-based Science models and the other toroidal models because they both contend that it is the movement of electromagnetic material within a torus structure that generates the negative and positive electromagnetic charge characteristics of electrons and positrons. They both contend that the difference between negative or positive charge is due to the movement pattern of electromagnetic material rather than there being two distinctly different types of electromagnetic material (i.e. one material-type that carries negative charge and the other that carries positive charge).

Despite their similarities, there are distinct differences between the STEM and CEWL models. The CEWL model considers that the electromagnetic material consists of a negative or a positive electromagnetic wave or pulse, with an electron and a positron consisting of a photon of energy 0.511 MeV that is joined head-to-tail to form a torus-shaped particle.

The STEM model, on the other hand, calls the electromagnetic material '**energen**'. As for the infinitesimally small jot of fundamental electromagnetic material must be associated with QM's point-form definition of electrons and positrons, energen has no structure or form. It is postulated low concentrations of energen display [inviscid flow]() (or frictionless gas-like) characteristics, and readily forms circular swirls when it is made to flow; and when energen becomes more concentrated, its viscosity increases to the extent that it can display physical characteristics analogous to those of a **viscous** liquid and can even progress to the consistency of a **semi-solid** gel.

The STEM model for all fundamental particles, including electrons and positrons, consists of an inner torus encompassed by an atmosphere-like outer torus. The inner torus, called its **energy-core**, consists of concentrated energen that spins (i.e. it either has a semi-solid gel consistency exhibits **solid spin**, or has the consistency of a viscous fluid and exhibits **fluid flow**) at close to the speed of light. The energy-core is enveloped by a swirling outer torus of less concentrated energen that has inviscid fluid-like (gas-like) flow characteristics, referred to as its **field-energy**, which flows around and through the energy-core torus. The field energy is responsible for the electromagnetic characteristics of fundamental particles, which in turn govern the manner in which they interact with other particles and electromagnetic fields. The energy-core provides the bulk of the particle's mass and its particle-like characteristics.

Largely based upon a Bowen and Mulkern type of calculation (figure 4), STEM considers the large central radius (**R** in figure 4) of the STEM electron's energy core to be 4 x 10^{-13} m (or 0.4 pm) and the small radius (**r**) to be 1.75 x 10^{-13} m (or 0.175 pm) to produce an estimate of the large outer radius (R+r) of 5.75 x 10^{-13} m (or 0.575 pm).

For the STEM model, the atmosphere-like swirling outer torus of field-energy is **chiral** (i.e. it has **helicity**), and can present with **left-handed chirality** (as in figure 5) for electrons or with **right-handed chirality** (as in figure 6a) for positrons.

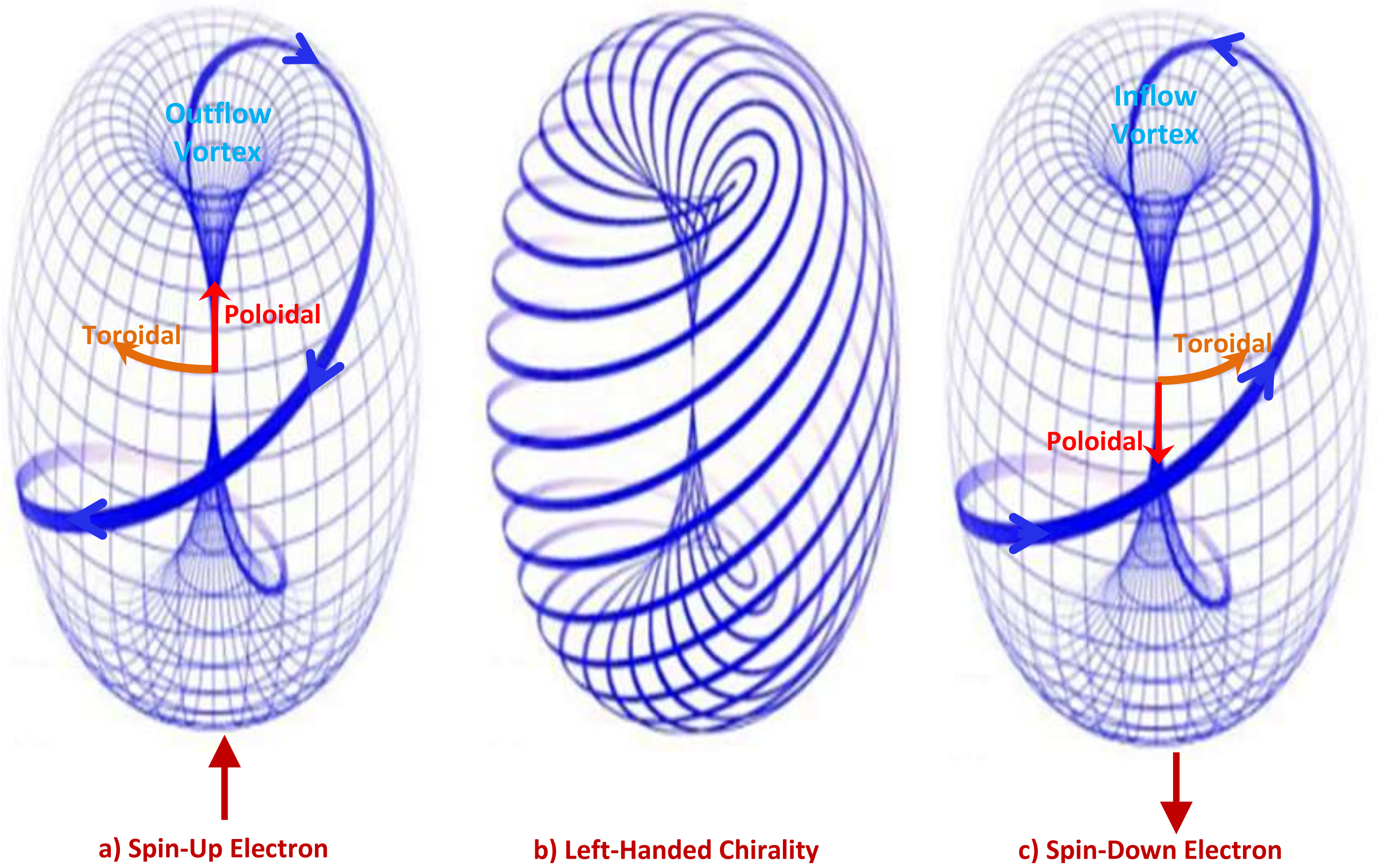


Figure 5: Chirality and Spin-Up/Spin-Down Electrons

The swirling flow pattern of the field-energy forms an **outflow vortex** and an **inflow vortex** at opposite ends of the outer torus as can be seen in figure 5. When the outflow vortex is upmost, as in figure 5a, it is considered to represent **spin-up** electron; and **spin-down** is when the inflow vortex is upmost (i.e. the outflow vortex is at the bottom) as in figure 5c. The **toroidal** and **poloidal** flow components determine whether the flow pattern represents left-handed (for electrons) or right-handed (for positrons) chirality. Left-handed chirality can be checked by pointing the thumb of a closed left fist in the poloidal direction at the outflow vortex, with the finger wrap direction indicating the toroidal flow component's direction. Note that this works regardless of whether it is in spin-up or spin-down direction, or anywhere in between, and that the right-hand can be used similarly to check for right-handed chirality.

In this Markoui animation, the difference between poloidal (labelled 'revolution') and toroidal (labelled 'rotation') movement components can be appreciated, with the rightmost combined animation having left-handed chirality. This excellent Markoulakis animation, related to a ½ spin fibre model for the electron [20], also shows the net flow of the field energy of an electron and positron (note: **N** is the outflow vortex end and **S** inflow end).

The **core-energy** of the STEM electron accounts for the bulk of an electron's energen, and thus its mass and associated angular momentum, with the external **chiral energy-field** being responsible for its **electromagnetic field** characteristics. It is thus a **particle-like** model, with electrons and positrons having distinctly different chiral forms but each having the same energen quanta and radial size. When STEM electrons and positrons are represented as point-form particles, the model satisfies the Dirac wave equation and thus, from a mathematical perspective, they can also be considered to be **wave-like**, which helps with a theoretical explanation of the particle-wave duality often claimed for electrons.

Unique to the STEM model is the concept that, although the field-energy has a chiral twisted flow pattern, due to its viscous nature, the energy-core is considered to either undergo physical spin should it be gel-like, or toroidal flow (i.e. without any poloidal flow component) should it act as an inviscid fluid.

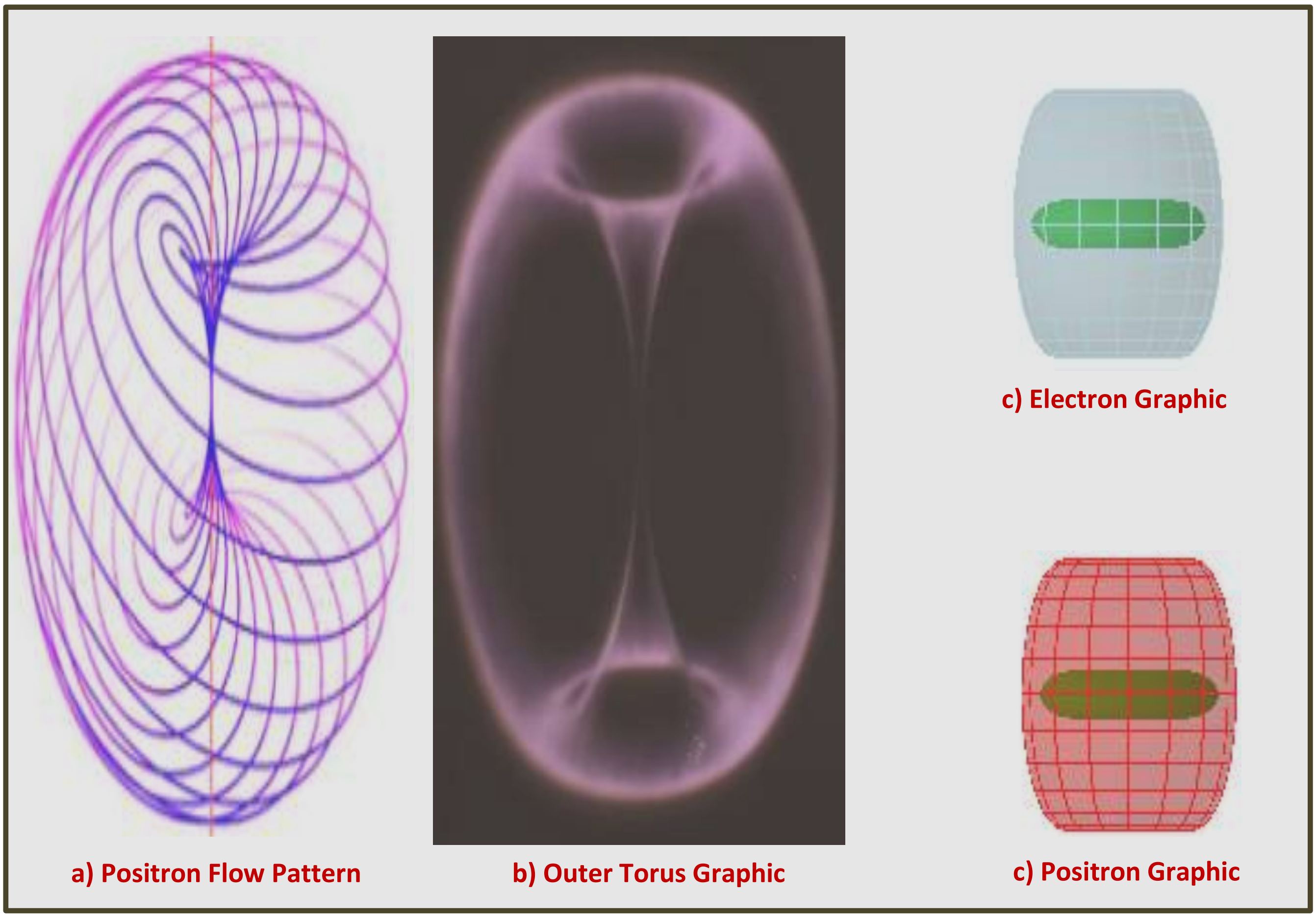


Figure 6: Positron and Electron Graphics

A cross-sectional representation of an electron and a positron is shown in figure 7. The toroidal flow component of the energy-field has the same direction as the core-energy's spin, with the latter being indicated by the red arrow-points and arrow-quills. The arrowed ellipses indicate of figure 7 indicate the poloidal flow direction of the energy-field.

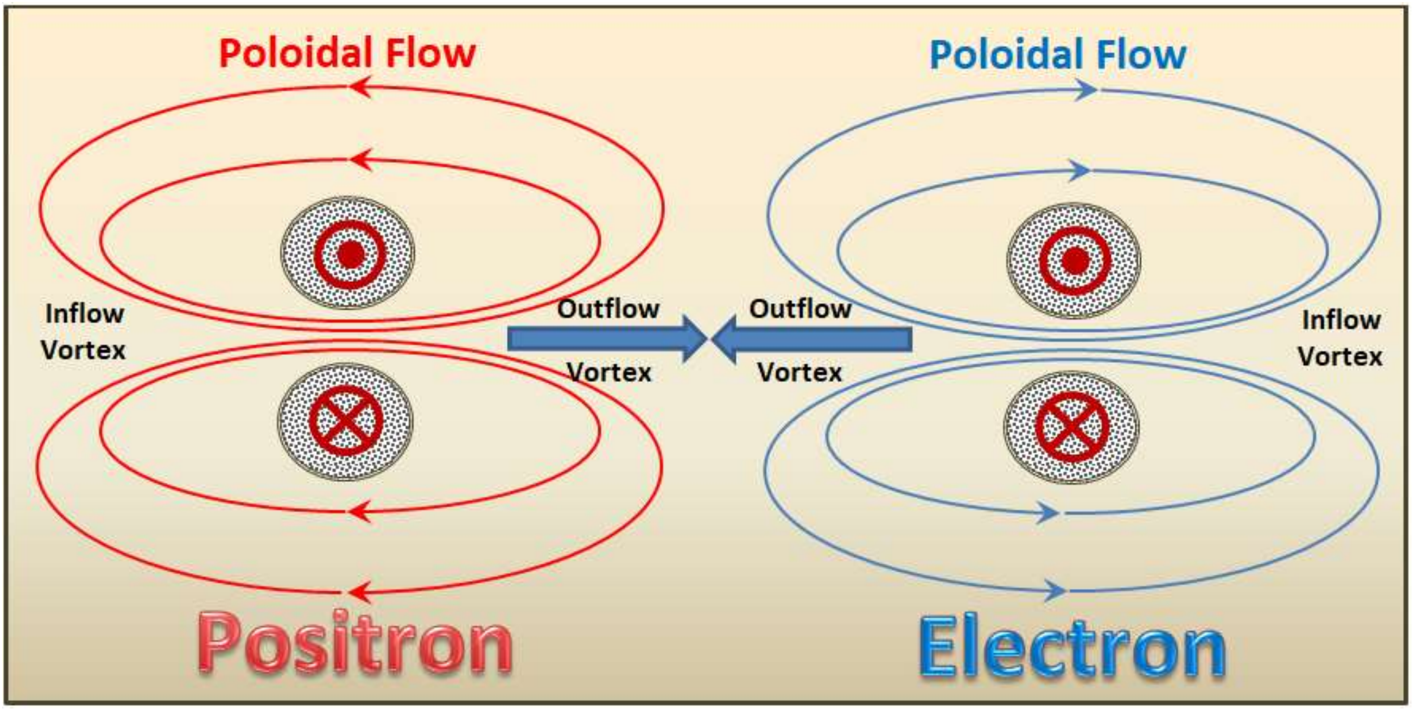


Figure 7: Positron and Electron Cross-Sections

In an energised environment additional energen can build up in the field-energy, so extending the strength and range of the particle's electromagnetic field. In a de-energised environment the field-energy can be reduced so that, at close to absolute zero, it can become ineffective. Although there may be some transfer of energen from energy-core to field-energy and vice versa, despite any such energen interchange, the amount of energen within the energy-core is considered to remain relatively stable, as is the electron's mass.

Chapter Summary

A major problem with the QM-based conventional Science model is that the size of the electron is reduced to a point-form definition to prevent the Dirac and Schrödinger wave equations generating unwanted singularities which, in turn, leads to them being allocated 'intrinsic' spin. Toroidal electron models, on the other hand, have nothing (i.e. no electromagnetic material) at their geometric centre of mass, and so can validly be treated mathematically as a dimensionless hypothetical dot with associated physical properties (e.g. width, mass, angular momentum, charge and quantum spin number) that are derived from the surrounding torus structure. A claimed added bonus is that the toroidal electrons, so defined, represent a physical model that satisfies the wave equations.

Apart from the CEWL and STEM models, most electron and positron models, including QM-based models, assume or imply that they are made from fundamentally different kinds of electromagnetic materials: one being responsible for negative charge and the other for positive charge.

The STEM electron and positron are considered to have the same structure as all fundamental particles. These particles consist of an inner torus of concentrated electromagnetic material (which is called energen), which forms the energy-core and represents the bulk of its robustness, mass and associated angular momentum, and an outer torus of less concentrated energen called the field-energy that envelops the energy-core and is responsible for its electromagnetic characteristics. The field-energy swirls around and through the energy-core torus, and has a chiral flow pattern. When the field-energy has left-handed chirality, the particle is considered to have negative charge and to be an electron; and when it has right-handed chirality it is considered to have positive charge and to be a positron.

Note that from this point onwards in this paper, the term '**conventional Science**' relates to the current status quo of Science opinion as it relates to Physics-based models consisting mainly of the **Orbital Nuclear Atomic Model** (**ONAM**), **the Standard Model** (**SM**) and the various forms of **Quantum Mechanics** (**QM**) specialisations, as well as the theory and practices of the applied disciplines of Chemistry and Electrical Engineering.

The Backstory about Positrons

The mystery about positrons started in 1898 when were Ernest Rutherford observed Beta Plus (β+) decay and discovered mysterious particle emissions that he called **positive beta particles**. They were considered to be a form of weird radiation from the radioactive decay of Uranium, and electrons from Beta Minus (β-) decay were similarly called **negative beta particles**. It wasn't until 1932 that Carl Anderson officially (re)discovered positrons by accident when conducting experiments related to cosmic radiation. Anderson's discovery was hailed as providing a validation of Paul Dirac's earlier theoretical prediction of the possible existence of the positron, the **anti-particle** of the electron.

Neils Bohr's nuclear model was developed around 1913, and evolved into Erwin Schrodinger's Quantum Mechanics model by 1926. However, positrons did not readily fit into either model because both contend that the only source of positive charge within matter relates to protons within the atomic nucleus. Even after the excitement of Carl Anderson's positron re-discovery in 1932, little has changed, and the mystery surrounding positrons continues.

Electrons are plentiful, and can be readily generated low-energy processes such as **electron guns** and the **Photoelectric Effect**, whereas positrons are relatively rare. Although β^+ decay produces low level concentrations of positrons, and provides a positron source as commonly used for medical probes and scanners, high-energy brute-force techniques (e.g. the 200 MeV high-energy Large-Scale Collider at CERN or Petawatt-plus lasers) are needed to synthetically generate useful quantities of positrons.

However, having a positron source does not provide an insight into their creation. There would seem to be three possible alternative explanations for the means by which positrons are created; namely:

1. Positron creation is an example of the direct dynamic and spontaneous creation of matter from gamma ray radiation via **pair production**.
2. **Positrons are created** by the high-energy impact conversion of electrons into positrons.
3. **Positrons pre-exist within matter** and simply require high-energy impact to release them.

Each alternative explanation will be discussed in turn in its own chapter.

Explanation 1: Pair Production

Electron-positron pair production is the most quoted example of the claimed dynamic creation of matter from photon energy. Pair production requires photon energy in the gamma frequency range, with the minimum net photon energy required being 1.022 MeV, which equates to the combined rest mass equivalence of an electron and a positron. The probability of pair production is claimed to increase with photon energy.

Breit–Wheeler pair production is the process by which a positron–electron pair is created from the collision of two photons in the gamma frequency range, with each gamma ray photon having a minimum energy of 0.511 MeV. It is represented by the following equation:

$$\gamma + \gamma \rightarrow e^- + e^+ \text{ (spontaneous simultaneous electron/positron creation)}$$

Despite being lauded within Physics communities and the wider press as an example of matter creation from electromagnetic radiation, the Breit–Wheeler process has never been observed in practice because of the difficulty in preparing colliding gamma ray beams and the very weak probability of such collisions. It is now widely interpreted as the possible splitting of one photon of energy greater than 1.022 MeV. Certainly, the actual pair production mechanism is speculative, and far from being well established, with there being wide variety of diagrams intended to represent and clarify the process. Figure 8 shows just four of these.

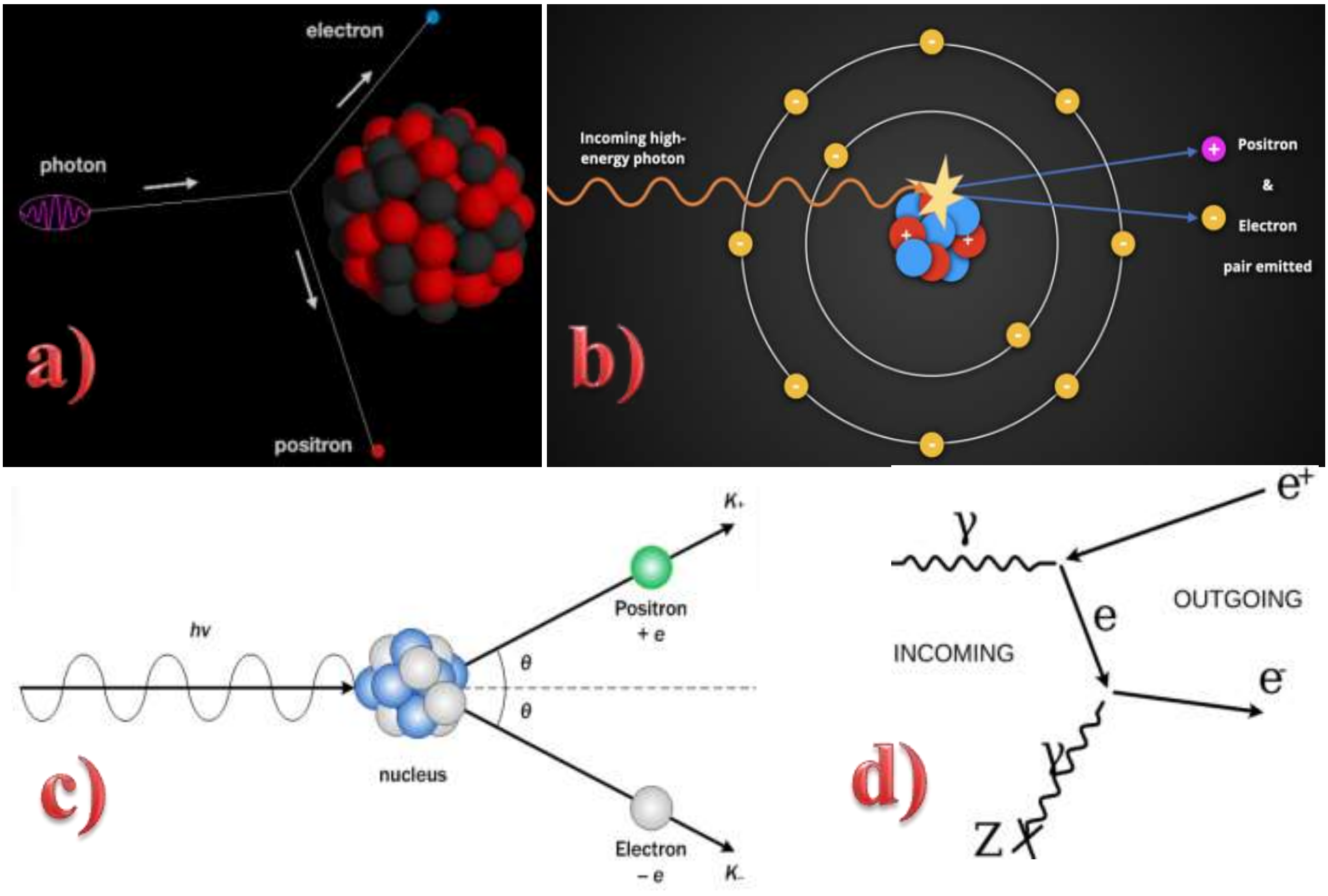


Figure 8: Electron-Positron Pair Production

So, *does the claimed Breit–Wheeler pair production occur by the magical splitting of a single photon by an atomic nucleus (as in figure 1a or 1c); the collision of a photon with an atomic nucleus (figure 1b); or the collision of a pair of photons (figure 1d)*? It all seems to be very confused and confusing. And note that, only in one diagram (figure 1b), the presence of orbital electrons is acknowledged and represented (albeit simplistically). However, for all such interpretations, the possible and highly likely interference between existing orbital electrons and the newly generated electron and positron particles is totally ignored.

The 2013 article by Sarri (reference [11]) describes one of the first Petawatt (=1015W) laser setups used to generate a positron stream (see figure 9). It provides a detailed discussion of the results and attempts to explain the creation process in terms of pair production.

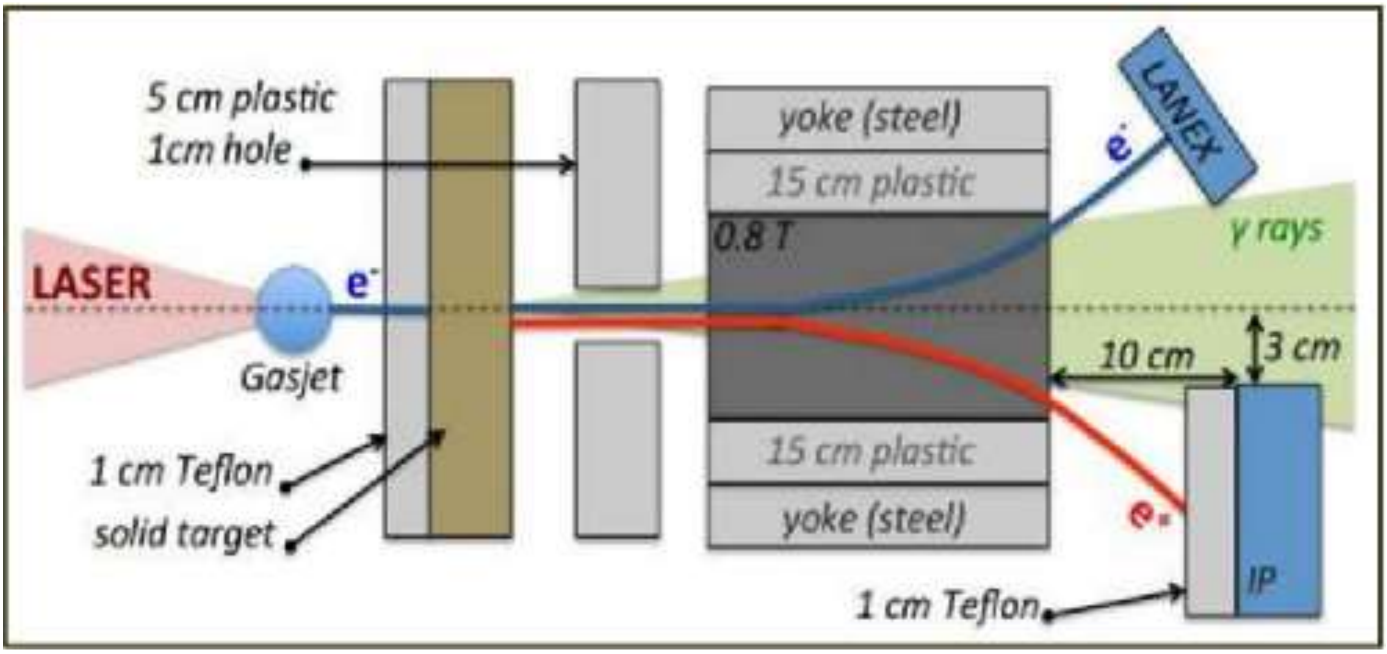


Figure 9: Benchtop Laser Setup for Electron and Positron Generation

The laser approach to positron generation involves bursts of laser light energy that bombard a solid target to produce an energised **electron stream** in the 80-200 MeV range. The Sari paper suggests that **gamma photons** are then generated by Bremsstrahlung, which is caused by the slowing down of the incident energised electrons. Bremsstrahlung is more effective for target atoms with a high Z number (atomic number) and a high packing density. The resulting gamma photons are then considered to create an electron--positron pair spontaneously via Breit–Wheeler pair production. These newly-created energised electrons and positrons then escape from the host material and are separated to generate separate electron and positron streams.

This explanation relies upon a quite complex hypothetical process, with electrons being energised by the laser that, via Bremsstrahlung, produce gamma rays that in turn somehow interact or convert into an electron-positron pair. The Sarri paper is technically excellent, and a good read, but its convoluted multi-process interpretation for positron creation is, from the SDG point of view, unduly complicated and far from being convincing or even possible.

Should pair production be the only (or even the main) means of electron and positron creation, it raises the question: *why aren't electrons and positrons present in equal numbers in Nature (i.e. 'normal' matter)?* Pair production creates pairs of electrons and positrons, and conversely electron–positron annihilation destroys them in pairs by converting them into gamma radiation. Should these two processes be the only or main ones that create and destroy electrons and positrons, then electrons and positrons should be present in Nature in approximately equal numbers, but they are not. So *why is there a scarcity of positrons in Nature, and where have all the positrons gone*?

Assuming that electrons and positrons are created and destroyed in equal numbers (i.e. in pairs), there are four possible scenarios that might account for why there is such a scarcity of positrons in Nature:

a) There is another process, as yet unidentified, that generates the vast quantity of electrons we find within matter without generating an equivalent number of positrons (or conversely, a process that consumes or destroys large numbers of positrons but not electrons),

b) Large numbers of positrons exist within anti-matter (as opposed to 'normal' matter) atoms, orbiting around negative-charged nuclei, somewhere as yet to be identified in the Universe,

c) Positrons are dynamically **created from electrons** by high-energy impact, or

d) Positrons **pre-exist within matter**, but to date have remained hidden and undetected.

Options (a) and (b) above would seem to be highly speculative wild-card possibilities that are quite unsupported. No attempt will be made to discuss or expand either of these two options. Options (c) and (d) correspond with earlier mentioned alternative explanations 2 and 3, and are discussed in the next two chapters.

Explanation 2: The Creation of Positrons from Electrons

Should a pair of electrons be traveling with their outflow vortices forward (the 'normal' orientation of electrons moving within an electric field according to STEM) and, should they be approaching each other head-on as shown in figure 10, then both their toroidal and poloidal flow components would be in the opposite direction to each other. This means that their energy fields should cushion any imminent collision and cause them to deflect each other or to rebound from each other intact.

However, should these two electrons be moving towards each other at a very high speed (such as a high-speed electron from the Sari setup of figure 9 colliding with an orbital electron), the cushioning effect their opposing energy fields could be rendered ineffective with the field energy of their outflow vortices becoming compressed with direct collision imminent. Such virtually instantaneous compression could be well expected to cause a **reversal of the poloidal flow direction** of the field energy of one or both electrons, which would instantly reverse their chirality. The result would be that one or both electrons would be converted into a positron.

So, instead of deflecting each other or rebounding from each other intact, the result of such high-speed collisions could well be the creation of two positrons recoiling from each other, or an electron and a positron recoiling from each other. Under these circumstances, the mix of particles exiting the target material would be energised electrons that have not collided with other electrons, or have survived a collision intact, combined with newly created positrons converted from electrons by head-on collision.

Sari (reference [11]), on the other hand, interprets the resultant mix of emitted electrons and positrons in terms of pair production. As explained earlier, this requires the generation of gamma rays via Bremsstrahlung of the energised electrons, with pairs of gamma rays would then somehow converting into an electron and a positron via pair production - quite a complex and daunting process compared with the simplicity of STEM's poloidal flow reversal of electron field energy.

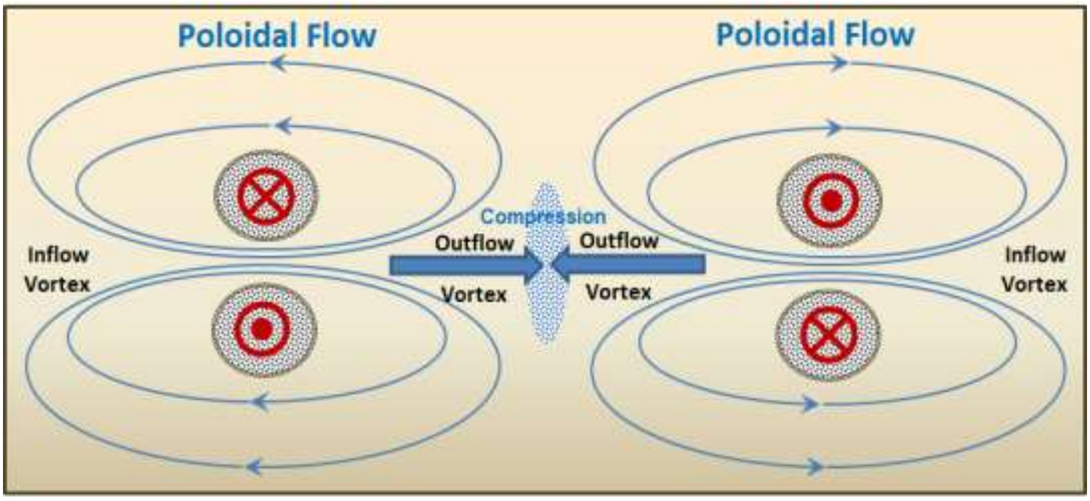


Figure 10: Head-on Collision between Two Electrons

The poloidal flow reversal of electron field energy can be interpreted as a process of **positron creation**, but it is really an electron conversion process. It is worth noting that a similar reversal of poloidal field energy flow direction is used to explain nucleon-type reversal (i.e. changing a neutron into a proton and vice versa) in STEM's explanation of Beta decay and Electron Capture (see reference [17]).

Explanation 3: Positrons Pre-Exist within Matter

As mentioned earlier, electrons abound within 'normal' material, and are readily released by electron guns, or can be ejected from metals by photons within and close to the frequency of visible light in a process called the photoelectric effect. Positrons, on the other hand, can only be produced from 'normal' material by high-energy impact of electrons, by gamma radiation, or via radioactive decay. This chapter explores the possibility that, as for electrons, positrons might **pre-exist** within matter but, unlike electrons, can only be released by high energy interactions such as the impact of highly energised electrons and/or by gamma radiation.

For positrons to exist within matter there would need to be a mechanism to keep them well separated from electrons so as to prevent mutual annihilation. One possibility is that they could be embedded into an atomic nucleus, which would keep them well clear of orbital electrons. This could be a possibility should a proton be a composite particle consisting of a neutron with an attached positron. This notion is supported by the generalised Beta+ decay, the equation for which is:

$$P \rightarrow N + e^{+} + \nu_{e} \qquad \text{where } \nu_{e} \text{ is a Neutrino}$$

However, there are no known atomic theorises or other evidence to support this concept, although there are some atomic theories, such as the Structured Atomic Model (**SAM**), that promote the concept of a neutron being a proton with an attached or shared electron. The Beta- (Beta Minus) decay process, which is the reverse process of Beta+ decay, converts a neutron into a proton. The generalised Beta- process equation is:

$$N \rightarrow P + e^{-} + \tilde{\nu}_{e} \qquad \text{where } \tilde{\nu}_{e} \text{ is an Anti-Neutrino}$$

Although Beta- decay supports the SAM approach, it does not support the concept that a proton could be a neutron with an attached positron. To support the concept of a proton being a neutron with an attached positron, a positron would need to be added to the neutron on the left-handed side of the above equation; instead an electron is released by the interaction.

Although having positrons being embedded within the atomic nucleus would keep them well separated from orbital electrons and allow positrons to exist within matter, it is highly unlikely that a positron attaches to a neutron to generate a proton. The only other place that positrons could possibly exist within matter is within orbitals around the atomic nucleus. So let's have a look at the atomic orbital option.

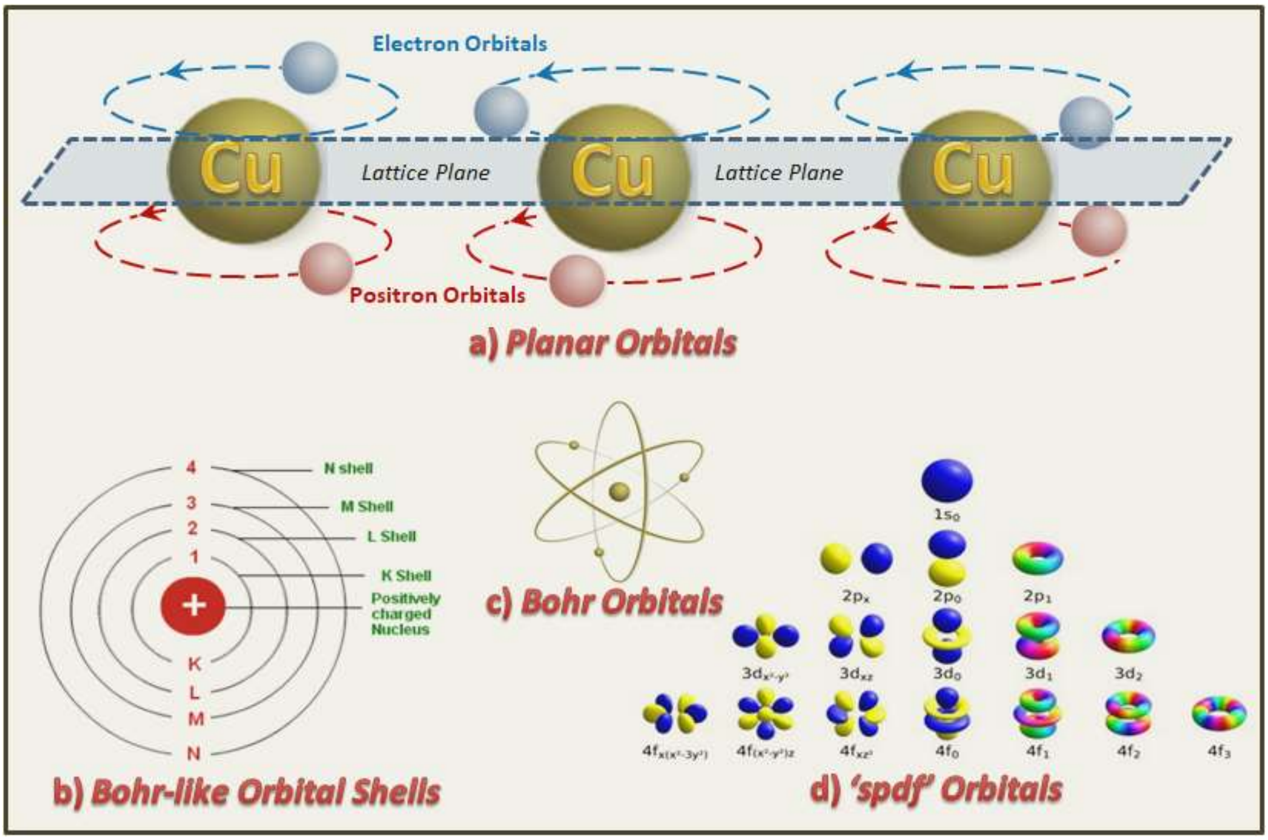


Figure 11: Alternative Atomic Orbital Schemes

For the early Rutherford/Bohr atomic models, electrons assumed shell-like planet-like orbitals (see figures 11b and c) around a nucleus. For planets, gravitational pull keeps them in orbits around the Sun, whereas electric field attraction was considered to keep negatively charged electrons in orbit around a positively charged nucleus. Since the advent of Quantum Mechanics, although 'spdf' orbitals (see figure 11d) that are derived from wave equations are far from planet-like in geometry, the planet-like sentiment remains, particularly in Chemistry texts. However, whereas our Solar has only 8 planets in orbit around the Sun, large atomic nuclei have many, many more electrons buzzing around an atomic nucleus: for example, according to conventional Science, gold, which is an enduring stable atom, has 79 electrons in orbit; uranium 92; and copernicium +112. Considering the speed of the electrons and the confined space around an atomic nucleus, this is a miraculous and mid-boggling proposition that beggars belief.

Although completely different to each other, both SAM and STEM have developed a physical structure for the atomic nucleus. With the STEM approach (see SDG's Atomic Structure paper: reference [17]), there is no need for the number of electrons to equal the number of protons for an element to be considered electrically neutral. The model thus does not support or require atoms to have multiple inner shell electron orbitals such as the inner 'spdf' orbitals or inner Bohr-like shells. Instead, STEM promotes **ionic orbitals** which, although functionally similar to those of conventional Science's conduction band electrons, have **planar orbitals** above and below the atomic nucleus rather than fully encompassing the nucleus. Geometrically, STEM's ionic orbitals are eerily similar to QM's $3d_1$ and $4f_2$ orbitals, and are about as simple a pattern as one can imagine. However, the possibilities unlocked by the adoption of ionic orbitals are amazing, particularly for explaining the cause and nature of electric current, electricity and electromagnetism.

Apart from having a planar geometry, each ionic orbital can support either electrons or positrons (not both). STEM suggests that good conductors, such as the metals, have ionic orbitals above and below their atomic nucleus, with one supporting electrons (e.g. upper as shown in figure 11a) and the other supporting positrons, so keeping electrons and positrons well separated at the atomic scale and preventing ongoing electron-positron annihilation events. This means that positrons may well be present in plain sight, having remained undetected because, apart from electric charge, they are identical. Also, unlike electrons, that are easy to eject from metals, positrons are difficult to remove from their host medium and require high-energy events to forcedly eject them.

As well as supporting the **ionisation** of elements, ionic electrons and positrons can form **covalent bonds** (see figure 12b), but without the electrons having to pass between nuclei of the bonded pair as for the conventional Science approach (see figure 12a), which requires really tricky navigation and timing.

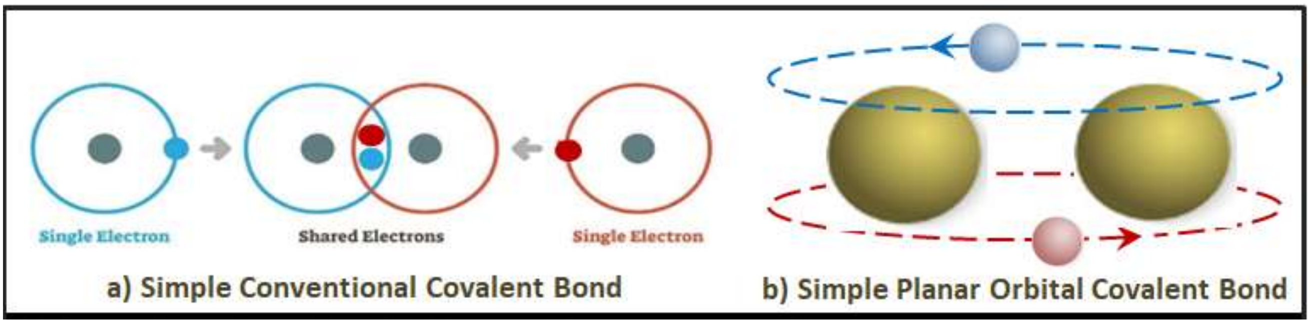


Figure 12: Covalent Bonding Schemes

STEM's proposed structure for the atomic nucleus (see reference [17]) can support ionic orbitals and provides an explanation for why positrons might be so difficult to eject from their host medium. However, even without the support of STEM's nuclear structure, ionic orbitals are just as feasible as the hypothetical QM 'spdf' or Bohr shell orbitals of conventional Science, which are somewhat oddities in themselves and in many ways incomplete.

In way of a summary, should positrons exist within matter, it would thus seem most unlikely that they would exist within the atomic nucleus. However, it is distinctly possible that they could exist within ionic orbitals. With both electrons and positrons having atomic orbitals, the only difference between them is their field energy chirality, which manifests as them carrying different charge: they both have the same mass, size, angular momentum and double-torus structure.

The proposition that positrons exist within matter and, like electrons, have their own orbitals, does not sit well with the conventional Science view of the atom. As soon as terms such as 'positron orbital' or 'positron charge carrier' are mentioned, the initial reaction of most people varies between confusion through to disbelief because it runs contrary to what they have been led to believe throughout their entire education. To minimise this problem, new terminology has been introduced. STEM uses the term **cetron** to refer to conventional Science's electron: the first two letters of **ce**tron stand for '**c**lockwise **e**lectron', indicative of its clockwise toroidal spin (as shown in figure 13a). The term **aptron** is used for a positron, with the first two letters of **ap**tron standing for '**a**nticlockwise **p**ositron'.

Furthermore, STEM often uses the term 'electron' generically so as to include positrons. When reference is made specifically to a conventional Science electron, it is variously referred to as a cetron, cetron electron or negative charge carrier (negative CC). A positron is specifically referred to as aptron, aptron electron or positive CC.

So, *where do positrons come from*? Should they pre-exist and occupy ionic orbitals within matter, it could well be argued that they simply require high-impact collision by energised electrons or gamma rays to dislodge and release them from their parent matter. However, a dynamic creation-and-release process involving high impact electron-to-electron or electron-to-nucleus collisions, as addressed in the previous chapter (i.e. Explanation 2), cannot be dismissed and remains a distinct possibility, particularly for the Beta decay process.

The Nature of Electric Currents

Electrical circuit theory is well established and straight forward, with electric current being defined as the one-way movement of negative **charge carriers** (**CC**) in the form of electrons. The Science convention, based upon like charge repulsion and opposite charge attraction, is for electrons to move from the **negative-to-positive** terminal of a power source, with Maxwell's left-hand grip rule allowing the determination of the circular magnetic field direction around a wire conductor. If, as for commercial and domestic electrical circuits, Benjamin Franklin's **positive-to-negative** flow convention be used, then Maxwell's right-hand grip rule applies, with CC movement being considered to be that of positive charge. The modified version of Maxwell's Right-Hand Grip Rule (see figure 13a) covers both situations.

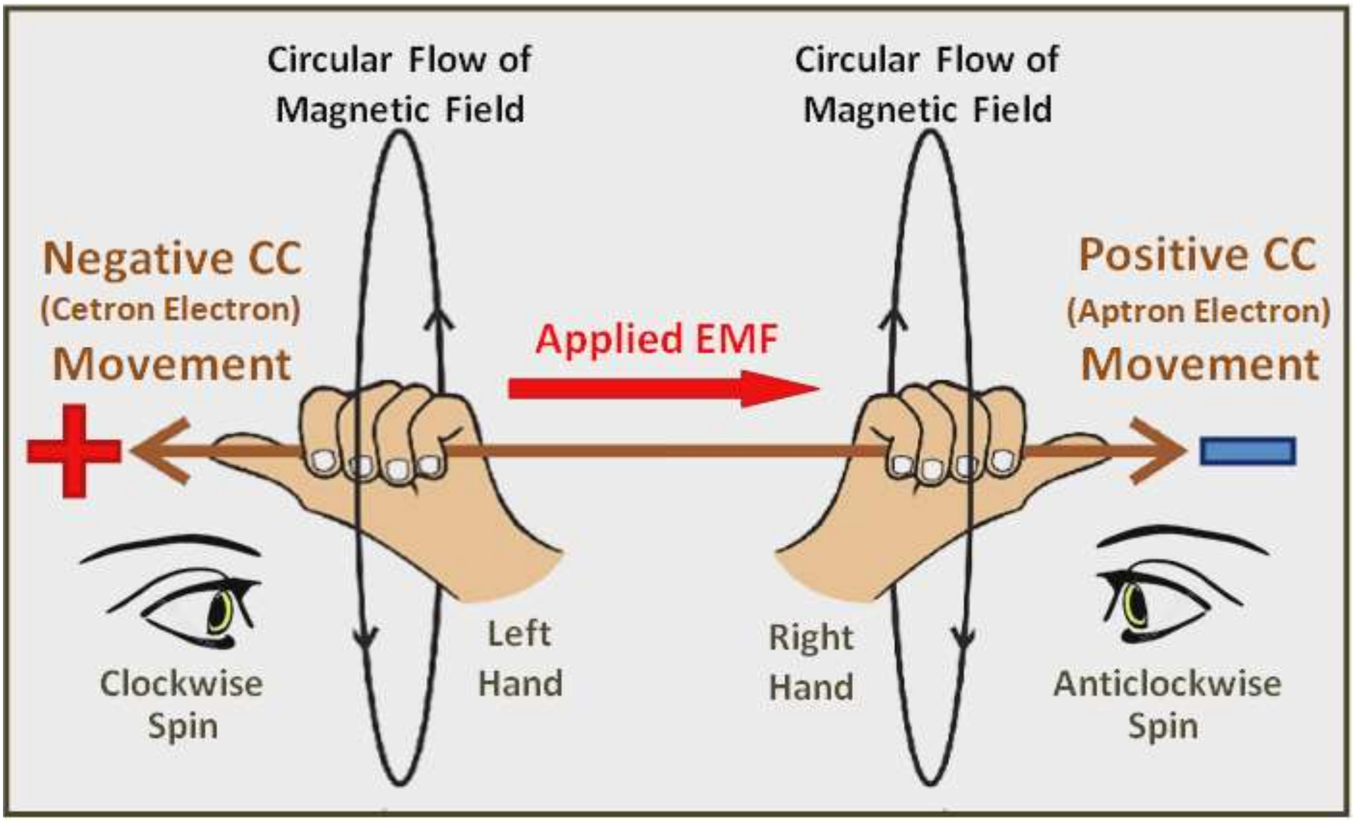


Figure 13a: Modified Maxwell's Right-Hand Grip Rule

With the development of **semiconductor** circuitry in the 1950's, it became apparent that **positive CC** as well as negative CC were required to explain electric current within semiconductor material and phenomena such as the Hall Effect. Initially, panic set in because conventional Science had no positive CC that could do the job. The work-around devised to resolve this dilemma, which has continued to the present day, was the promotion of a quasi-particle, the **positive-hole** (or electron hole).

A positive-hole is a temporal **cation** that is created by the removal of an electron from a neutral atom, typically a silicon atom within the semiconductor substrate. Such cations are considered to be '**temporal**' because, at any stage, the cation (or hole) can acquire another electron to convert back into the neutral atomic state. Thus the holes can be turned ON and OFF, but they definitely cannot move or transfer positive charge because they are **static** atoms that are locked into a rigid crystalline structure.

Clever animations can create the illusion that holes can move by having the electrons hole-hopping in a coordinated fashion. Also there are convoluted explanations involving wave-vector dispersion to explain claimed quasiparticle characteristics associated with positive holes. These attempts to validate the concept do not change the fact that positive-holes cannot move as freely as do mobile electrons and, as such, do not and cannot provide the functionality required for a positive charge carrier (i.e. to transfer positive charge).

On the other hand, STEM's aptron electron represents an ideal positive CC because it is just as mobile as a cetron electron. A copper atom is considered to have a pair of ionic orbitals; one supporting up to two cetron electrons and the other supporting up to two aptron electrons. For **copper wire**, the initial copper rod creation process, and the subsequent multiple passes of stretching, extrusion and annealing, produce a product with outer layers of copper atoms being aligned parallel to the outer surface of wire, but becoming increasingly more randomly aligned near the centre line of the wire. When an externally generated or induced **electromotive force** (**emf**) is applied across a length of a copper wire, orbiting negative CC respond by skipping between orbitals (not necessarily adjacent) so as to move away from the negative terminal, heading towards the positive terminal. Orbiting positive CC move in the opposite direction away from the positive terminal, heading towards the negative terminal as shown schematically in figure 13b.

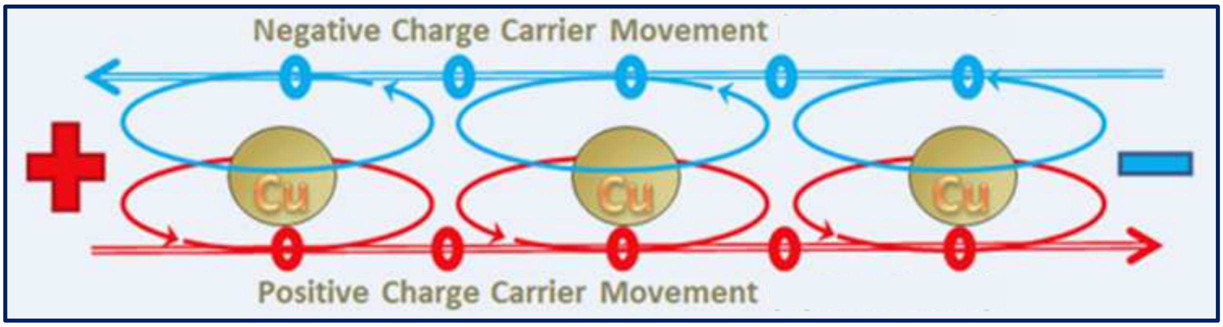


Figure 13b: Positive and Negative Charge Carriers Moving as an Electric Current

The reason why CC move under the influence of an applied emf is that, when the tangential direction of travel of a CC within an ionic orbital aligns with the direction of an applied or induced emf, the nudge received from the emf simply pushes or entices it to keep going in that direction. This results in a large number of CC skipping out of their orbitals and heading towards the appropriate terminal with their **dipolar form** helping to align them and manage their spacing in loosely-formed conga-type lines that are called **strands**. Strands form and reform dynamically as dictated by a variety of factors such as obstructions, or flaws, kinks, or changes in carrier metal's structure. When CC meet an unpassable barrier, they either join an available nearby ionic orbital or they accumulate partially aligned, so building charge that represents a local source of emf.

Should the emf direction suddenly change, as for AC electricity, the CC simply start moving in the opposite direction, exiting from the opposite side of their ionic orbitals (i.e. at a point 180^{O} distant), with strands quickly (almost immediately) forming in the opposite direction. A change of applied polarity in an AC circuit is like the music stopping in a game of musical chairs: when the music (emf) stops, there is an almighty scramble of CC seeking available chairs (orbitals), before the music re-starts and CC begin to skip out of their (new) orbitals, but this time moving in the opposite direction, forming new strands in the process.

The manufacturing process for copper wire creates a product whose outer-layer atoms are aligned parallel to the outer surface of wire, but become increasingly more randomly aligned towards the centre-line of the wire resulting in more resistance centrally. For DC circuits and short-distance runs of domestic AC electricity reticulation, the wires used are relatively thin and the **current density** is fairly evenly distributed across the cross-sectional area. However, for **high-voltage AC transmission lines** where the transmission wire used is thicker, the random nature of the central structure becomes more significant and a skin effect develops.

The **skin effect** is the phenomenon wherein most of the electric current flow takes place within a narrow 'skin-like' outer-zone of the wire. Within thicker long-distance transmission lines, the current density is higher near the wire surface where the copper atom crystal structure is more ordered and regular, which facilitates the ordered migration of CC. With resistance increasing with depth within the wire, with increased frequency and/or voltage, less CC movement and thus current flow occurs centrally, resulting in reduced skin depth. The skin effect thus effectively reduces the functional cross-sectional area of the wire conductor and increases the resistivity of the transmission line: at 60 Hz in a copper cable-, an outer skin depth of 8.5 mm carries about 98% of the current load. For high voltage transmission wires the skin effect can be accentuated by CC travelling along the outside surface of the wire so as to cause minor arcing, which makes crackling sounds and ionises molecules in the air: due to the lower work function of cetron electrons compared with aptron electrons, these external runners are invariably cetron electrons.

One practical means of reducing the skin effect is to use transmission lines made from multiple small-diameter wires, such as the woven Litz wire. Also, high-voltage, high-current overhead power lines often use **aluminium cable** strengthened with a **steel core**: the steel core has higher electrical resistance but is central, well beneath the skin depth and where little current flows. For applications involving high current (in the order of thousands of amperes) and short, straight runs, and where high transmission-line strength is not needed, **hollow tube conductors** can be used.

Within a **thin flat copper plate**, due to the pounding, rolling and annealing processes used in its manufacture, the copper atoms are aligned in planar single layer structures that are parallel to the plate faces. Thus the ionic orbital planes are parallel to the plate surfaces, which is most important to the formation of eddy currents (see the 'Eddy Currents and the Hall Effect' chapter of Electricity and the Duplicit Electron: reference [19]).

According to STEM, an electric current consists of negative and positive CC moving in opposite directions under the influence of an applied emf. So far, this concept is only a **hypothesis**. Let's now look at some **physical evidence** that can support this hypothesis and help to convert it into a substantive **theory**.

Broad evidentiary support for there being positive CC involvement in electric current includes lightning, which can be either negative or positive charge discharge; and solar wind, which is electrical current derived from the sun, comprising of both positive and negative charge. Cations (positive) and anions (negative) are involved in many instances of electric current within gases and liquids, including Redox reactions within chemical batteries. Nerves within animals (including humans) pass an electric signals using CC consisting mainly of positively charged sodium, potassium, calcium, and magnesium ions. The ionosphere where the positive CC are oxygen, hydrogen, and helium ions; electrical gas discharge which is due to cation and electron movement; and electric current within oceans involves salt cations and electrons.

Two forms of **direct evidence** indicating that electric an current involves the movement of both negative and positive CC are **arc welding** and **fractal wood burning**.

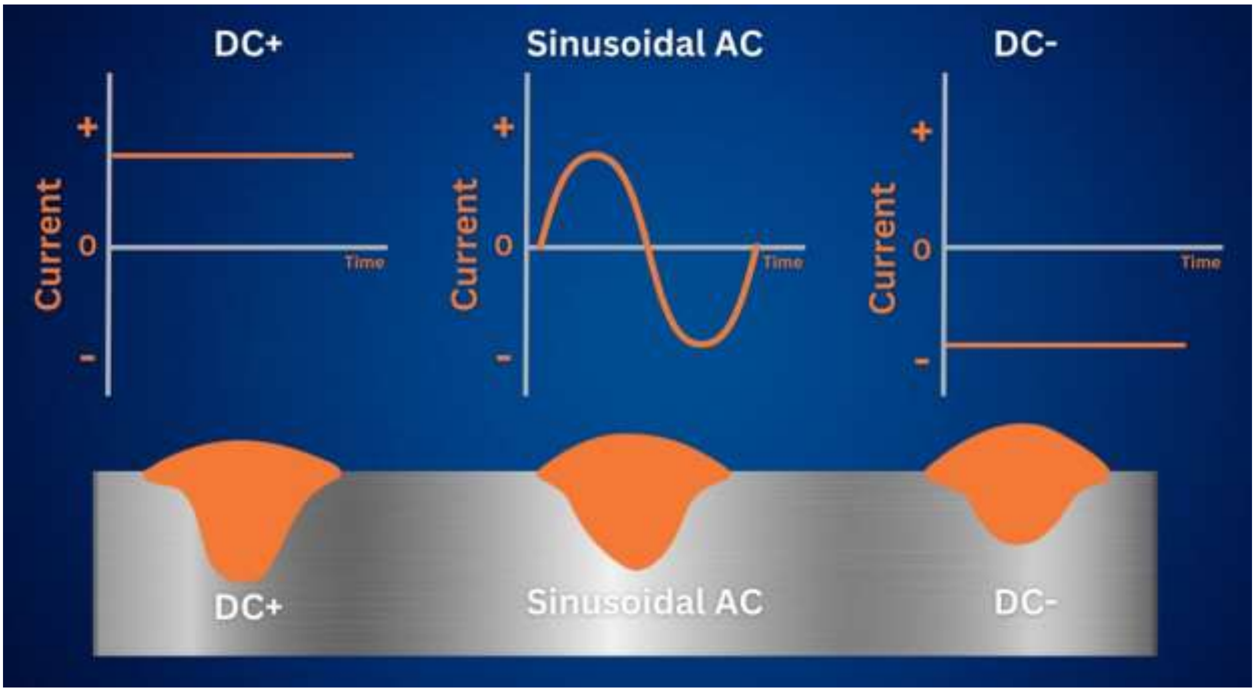


Figure 14a: DC and AC Weld Characteristics

Figure 14b: Fractal Wood Burning Example

The welding rod of an arc welder may be attached to the positive or the negative terminal of a DC power supply, or to an AC power source. The arcs are created by CC jumping from the tip of the welding rod across the gap to complete the electric circuit, so generating enough heat (up to 6500^{O}F) to cause a partial melt of the target and the weld rod. Electrode-negative (**DC-** or straight) polarity involves the attachment of the welding rod to the negative terminal of DC power and, for electrode-positive (**DC+** or reverse or DCEP) polarity, it is attached to positive terminal. Should DC current be due to the one-way movement of cetron electrons then DC- welding is easily explained by cetron electrons from the rod causing the arc, but DC+ welding would not be possible unless cetron electrons jump from the weld-target to the welding rod, or should protons jump from the welding rod to the target, which they don't.

The characteristics of DC+ and DC- are different: DC- polarity has a faster melt-off of the electrode, faster deposition rates, is generally easier to work with, and involves less power usage. Also, due to the higher work function of aptron electrons that create the arc, a DC+ welding rod heats up more than a DC- rod, and because the aptron electrons have to be more energised (i.e. acquire more kinetic energy) to exit the welding rod, a deeper weld results, as represented in figure 14a. However, the heating aspect of the DC+ rod is useful to melt welding flux and provide a seal to the new weld, which is most useful in many situations (e.g. underwater welding). Because it involves the alternating use of cetron and aptron electrons, sinusoidal AC welding characteristics fall somewhere between those of DC- and DC+.

Fractal (or **Lichtenberg**) **wood burning** involves the use of high voltage (in the order of 2,000 volts) DC electricity to generate stunning and unique Lichtenberg figures that spread outwards through the wood from each electrode. Figure 14b is an example of the Lichtenberg figures generated by fractal wood burning. It is really worth viewing wood burning in action as demonstrated in these 3 samples: video 1, video 2 and video 3.

Warning

Fractal wood burning is an extremely dangerous process and many people die each year by attempting to create their own burnings. It is a far more dangerous process than indicated by the three videos referenced. **This video** provides some insight into the potential dangers. Wood burning is not just fascinating: it is deadly. So do not try it yourself unless you study the topic in depth and know what the required safety measures are, and can afford the time and financial cost to install them before proceeding.

As can be seen in all fractal wood burning videos, the Lichtenberg figures develop simultaneously from both the positive and negative electrodes as the electric current follows leader lines within the wood that represent the pathways of least resistance. Due to the high resistance of the wood, it heats up and burns to form carbon, which is a good conductor, and which allows the burning to move outwards from the electrodes. Multiple burn paths quickly develop and simultaneously expand from each electrode to produce quite stunning and unique Lichtenberg figures.

The fact that, for fractal wood burning, Lichtenberg figures develop simultaneously from both electrodes, cannot be explained by just cetron electrons moving away from a negative electrode towards a positive electrode, which is conventional Science's definition of DC electricity. On the other hand, the phenomenon can be easily explained should DC electric current consist of the simultaneous two-way movement of cetron and aptron electrons in opposite directions. In fact, with the STEM approach, simultaneous burning would be expected from each electrode, and thus fractal wood burning is compelling evidence that the STEM-supported concept of electric current is valid and correct.

The above two direct forms of evidence elevate STEM's **hypothesis** that an electric current consists of negative and positive CC moving in opposite directions under the influence of an applied emf to the status of a substantive **theory**.

A simple **experiment** that would further **validate the theory** relates to arc welding. It is: *locate a strong magnet so that its magnetic field is 90^{O} to the arc direction of welder. Using an appropriate weld-rod type, with the welder wired for DC- welding, the weld arc should consist of cetron electrons and be (slightly?) deflected by the magnetic field as shown in the diagram right. With the welder wired for DC+ welding, the weld arc should consist of aptron electrons and be deflected in the opposite direction by the magnetic field as shown right*.

The experiment should also be able to quantify the increase of kinetic energy of the aptron electrons from the DC+ weld compared to the cetron electrons derived from the DC- weld.

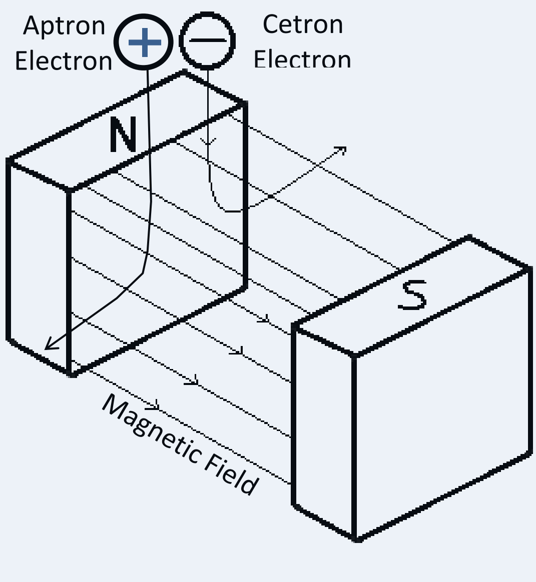


Figure 15a is a 3D X-ray representation of cetron and aptron electrons freed from their ionic orbitals and moving through a copper wire under the influence of an applied emf (**E**). The CC move as an electric current with their outflow vortices foremost. Each CC is annotated with a curved arrow indicating the direction of its outer energy field flow, with its toroidal and poloidal flow components indicated by **T** and **P** respectively. Note that the poloidal flow component of the cetrons is in the opposite direction to that of aptrons so that they cancel each other out. However, their toroidal flow component is in the same direction and thus combines to produce the **circular magnetic field** that has a direction in agreement with the modified Maxwell's Grip Rule of figure 13a.

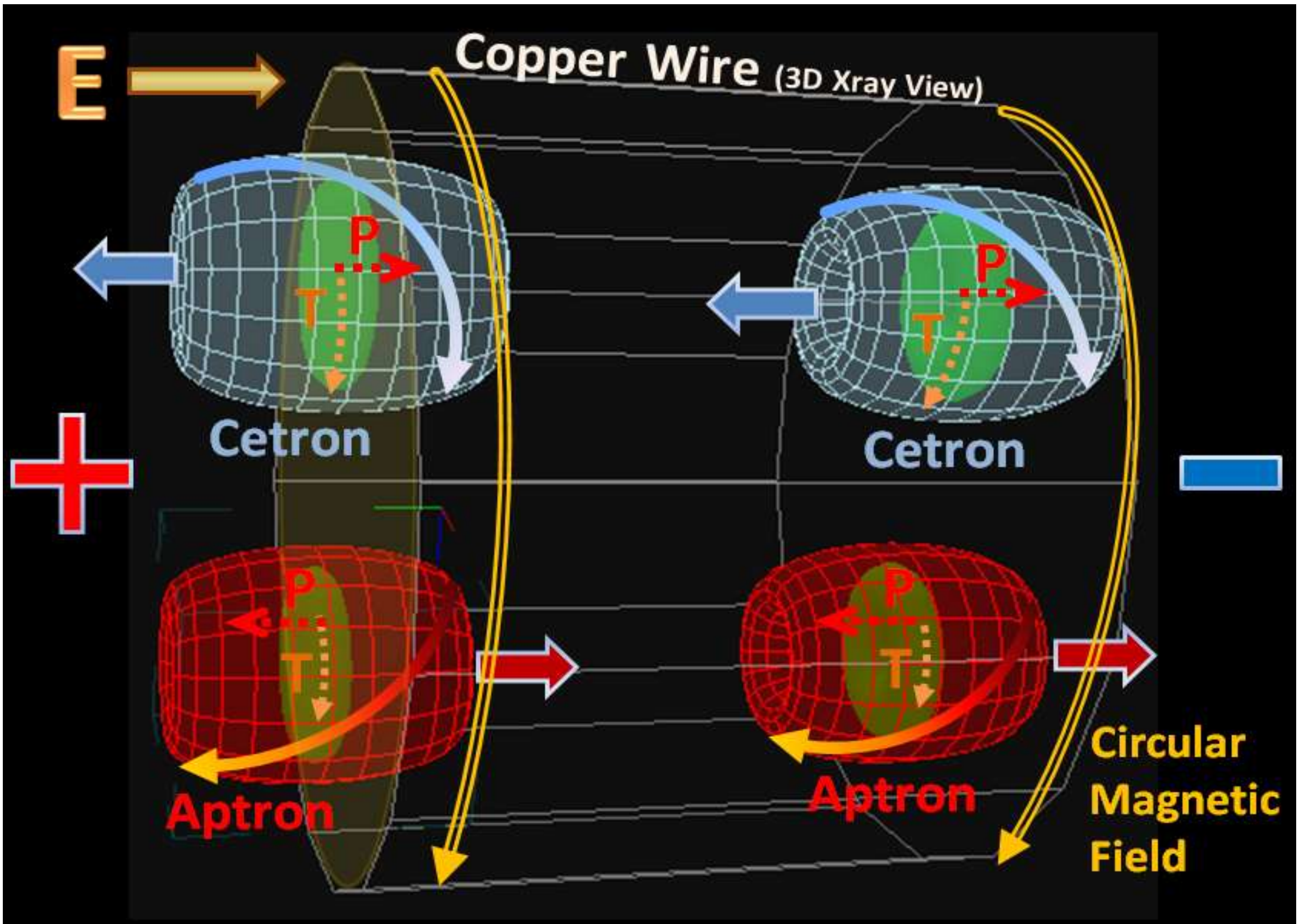


Figure 15a: EMF Induced Cetron and Aptron Electron Movement

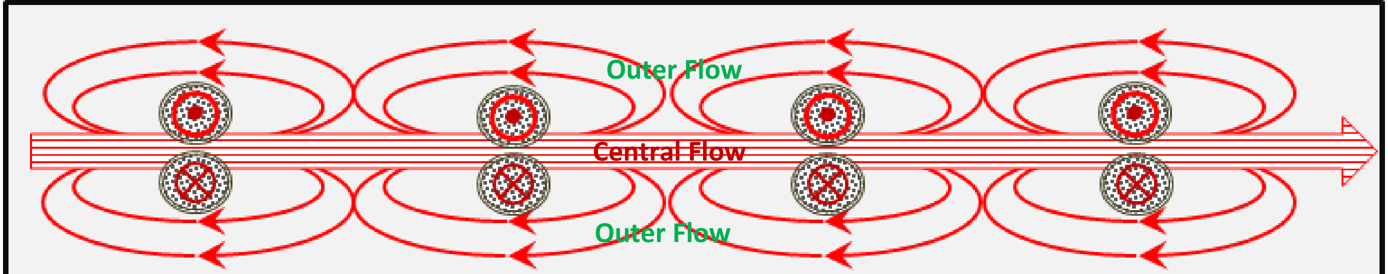


Figure 15b: Aptron Electron Strand Formation

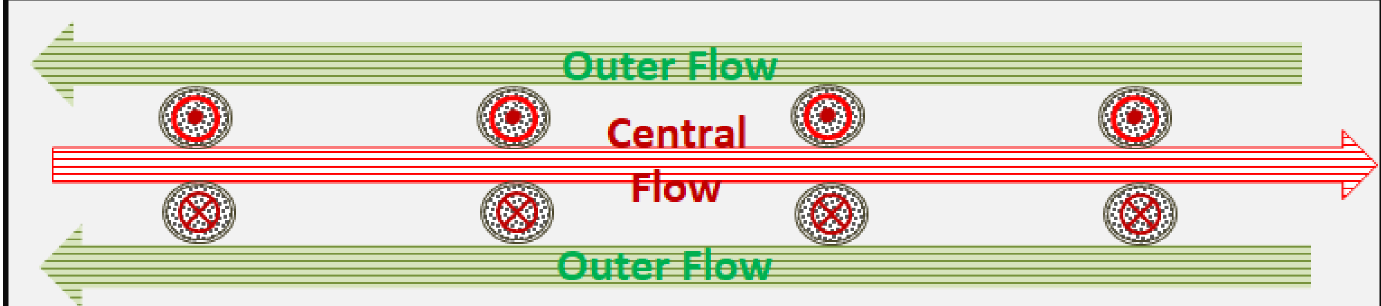


Figure 15c: Central and Outer Flows of an Aptron Strand

Figure 15b is an idealised representation of positrons moving as a strand, with the field energy flowing through their energy cores combining to form a central jet of field energy labelled as its **central flow**. Their outer flows also combine to form an outer hollow cylinder of field energy labelled as its **outer flow**. Figure 15c is a generalised representation of the two flows, with the central flow streaming in the direction of CC movement and the outer flow moving in the opposite direction. The same outer/central flow pattern is generated for cetrons moving in strand formations in the opposite direction.

In a normal current-carrying wire (i.e. one not containing a capacitor), when the applied emf stops, the CC relocate to the closest amenable ionic orbital, which causes the circular magnetic field around the wire to dissipate.

The average speed of the CC within strands is in the order of 40 to 80 centimetres per hour, whereas the central flow field energy jets through the wire conductor at close to the speed of light. Thus, although the CC move relatively slowly through an electric circuit and are responsible for the current's amperage, circuits activate (or power up) almost instantly upon being switched on due to the speed of the field energy of the central flows. The outer flows are more subdued and less concentrated, but are sufficient to balance the field energy flows within the circuit.

Should a pair of **metal probes** be attached to each terminal of a DC power source then the CC cannot move beyond the break in circuit represented by the probes. Instead, CC accumulate in static strand-like structures at the outer surface of the probe tips, with their central outflows extending beyond the probe tips as an **electric field**: a positive field due to the accumulation of aptron electrons on the positive terminal side and a negative field due to the cetron electrons on the negative terminal side. The next chapter discusses the nature of these electric fields in more detail.

Should the probes be replaced by a pair of flat copper plates that are held parallel and close to each other, a **capacitor** is created. The gap between the plates means that no current flows between the plates, and the CC accumulate as strand-like structures at the outer surfaces of the plates, generating an electric field across the gap. Capacitor electric energy charge and discharge is described in more detail in the 'Capacitors and Inductors' chapter of Electricity and the Duplicit Electron (reference [19]).

The STEM suggestion that both electrons (cetrons) and positrons (aptrons) exist within matter is **new** and contrary to common belief. Below two of the most frequent questions related to this concept and STEM's response:

1. *Should electrons and positons exist together within matter, wouldn't they mutually self-destruct via the electron–positron annihilation phenomenon?*

Response: Electron-positron annihilation occurs when a cetron and aptron electron collide and annihlate each other, resulting in the creation of a pair of gamma rays, each with opposite chirality, which separate in opposite directions. The energy of each gamma ray is approximately equal to the rest mass of an electron (i.e. 0.511 MeV). The annihilation process is represented by the equation:

$$e^- + e^+ \rightarrow \gamma^+ + \gamma^-$$

Electron–positron annihilation occurs when positrons are allowed to randomly intermingle and interact with electrons. However,when electrons and positrons move together in the same direction, such as with positron generation in a laboratoty (e.g. as described in the 2013 article by Sarri: reference [11]) or travel within **cosmic radiation**, electron–positron annihilation does not take place, with the cetron electrons able to be easily separated from the aptron electrons (or positrons) by a magnetic field,

Within a metal conductor, the negative and positive CC are confined to their separate **ionic orbitals**; and when an emf is applied, they start to skip between orbitals, with all such movement being in same-charge strand-like structures. Thus, electron–positron annihilation cannot and does not readily take place within a metal conductor.

The electron-positron annihilation phenomenon is covered in more detail in the SDG's paper on EMR and Light (see reference [18]), but here is a brief overview. Should an electron and positon be involved in a the moderately low-speed head-on collision as represented in figure 7, the poloidal component of their outflow field energy is compressed, causing instantaneous recoil. However, due to having the same toroidal flow direction, they have mutual attraction that is sufficient to prevent total separation upon initial recoil, and a rapid hammering process (hit-recoil-hit-…) ensues that converts the total energen of the particles into a pair of gamma frequency electromagnetic radiation (EMR), with photon emissions in opposite directions (i.e. 180^O away from each other).

2. *If great numbers of both positrons and electrons co-exist in approximately equal numbers within metal conductors, why has the presence of positrons in matter remained undetected experimentally?*

    Response: The work function for positive CC is considerably higher than that for negative CC. Thus, for low energy interactions such as the photoelectric effect, electron guns and cathode ray tubes, only electons are emitted. Positrons are only emitted in response to high energy impact involving more than 1 MeV, such as gamma or Xray ray bombardment, or by highly energised particles (e.g.electrons).

    Although the reason for the much higher work function required to release positive CC is not really known, there are several possibilities. One possibility is that, for metal conductors, cetron ionic orbitals mainly face outwards whereas aptron orbitals face inwards, which shields them from the relatively low energy level EMR (e.g. light). Another possibility is that motor force, derived from the electromagnetic fields of atoms within a metallic lattice, pushes 'freed' aptron electrons inwards and pushes 'freed' cetron electrons outwards. Yet another possibility relates to the dipole nature of cetron and aptron electrons: the cetron electron has a pseudo-positive side (its inflow vortex side) that would be facing the nucleus as it exits the electromagnetic field of the atom, which gives it an extra push via like-pole repulsion. The reverse would apply to aptron electrons, with their pseudo-negative side holding them back due to opposite-pole attraction. With there being so many possible reasons for the higher work function, there is no obvious winner, and more targeted laboratory-based research is required.

    Structurally, the only difference between positive and negative CC is the chiral difference of their field energy. Moving in opposite directions as an electric current, they both contribute to the net electric charge movement and to the circular magnetic field generated around a wire conductor due to current flow. Due to their close similarity, it is most difficult to tell them apart, particularly within a metal conductor, and, with current conventional Science theory, nobody has been predicting their existence within matter, let alone be actively searching for them.

    Importantly, both types of CC are needed to adequately explain the fractal wood burning phenomenon, the Hall Effect and Eddy currents. Along similar lines, the arcs generated by DC- and DC+ welding rods are physical manifestations of cetron electrons and aptron electrons forcedly jumping a gap: a fact easily observed but rarely noted or researched by Scientists. However, in defence of Scientists, most welding technology research is undertaken by industrial OR groups rather than by particle Physicists.

Any movement of electric charge via CC, albeit in terms of just negative or just positive CC or combined, will generate a circular magnetic field around a wire conductor, and thus can be described as being an **electric current**. However, STEM contends that, for all electric circuits powered by an applied emf (albeit produced by a chemical battery, a solar-cell, a piezo-electric device, or a thermocouple device) or by **magnetic induction**, an electric current consists of cetron and aptron electrons moving simultaneously in opposite directions though the circuit, with each type of CC contributing equally to the circular magnetic field so generated around a current-carrying wire conductor.

The flow pattern of the energy fields of CC is important to an explanation of **motor force** (see reference [19]); and facilitates **electromagnetic induction** (the ability to induce an electric current by passing a wire through a magnetic field, as explained in the 'Electromagnetic Induction' chapter of Electricity and the Duplicit Electron: reference [19]).

As a closing note, this video by Eric Dalgetty provides an example of an electron-only electric current. Dalgetty generates a low-energy cetron electron stream from a tungsten filament, which impacts a metal conductor collector plate. In order to maximise cetron production and cause an electric current to flow, the voltage between the collector plate and anode is quite high (about 600 volts), with the copper wire coil and plate acting as a capacitor, albeit a very inefficient capacitor. The significant increase of cetron electron concentration within the collector plate causes an electrical imbalance (i.e. an emf), and drift movement of cetron electrons from negatively charged collector plate through the wire towards the LED takes place. The emf generated by the added cetrons causes aptron electrons to move in the opposite direction (STEM refers to this as a **symbiotic response**), with the net current movement lighting up the LED (which is wired to light up in forward bias mode). The current generated by this fairly unique setup would most likely involve more cetron than aptron electron movement.

It is also worth pointing out that, although conventional Science describes and quantifies the close relationship between magnetic and electric fields, it does not explain the cause of the characteristics of the fields nor provide an explanation for why or how they are related. The STEM approach provides feasible explanations for the phenomena of electromagnetism and electricity without violating any of the empirically derived laws and equations related to these phenomena. And importantly, the specific claim that electron orbitals are planar, and can support both electrons and positrons, has major implications for current atomic theory.

Electric and Magnetic Fields

An **electric field** can be represented as a vector quantity in that it has both magnitude and direction. For visualisation purposes, the abstract concept of **electric lines of force** (or **electric field lines**) was introduced by Michael Faraday in 1837, and nothing much has changed since then. Electric field lines are imaginary lines drawn to show the direction of movement of a hypothetical positive charge (e.g. a proton) within the electric field created by a single electric charge. Electric field lines point radially away from a positive charge and radially inwards for a negative charge as shown in figure 16a. Should the electric field lines be defined as being the movement of a hypothetical negative charge (as opposed to a positive charge) then the misleading arrow direction would be reversed.

As shown in the lower half of figure 16a, the STEM representation of an electric field superficially resembles Faraday's electric field lines, but without the rather meaningless directional arrows. Rather than being abstract lines, the radial spoke-like lines represent field energy emitted by the electric charge that is chiral, and which STEM calls **wisps**. The **red** wisps indicate that the field energy has right-handed chirality as derived from a positive charge, and the **blue** wisps indicate left-handed chirality from a negative charge. The wisps colour reduces outwardly reflecting an outwards radial decrease of field energy density, and thus reduced field strength and a reduction of chiral coherence.

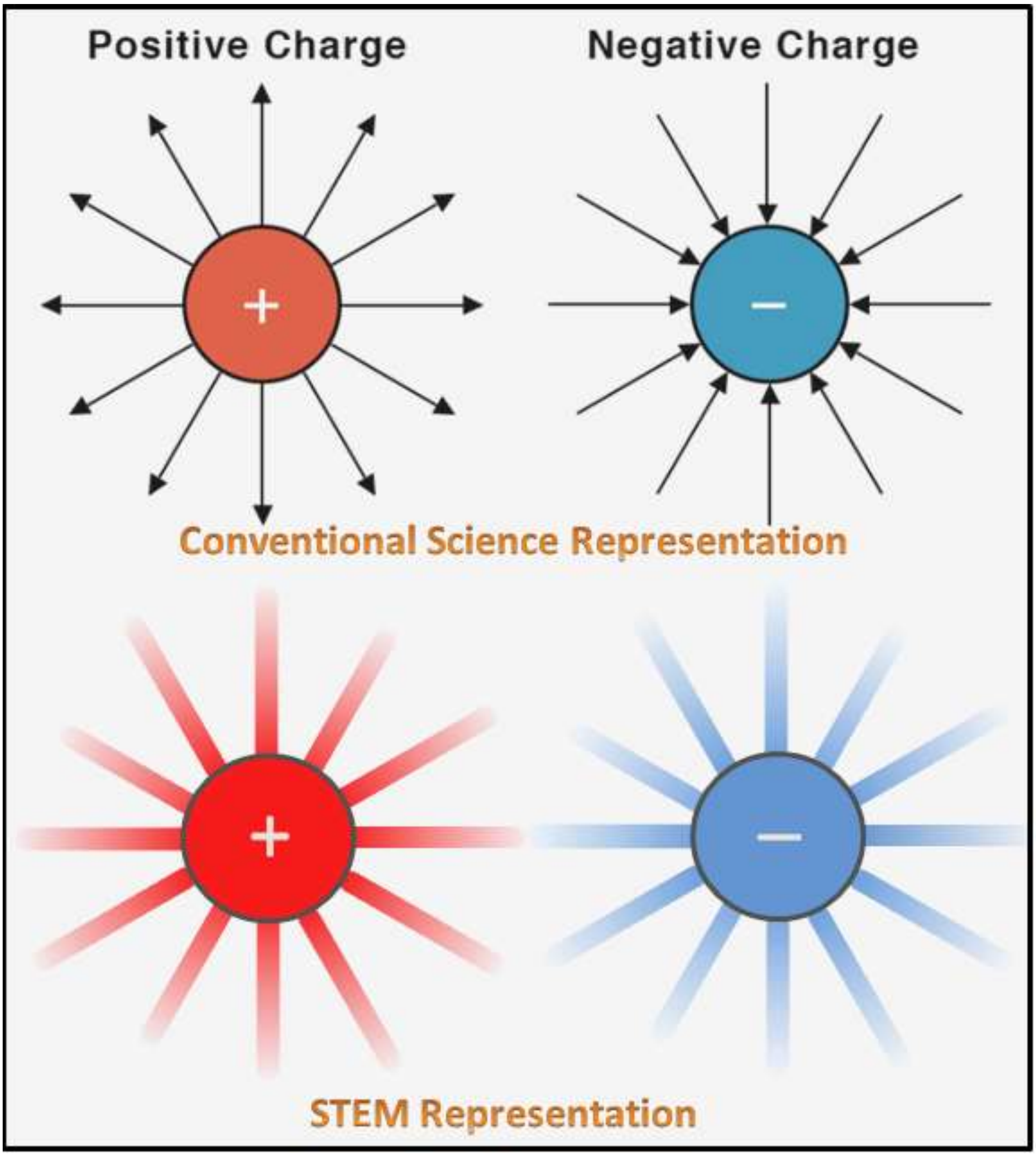


Figure 16a: Positive and Negative Monopole Electric Charge Representation

Often quoted sources of monopole negative and positive electric charge are the electron (-1e) and the proton (+1e). However, for all intentive purposes, a positive and negative electric charge effect can be created by attaching a pair of **metal probes** to the opposite terminals of a DC power source. As shown as figure 16b using the STEM notation, the electric fields associated with these probes approximate to one half of a monopole electric charge.

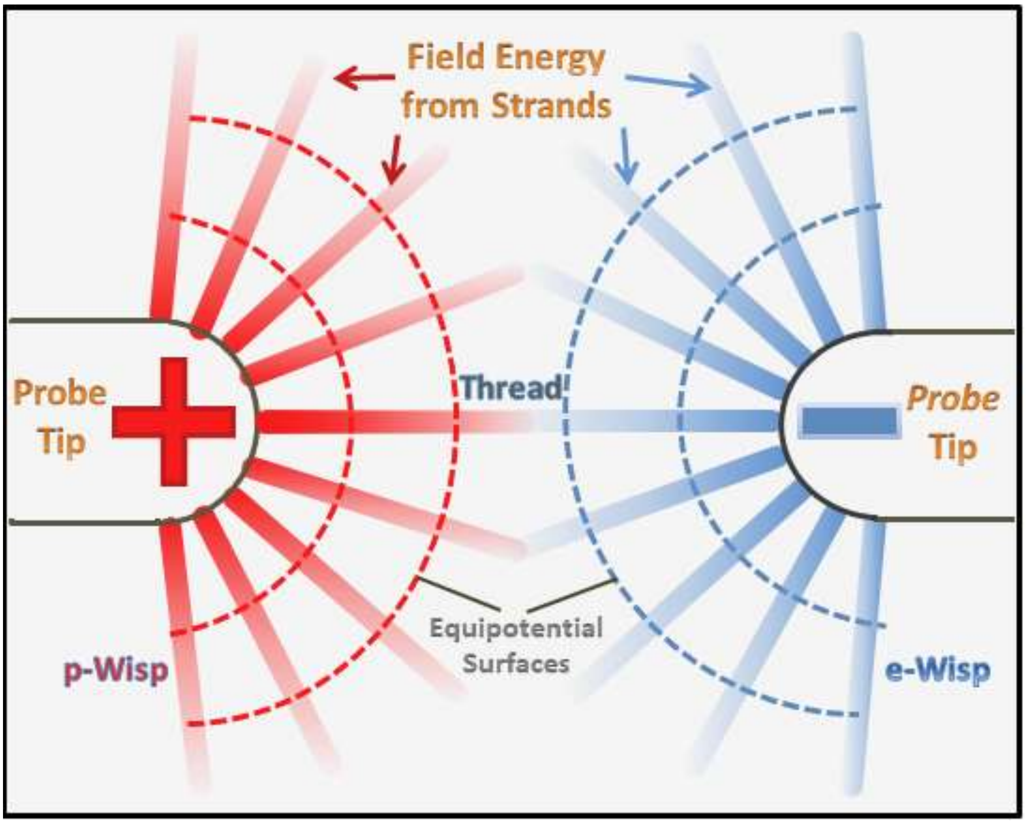


Figure 16b: Wisp Distribution around Powered-up Probe Tips

In a powered-up probe setup, the applied **emf** pushes CC towards the probe tips but, because they cannot move beyond the probe tips, they concentrate at the surface of the probe tips, forming static outwards-facing strand-like structures, with their combined inner flow field-energy extending outward beyond the probe tips as **wisps**. Upon initial power-up, a concentration (or compaction) process takes place involving minor movement of free CC as they align and shuffle closer together as wisps form and strengthen, which registers as a **transient micro-current**, after which there is no further forward movement of CC.

P-wisp emanate from the positive charge side and have right-handed chirality, and **n-wisp** from the negative side have left-handed chirality. In air, the distance that a wisp extends radially beyond its probe tip is dependent upon the strength of the emf being applied by the power source, and shape of the probe tip. The circular red and blue dashed lines of figure 16b represent **isoclines** of equal wisp-related density (or intensity).

Figure 17 is a typical representation of conventional Science's electric lines of force between a pair of fictional monopole positive and negative charges. An electric line of force is a smooth curve drawn in an electric field for which the tangent at any point on the curve indicates the direction of the electric field at that point. To represent the lines of force that would be associated with a corresponding pair of positive and negative probes, the appropriate regions have been greyed-out in figure 17.

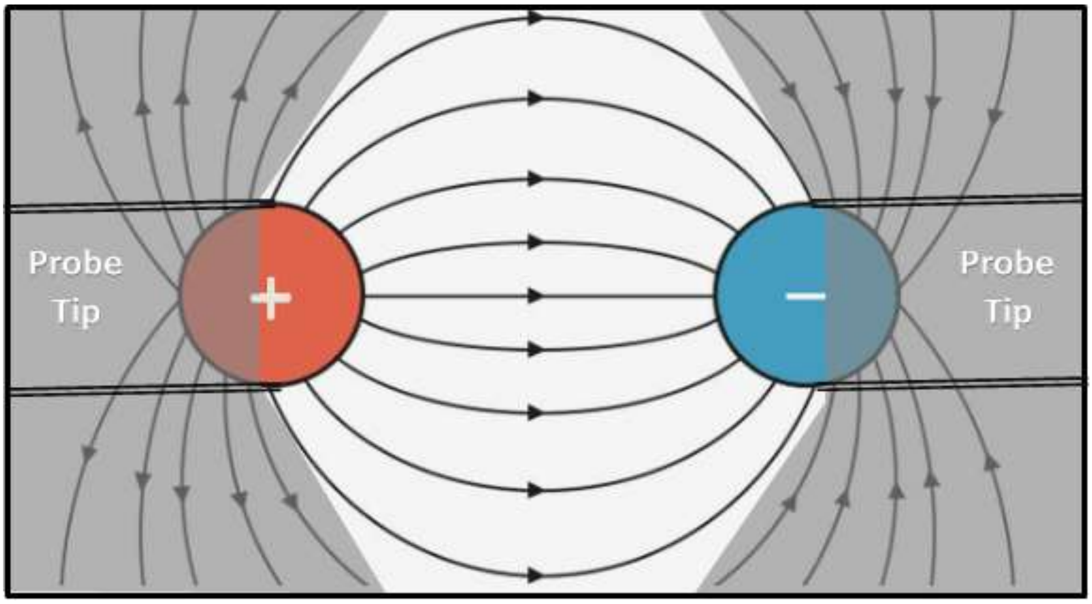


Figure 17: Lines of Force for Opposite Polarity Monopole Charges (or Probe Tips)

As for any monopole electric charge, the wisps emanating from the probe tips consist of a jet of field energy moving in a straight line, as represented in figure 16b and the top part of figure 18. Wisps are chiral, with their flow pattern reflecting the toroidal and poloidal flow components of the CC from which they are derived. Whenever n-wisps and p-wisps intersect (and there are billions of intersections in 3D), their flow components are additive (or subtractive). Looking at just the toroidal component at selected intersection points, a tangent to the **net toroidal flow** can be determined: they are the thin dark lines annotated as 'Tangents to Net Circular Flow' in figure 18.

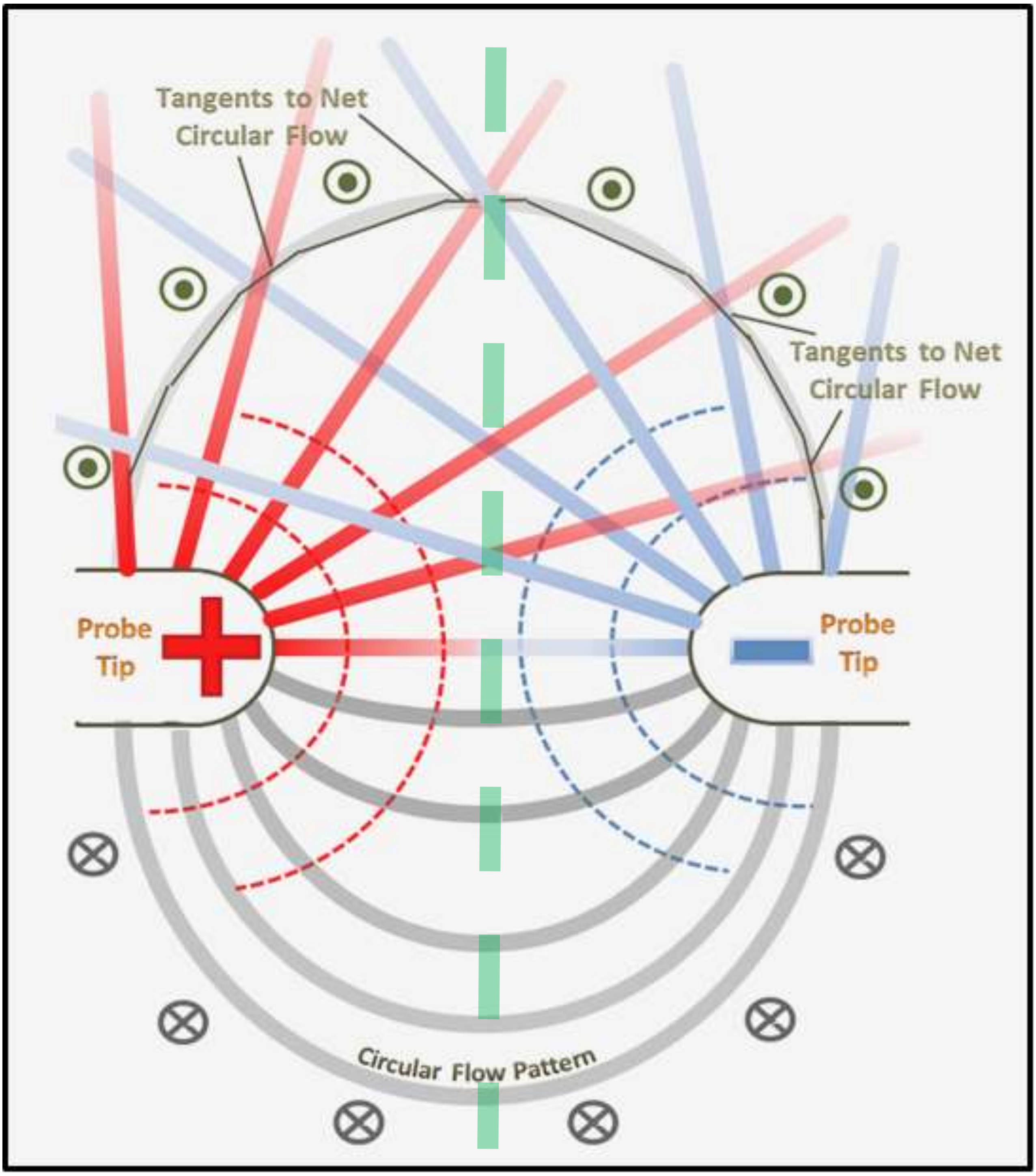


Figure 18: Circular Magnetic Field and Pseudo-Thread Formation

The 'Tangents to Net Circular Flow' of figure 18 represent the tangential direction of the **circular magnetic field** component of the electric field between the probes, which is analogous to the circular magnetic field produced around a current-carrying wire. The grey arrow-heads indicate that the circular magnetic field flows out of the page, and the arrow-quills a flow into the page. It is worth noting that in the 1860's **James Clerk Maxwell** identified the circular magnetic field component within and electric field, but incorrectly attributed it to a non-existent displacement current: no such displacement current was ever found but the terminology has persisted.

The **locus of the tangents** shown generates an elliptical arch connecting the probes, shown as banding in the lower-part of figure 18, grey-scaled to highlight the reduced electric field intensity moving away from the centre line between the probes. These elliptical arches have a similar geometry to conventional Science's electric lines of force (see figure 17), and they join opposite polarity electric charges (here the pair of probes) and are called **threads**. Threads are **notional** rather than physical but, unlike abstract lines of force, they are not directional because there is no net transfer or purposeful exchange of field energy (i.e. energen) between the probes (or any pair of electric charges).

Figure 19 is a composite representation of the key aspects of the electric field between a pair of probes as a lead-up to a discussion of the behaviour of free CC within the electric field.

Field energy is pumped out from the probes via wisps at a rate that is in excess of the more gentle retrieval rate of their inflows. Consequently, field energy accumulates centrally between the probes in the area labelled '**Central Accumulation Region**' in figure 19, with the dark grey dashed graph providing an indication of the field energy distribution profile between the probes. With an equal flow from each probe, there is no transfer of field energy across the plane between the two probes, with the electric field being zero within this plane. This corresponds to the conventional Science view that, at the central plane between a positive charge (+1e say) and an equal negative charge (-1e say), the electric field is zero.

Realistically, minor amounts of field energy is leaked to the outside world and thus become lost from the probes, but there is no net transfer of field energy flows between the two probes (or any corresponding electric charges). This means that the field energy of the circular magnetic field (its direction is once again indicated by the arrow-points and arrow-quills in figure 19) consists of a denser concentration of field energy centrally. The central concentration of field energy is also the reason why the circular isoclines indicating equal field energy distribution (see figure 18) have been removed from figure 19: such isoclines are only meaningful for an isolated monopole electric charge.

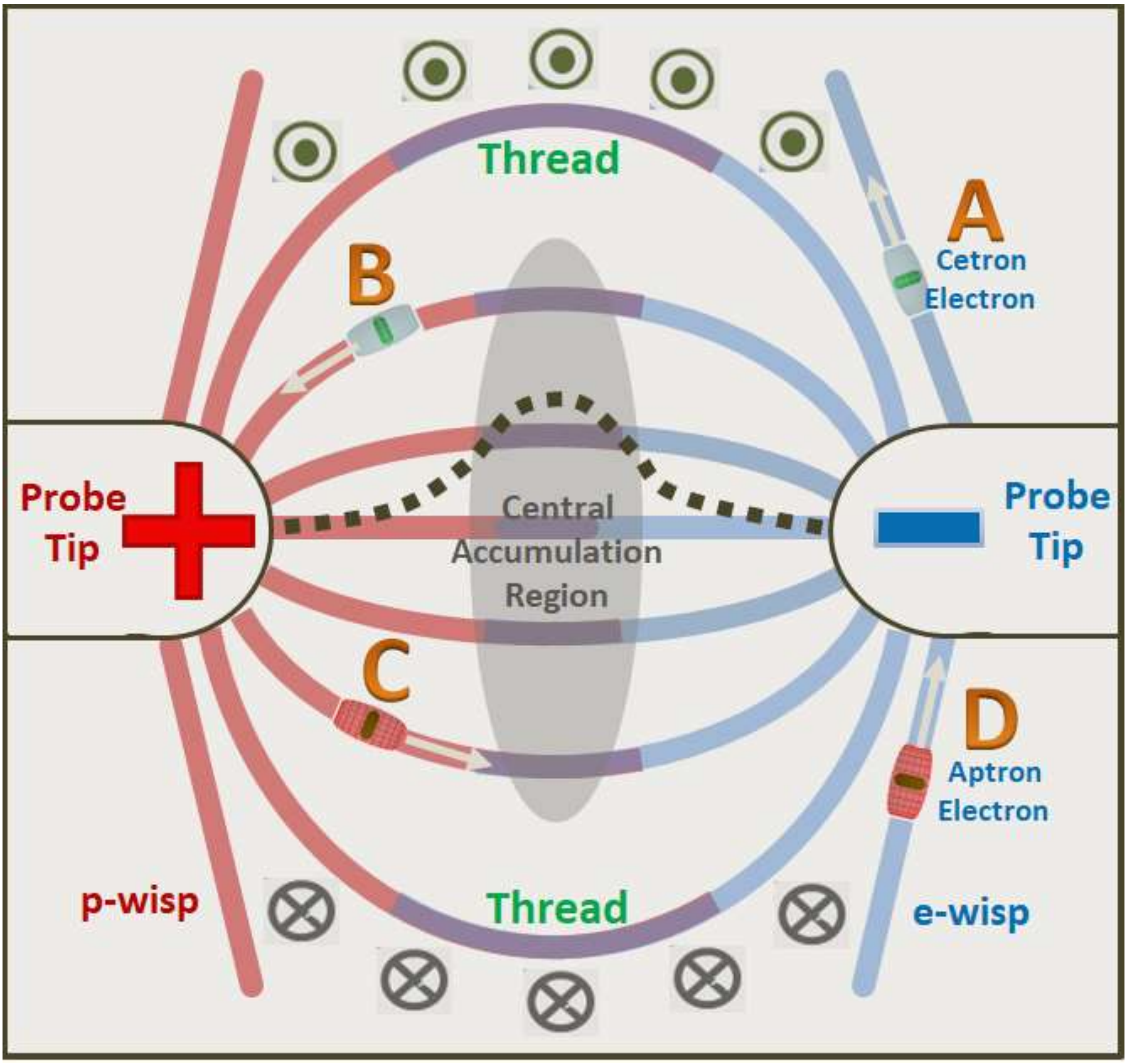


Figure 19: Thread/Wisp and Circular Magnetic Field Patterns for a Pair of Probes

The spin axis of **free CC** within an electric field are aligned to the circular magnetic field, which means that their orientation corresponds to the direction of the thread in which they find themselves, as shown in figure 19. This, however, does not mean that they keep in or move along any particular thread because their movement is controlled by the wisps they encounter, the circular magnetic field, and the effect of the central concentration of field energy between the probes.

With its outflow vortex foremost, the poloidal and toroidal components of the field energy flow of **cetron A** in figure 19 would correspond to that of the e-wisps from the negative probe tip, causing it to move away from the negative probe tip in the e-wisp outflow direction. The movement of this negative CC is like that of a leaf moving within a stream, and is attributed to **like-charge repulsion**. As the e-wisp flow rate and chirality dissipates outwards away from the probe, the like-pole repulsion effect reduces.

Cetron B also moves with its outflow vortex foremost, and is under the influence of p-wisps. As its toroidal flow component is compatible with that of the p-wisps, its outflow field energy is readily drawn in by p-wisp inflows (i.e. the inflow of p-strands within the positive charge probe tip), which causes it to be pulled towards the positive probe. Such movement towards the positive probe accelerates the closer the cetron is to the probe tip and is attributed to **opposite-charge attraction**.

Similar explanations apply to the movement of aptrons C and D, but with their toroidal flow component being the reverse of cetrons, free aptrons behave as if repelled from the positive probe and attracted to the negative probe.

Keep in mind that 2D diagrams of electric and magnetic fields are a cross-section of a 3D structure, with the circular magnetic fields, threads and central field energy distribution profiles being curved 3D surfaces (e.g. ellipsoids, cubic spline surfaces etc.). Wisps, on the other hand, are lines that each has a different orientation that is perpendicular to the part of the probe surface from where they are generated, with those shown being only a representative sample of those within the cross-sectional plane. Along similar lines, the free electrons (cetrons and aptrons) shown in figure 19 would move in the direction of the circular magnetic field as well as laterally, and would thus follow a spiral trajectory.

Whenever two **electric charges** are brought reasonably close to each other, wisp outflow energen causes a central accumulation region. When **opposite charge** probes are brought close, as shown in figure 19, the central energen circulates as a circular magnetic field that is derived from the combined toroidal flow component of the e-wisps and the p-wisps. This flow direction movement is compatible with and amenable to being retrieved by the inflows of the static strands responsible for the wisps. The combined pull by the strand inflows on the denser central accumulation of field energy draws each probe inwards which is interpreted as **opposite-charge attraction** (or mutual attraction) between the two probes. The closer the probes get to each other, the denser the accumulated field energy becomes, and thus the mutual attraction increases accordingly.

As the probes get really close to each other, wisp field energy from each probe can reach and be drawn in more directly by the inflow of other probe, resulting in very strong attraction. When the probes are about to touch, the central field-energy outflow of each probe is almost fully taken up the inflow of the other probe and, should the emf of the power source be high (in the order of 1000 plus volts), the energen outflow can be so strong that some outer cetron electrons in the static strands of the negative probe prematurely jump the gap. As they jump the gap these cetron electrons ionise air and water molecules along the way, so generating heat and light that ranges from an **electric spark** to an **electric arc**.

Due to aptron electrons having a higher work function than cetron electrons, they require more forceful coercion to leave the host medium in comparison to cetron electrons. Consequently, it is only cetron electrons that prematurely jump the gap from the negative to the positive charged probe. However, with a setup such as DC+ welding, enough energy can be supplied to coerce an aptron electron arc to be generated.

By the time that the two probes are in physical contact with each other, there is suddenly zero electrical resistance and, unless there is an adequate resistance in the circuit attached to the probes, a rapid and un-moderated energy transfer occurs which is called a **short-circuit**

When two electric charges with the **same charge** are brought close together, their wisp outflow field energy has the opposite toroidal flow direction to each other which results in an accumulation of central energen that is **stagnant** (i.e. it has no significant circular flow movement). Wisp outflows from each pole (or probe) thus push against the central concentration of stagnant field energy, so pushing each other further apart, which is interpreted as **like-charge repulsion**.

Although the phenomena like-pole repulsion and opposite-pole attraction for electric and magnetic fields may appear similar and all involve the interaction of field energy; however, the mechanisms involved are subtly different,

Experiment STEM claims that for a pair of electric charges there is a central accumulation of field energy centrally. When the pair are of opposite charge, it is claimed that a circular magnetic field builds up centrally but, for same charge pairs there is no circular magnetic field, although there could be a slight circular field moving in opposite directions detectable near to each charge. This can be easily tested by attaching two probes (effectively in parallel) to each terminal of a DC power source to provide two positive and two negative probes, and checking both situations.

Should the probes be replaced by a pair of copper plates that are held parallel and close to each other, a **capacitor** is created. The gap between the plates results in no current (i.e. CC) flow between the plates, but a wisp-based electric field and associated circular magnetic field are created between them. Capacitor electric energy charge and discharge is described in the 'Capacitors and Inductors' chapter of Electricity and the Duplicit Electron (reference [19]).

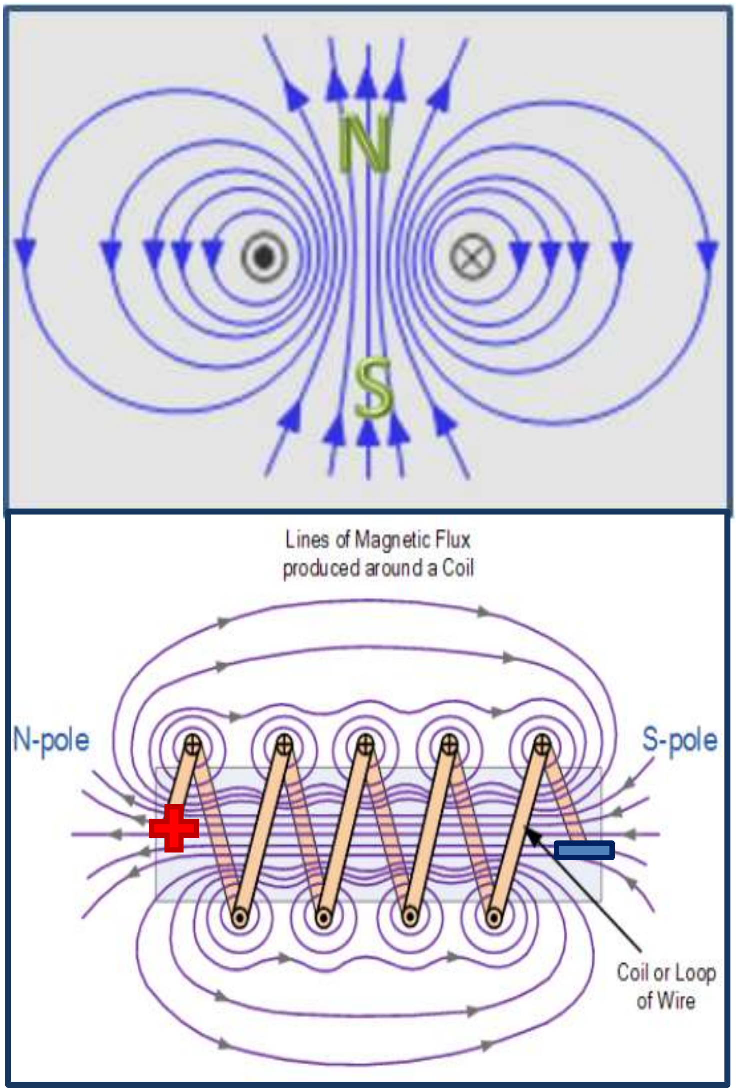


Figure 20: Magnetic Field Induced by a Current Loop

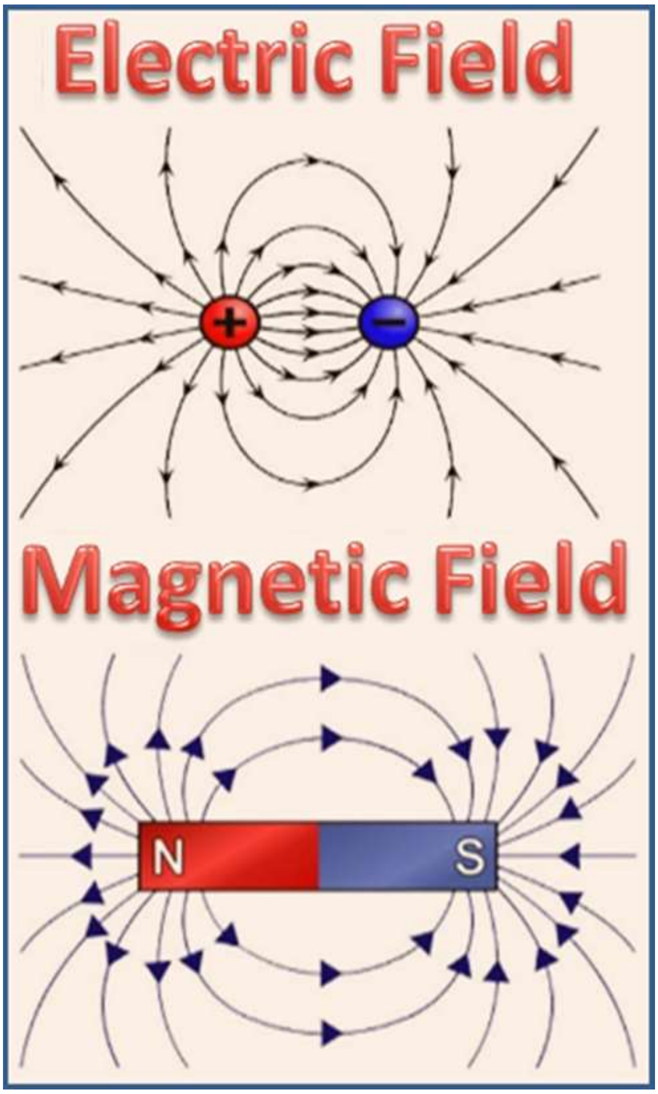


Figure 21: Electric and Magnetic Field Patterns

When an electric current is passed around a looped wire, a **loop current** is created with the duplex movement of cetrons and aptrons around the loop generating a circular magnetic field that passes through the centre of the loop. Assuming a conventional positive-to-negative current flow for figure 20, Maxwell's Right Hand Fist Rule provides the circular magnetic field direction which concentrates centrally so as to generate **implied** North and South poles as shown. The magnetic lines of flux so produced are similar to those that form around a bar magnet (figure 21). Multi-loop **coils** increase the intensity (or flux) of the generated magnetic field for each added loop. An increase in the electric current flow rate within the coils will also increase the flux levels.

A significant difference between a magnetic and an electric field is that a magnetic field has no net poloidal flow component whereas an electric field has distinct poloidal and toroidal flow components. Also, a magnetic field involves divergent flow of field energy away from a North pole and convergent flow into a South pole, albeit via implied poles. An electric field, on the other hand, has no net flow of field energy between electric poles, but does have a circular movement of field energy between poles in the form of a magnetic field. Small wonder that electric and magnetic fields are considered to be closely inter-related as encapsulated by the term '**electromagnetic**'.

As for an electric field, in a perfect world, no field-energy flux is lost from a magnetic field, with the field-lines being closed loops which never begin or end as shown bottom in figure 21. But unlike electric fields for which wisps are straight, magnetic lines of flux are always curved and never straight, and the net magnetic flux through any closed surface (i.e. enclosed and that flowing in and out) is zero (i.e. Φ_B= 0).

An explanation has already been provided for attraction and repulsion for positive and negative charge, and for free charged particles within an electric field. The explanation of attraction and repulsion are similar for electric and magnetic poles, but are certainly not the same.

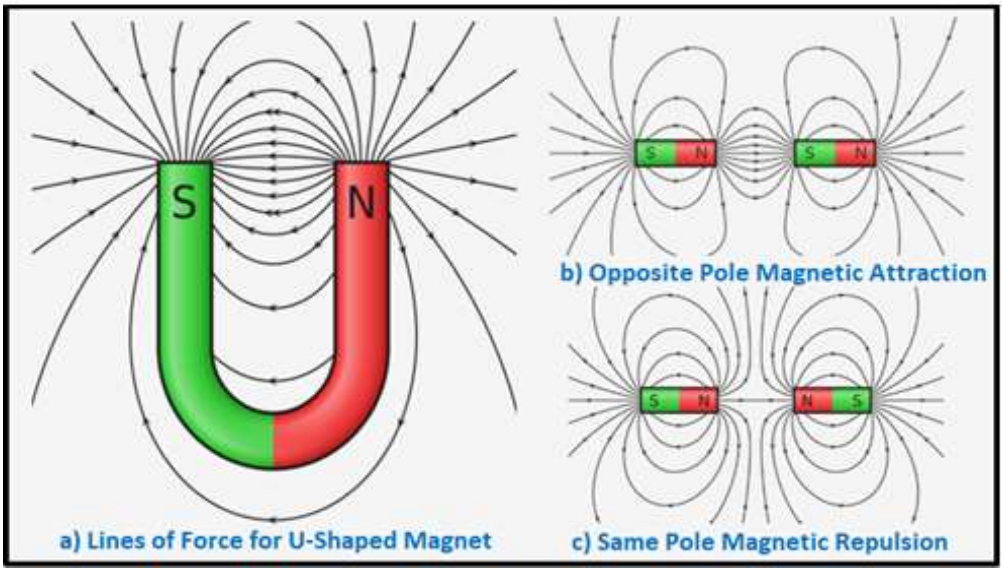


Figure 22: Opposite Pole Attraction and Like Pole Repulsion for Magnets

With magnetic flux flow from a North pole into a South pole, as shown in the field-energy lines of figures 22a and 22b, the South pole acts like a fishing-reel that pulls or draws the North pole towards itself, which is interpreted as opposite-pole attraction.

When both poles are North poles, the magnetic flux (field energy) outflow from the North poles push against each other and have nowhere to go except outwards as shown in figure 22b, which is interpreted as magnetic like-pole repulsion. When both poles are South poles, the only way that field energy can be obtained is sideways between the South poles, which becomes compressed to produce a similar flow line pattern to like North poles, except that the flow direction is reversed; however the result is the same, and that is magnetic like-pole repulsion.

To recap, STEM's notional threads and conventional Science's electric lines of force are similar but not equivalent. Diagrams for conventional Science's lines of force (e.g. figure 17 or top in figure 21) are quite misleading because they clearly suggest a one-sided flow of field (or electromagnetic) flux from the positive to the negative charge which, if true, would lead to a charge imbalance. For STEM, there is an accumulation of field energy centrally that has a circular flow that presents as a magnetic field for a pair of opposite charges; or is stagnant, with no circular flow or magnetic field, for a pair of like charges. In neither case is there a net transfer or exchange of field energy between the charges.

Summary

A major problem with the QM-based conventional Science model is that the size of the electron is reduced to a point-form definition which leads to them being allocated 'intrinsic' spin. Toroidal electron models, such as STEM, have nothing at their geometric centre of mass, and so can validly be treated mathematically as a dimensionless dot with associated physical properties (e.g. width, mass, angular momentum, charge and quantum spin number) that are determined by the surrounding torus structure.

The STEM electron and positron consist of an inner torus of concentrated electromagnetic material (which is called energen), which forms the energy-core and represents the bulk of its mass and associated angular momentum; and an outer torus of less concentrated energen called the field-energy that envelops the energy-core and is responsible for its electromagnetic characteristics. The field-energy has a chiral flow pattern: left-handed chirality for a negatively-charged cetron electron, and right-handed chirality for a positively-charged aptron electron.

The STEM electron radius is considered to be 4 x 10^-13 m) which, as addressed in the Appendix, produces a spin estimate corresponding to the speed of light, and an angular momentum estimate for the electron that requires no fiddle-factor to adjust its gyromagnetic ratio (i.e. its g-factor is 1). Also, when the STEM electron is represented as a spherical equivalent, that sphere's radius is reasonably close to the CODATA radius estimate based upon the classical spherical model.

Metal conductors are considered to support cetrons and aptrons in ionic orbitals. Due to a high work function, aptrons require high-impact collision by energised electrons or gamma rays to dislodge and release them from their parent matter as free positrons, whereas cetrons are more readily released. Positrons may also be dynamically created-and-released by high impact electron-to-electron or electron-to-nucleus collisions, particularly in a Beta decay context.

STEM considers that an electric current consists of negative (cetrons) and positive (aptrons) CC moving in opposite directions under the influence of an applied emf, with each type of CC contributing equally to the circular magnetic field generated around a current-carrying wire conductor. Two forms of direct physical evidence put forward to confirm that electric an current involves the movement of both negative and positive CC are arc welding and fractal wood burning, and two simple experiments have been proposed to verify STEM claims.

The significant differences between a magnetic and an electric field are that a magnetic field has no net poloidal flow component whereas an electric field has distinct poloidal and toroidal flow components. A magnetic field involves divergent flow of field energy away from a North pole to convergent flow into a South pole, albeit via implied poles. An electric field has no net flow of field energy between electric poles, but does have a circular movement of field energy between a pair of opposite-charge poles in the form of a circular magnetic field.

References

(note: many references in this paper have been provided via direct links)

[1] Cambier, J. and Micheletti, D. (2000) Theoretical Analysis of the Electron Spiral Toroid Concept.

[2] Consa, O. (2018) Helical Solenoid Model of the Electron. Progress in Physics, 14, 80-89.

[3] Consa, O. (2018) The Helicon—A New Preon Model. Progress in Physics, 14, 215-219.

[4] Bergman, D.L. and Wesley, J.P. (2002) Spinning Charged Ring Model of Electron Yielding Anomalous Magnetic Moment. Common Sense Science, 1, 63-67.

[5] Kanarev, P. (2012) Particle Resolution. Proceedings of the NPA, Albuquerque.

[6] Kyriakos, A. (2004) Geometrical Illustration of the Electromagnetic Representation of Dirac's Electron Theory. ArXiv: quant-ph/0407071v1.

[7] Wayte, R. (2010) A Model of the Electron. Progress in Theoretical Physics.

[8] Williamson, J. and Van der Mark, M. (1997) Is the Electron a Photon with Toroidal Topology? Annales de la Fondation Louis de Broglie, 22, 133.

[9] Osmera, P. (2012) Fractal Dimension of Electron. Proceedings of MENDEL.

[10] Yao, A. and Padgett, M. (2012) Orbital Angular Momentum: Origins, Behavior and Applications. Advances in Optics and Photonics, 3, 161-204. https://doi.org/10.1364/AOP.3.000161

[11] Sarri, G., et al. (2013) Table-Top Laser-Based Source of Femtosecond, Collimated, Ultra-relativistic Positron Beams. Physical Review Letters, 110, Article ID: 255002. https://doi.org/10.1103/PhysRevLett.110.255002

[12] Bowen, D. (2106) The Real Reason Why the Electron's Bare g-Factor Is 2 Times Classical. Journal of Modern Physics, 2016, 7, 1200 -1209, https://www.scirp.org/journal/paperinformation.aspx?paperid=67682

[13] Bowen, D and Mulkern, R (2015) An Electron Model Consistent with Electron-Positron Pair Production from High Energy Photons. Journal of Modern Physics, 2015, 6, 1334 -1342, Article link

[14] Garaud,J. Radu, E. and Volkov, M (2018) Stable Cosmic Vortons, arXiv:1303.3044v2

[15] Odom, B. Hanneke, D. D'Urso,†B. and Gabrielse, G. (2006) New Measurement of the Electron Magnetic Moment Using a One-Electron Quantum Cyclotron, Physical Review Letters, 97, Article ID: 030801 https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.97.030801

[16] MacGregor M. (1992) The Enigmatic Electron, Klurer Academic

[17] The STEM Development Group, (pdf 2023) 'Atomic Structure: STEM and the Orbital Model'

[18] The STEM Development Group, (pdf 2023) 'The Nature of Light'

[19] The STEM Development Group, (pdf 2024) 'Electricity and the Duplicit Electron'

[20] Markoulakis E and Antonidakis E (2022) A ½ spin fiber model for the electron, Int. J. Phys. Res. 10 (2022) 1–17. doi:10.14419/ijpr.v10i1.31874. https://hal.science/hal-03544897

Appendix: Electron Size and g-Factor

The physical size of an electron is highly disputed. From a Quantum Mechanics perspective, the electron is a point particle with a point charge and no spatial extent, which infers that any momentum or charge that the electron has would be 'intrinsic' (i.e. undefined). From the QM perspective, the smaller the electron radius estimate the better, with estimates weighing in from a very low 10^−19 m to the CODATA classical spherical-electron radius of 2.82 ×10^−15 m.

For the spherical electron model, its angular momentum (S) = v.m.R. Thus the velocity (**v**) of its equatorial surface is:

v = S / (m_e*R) = 5.27 10^−35 / (9.1 × 10^−31 * 2.82 x 10−15) = 2 * 10^10 m/s

where R = 2.82 ×10^−15 m,

S = 5.27 x 10-35 Js (based upon the Bohr electron, the QM estimate of intrinsic spin is half of **h-bar**, the reduced plank constant, = 0.5 x 1.054571817 × 10−34 = **5.27 x 10-35** Js),

and the mass of an electron m_e = **9.1 × 10^−31** kg.

At 2 * 10^10 m/s, the surface velocity of an electron with a radius of 2.82 ×10^−15 m would be about 100 times the speed of light (c = 3 x 10^8 m/sec), and is thus totally untenable. The smaller QM estimate of electron radius (in the order of 10^−19 m) produces a surface velocity which, at more than a million (10^6) times the speed of light, is an even more unrealistic option. Consequently, conventional Science refrains from using a radial size estimate in calculations of an electron's intrinsic spin or magnetic moments. Instead it utilises the precessional characteristics to quantify these properties.

Experimentally, the **gyromagnetic ratio** for magnetic dipoles, inclusive of particles such as electrons, can be determined from their **precession**, called Larmor precession, which occurs when they are subjected to an externally applied magnetic field (**B** in teslas). When the particle's spin axis is oblique to the direction of the external field, the precession frequency (**f** in hertz) is proportional to the magnetic field strength, or specifically: f = ɣ/(2.π).B, which allows the gyromagnetic ratio ɣ to be accurately determined experimentally.

The gyromagnetic ratio (**ɣ**) is the ratio magnetic moment to angular momentum, which are two of an electron's intrinsic properties. It can be calculated as **ɣ** = μ/S = q/(2m), where μ is the electron's magnetic moment. The CODATA estimate for μ is **9.285 x 10-24** J T^{-1} rounded, and q = charge of an electron **= 1.60218 x10^-19** C (coulomb).

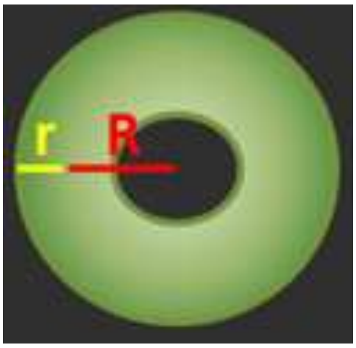
Using μ and S, ɣ = μ/S = 9.285 x 10-24 / 5.27 x 10-35 = 17.62 x 10^10 (C/kg).

Using q and m_e, ɣ = q/(2.m_e) = 1.60218 x10^-19 / (2 x 9.1×10^−31) = **8.8 x 10^10** (C/kg).

ɣ calculated using μ and S is approximately double that using q and m, Thus the Landé g-factor (g =a dimensionless constant) is used to correct the discrepancy as: Gyromagnetic Ratio ɣ = μ / S = g.q/(2.m_e), where g = 2.

The g-factor acts as a fiddle-factor to convert any theoretical estimate of ɣ (here using estimates of the electron's intrinsic μ and S), into its expected or measured value. Currently g for an electron has been determined to about 18 digits, and it currently stands at 2.00232 rounded to 6 significant digits, but more commonly it is considered to be 2.

The STEM electron is a physical model consisting of a toroidal energy core that spins or flows. The torus has a radius **R** (see figure right) = 4 pm = 0.4 x 10^-12 m = 4 x 10^-13 m; and a small radius r of 0.175 x 10^-13 m.



Because the STEM electron model is a physical structure rather than a point particle, its magnetic moment can be calculated as μ = I.A = q.(v/d).A

where q = charge of an electron = 1.60218 x 10^-19 coulomb,

v = c = 3 x 10^8 m/sec (spin/flow speed of energen electron's energy core

d = distance = circumference of the centre-circle of the energy core torus = 2.π.R m,

R_i = Inner torus radius = R-r = 3.825 x10^-13,

and A = central area of the energy core torus through which flux flows = π.R_i^2

Thus **μ** = q.c.R_i^2/2 = 1.60218 x10^-19 x3x10^8 x (3.825 x10^-13)^2 / 2 = **9.193 x 10^-24** J T^{-1},

which is close to conventional Science's intrinsic magnetic moment of or **9.285 x 10-24** J T^{-1} rounded (ex CODATA).

The STEM electron's angular momentum S = I.w where I = moment of inertia = m.R^2 for a torus

and w = angular velocity = c/R radians/sec

Thus angular momentum S = I.w = cmR = 3x10^8 x 9.1 × 10^−31 x 4 x 10^-13 = **1.09 x 10^-34 Js**, which is approximately double that of conventional Science's h-bar estimate of 0.527 x 10-34 Js.

Using STEM's S and R values, the **v** = S / (m_e*R) calculation for the spin/flow velocity of the electron's energy core becomes: 1.09 x10^−34 Js/ (9.1×10^−31 kg * 4 x10^−13 m) = 2.99*10^8 m/s, which is effectively c = 3 x 10^8 m/sec

Next, using the STEM's S and CODATA's μ, with ɣ = q/(2.m_e) = μ/(g.S) = 9.285 x 10^-24/ (**g** x 1.09 x 10^-34)

= 8.52 x 10^10 for **g =1**, or

= **8.8 x 10^10** for **g=0.97**

Thus the STEM g-factor is 0.97, which is very close to 1 and, with a very slight reduction of R, could equal 1 exactly.

The STEM electron model is a physical model, and the STEM estimates for S and μ have been made using the size and geometry associated with that model. The CODATA estimate (9.285 x 10-24 J T^{-1}) for intrinsic μ is approximately equal to the STEM estimate (9.193 x 10^-24 J T^{-1}) for angular momentum. Because STEM's angular momentum (S) estimate is approximately double that of conventional Science's estimate of intrinsic spin, it would seem fair to contend that the conventional Science estimate of intrinsic spin is incorrect, requiring a g-factor correction of 2, whereas STEM requires no such fiddle-factor adjustment, having a g-factor of 1.

Richard Feynman, using **L** for an electron's angular momentum rather than **S**, stated that μ = q.**L**/(2.m_e) '*is true for orbital motion, but that's not the only magnetism that exists. The electron also has a spin rotation about its own axis (something like the earth rotating on its axis), and as a result of that spin it has both an **angular momentum** and a **magnetic moment**. But for reasons that are **purely quantum-mechanical**—there is no classical explanation—the ratio of μ to **L** for the electron spin is twice as large as it is for orbital motion of the spinning electron*' The Feynman Lectures on Physics, vol. 3, chapter 34, p34-6.

Those '*purely quantum-mechanical*' issues can be attributed to the unrealistic QM point-form definition of an electron but, with the STEM physical electron model, there is now a '*classical explanation*' to address the quantum weirdness of conventional Science's electron model and the claimed 'intrinsic' properties of electrons.

As a final note, the intriguing question of *why the CODATA experimentally-determined estimate of electron radius (2.82 ×10^−15 m) is so much smaller than the STEM electron radius (4 x 10^-13 m)* must be addressed. The CODATA estimate is based upon X-ray deflections from an electron considered to have a spherical shape, whereas the STEM electron has a toroidal shape. Should the energen of the STEM electron's energy core be considered to be spherical rather than toroidal, then the radius of that sphere would be 8.3 x10^-15 m, which is only 3 times that of the CODATA electron radius (2.82 ×10^−15 m). Considering incompatibilities of the models and the size-scale involved (10^-15 m), a multiple of 3 is not a huge difference, and the two estimates can be considered reasonably close to each other.

The other aspect related to the different CODATA and STEM radii estimates, is that the electron is a very agile and mobile particle. As a continually moving particle, an electron is a difficult-to-hit target that re-orientates itself and moves instantaneously in response to any electromagnetic field it encounters. The electron is bombarded by just that, electromagnetic field energy in the form of X-rays (i.e. EMR in the X-ray frequency band), with the hit statistics and the deflection patterns being recorded, and then fed into collision simulation software to estimate the radial-size of the electron. It is a complex process fraught with potential error and, although the CODATA radius estimate is quoted to high precision (lots of significant figures), it has very low accuracy (or reliability), as evident in the wide range of estimates that have been made by different techniques and research groups.

In summary, STEM's electron radius (R = 4 x 10^-13 m) produces a spin estimate corresponding to the speed of light, and an angular momentum estimate that produces g-factor of 1, whereas the conventional Science g-factor is mysteriously 2, apparently due to a '*purely quantum-mechanical*' thing. Also, when the STEM electron is represented as its spherical equivalent, that sphere's radius is remarkably close to the CODATA estimate of electron radius using the classical spherical model. At this stage of its development, the STEM electron model and size estimate is looking pretty good when compared with the QM-based electron model currently supported by conventional Science.