

Charge Carriers, Electric Currents and Related Electromagnetic Phenomena

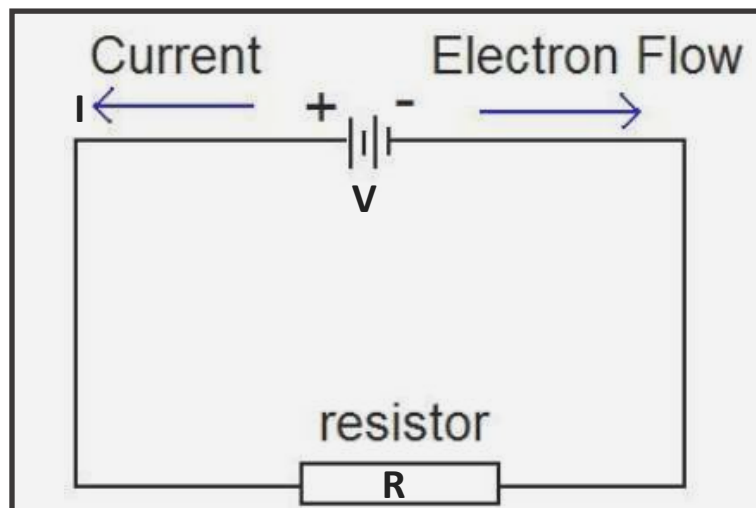
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Abstract

Although an explanation of electric current in terms of the one-way movement of electrons is widely accepted, and represents a reassuringly simple model, there are several problems when it comes to explaining phenomena such as the Hall Effect, electrical currents within semiconductor circuitry and the generation of electric and magnetic fields by electric currents. This article considers options that might better and more consistently explain these phenomena and overviews some unexpected implications of these options for covalent bond formation and the cause of radioactive decay.

Electric currents are usually explained by the one-way movement of electrons from a negative terminal to a positive terminal for chemical power sources, or from an implied negative terminal to an implied positive terminal for induced electric currents. However, the convention for electric current flow (I) is the opposite of electron flow, being from a positive to a negative terminal as shown in the simple electrical circuit below.



Circuit resistance, such as a **resistor** and/or other circuit components control the rate of electron movement: without such resistance, the circuit would short out with the unrestrained movement of electrons. The relationship between electron movement is reflected by **Ohm's Law** $V = I \times R$. The resistance (**R** in ohms) provided by the resistor, as per the diagram above, limits the electron or current flow rate (**I** in amperes) for the potential difference (voltage **V**) applied by the power source. Voltage simply reflects the relative pressure applied to induce electrons to move in a particular direction: it is often referred to as the **electromagnetic force (emf)**.

Within a DC circuit, electron movement is quite slow (about 23 micro-metres per second in copper wire), whereas electric circuit **activation** takes place at close to the speed of light. It is far from clear how such almost instantaneous activation is achieved by such slow moving electrons.

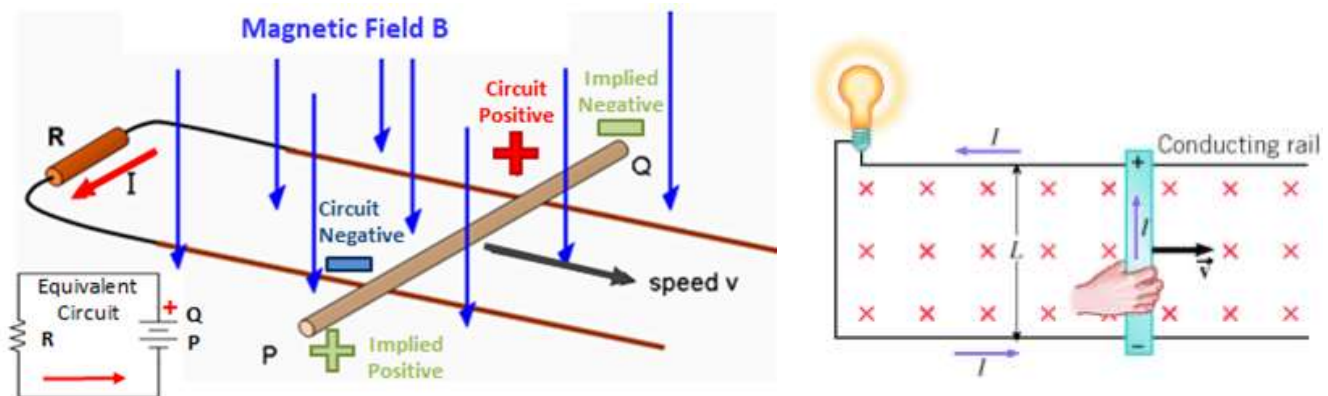
For a battery-based power source the negative terminal is considered to generate a surplus of electrons, with the possibility that an electron build-up would occur between the negative terminal and the resistor, and a corresponding electron deficit on the positive side: let's call this possibility **Alternative-A**.

Another possibility is that the number of electrons within each of the connecting circuit wires (i.e. on the negative side of the resistor and on the positive side) remain the same whether power is being applied or not, with the number of electrons added at the negative terminal being matched by the number being removed at the positive terminal. For a given emf, the electrons would be end-to-end shunted at the same rate across the circuit with their distribution densities in each section of the circuit remaining constant at all times. Let's call this possibility **Alternative-B**.

Alternative-A and Alternative-B are pretty much mutually exclusive, and yet they are variously invoked to explain the generation of electric currents and electric fields, which can be quite confusing.

Should the section of the circuit between the negative terminal and the load resistor be summarily cut-off and isolated, that section does not contain an excess of electrons; nor does the other part on the positive side have an electron deficit. One would think that this should pretty well eliminate Alternative-A.

For an electromagnetically **induced electric current**, no concentration of electrons is involved, which is also fully compatible with Alternative-B. For induction, the movement of a wire through a magnetic field, or changing concentrations of magnetic field flux, induces electrons to move, for which there are **implied terminals** dependent upon the electron movement direction, as can be seen in the figure below for a moving rod (PQ) within a fixed magnetic field (B). However, here the polarity of implied terminals is the reverse of the polarity of the **equivalent circuit terminals**, which can be quite confusing and very difficult to justify.



For a **chemical source** (e.g. a battery), an electric current is considered to be due to the one-way movement of electrons from the negative terminal that represents an electron concentration, that acts as an electron **source**, to a positive terminal where there is an electron deficit, that acts as an electron **sink**. With there being an equal number of electrons leaving the negative terminal to those being consumed at the positive terminal, as controlled by the circuit load, this scenario is also compatible with Alternative-B.

So far, Alternative-B appears to be the distinct winner for both induction and chemical sources of electric current generation. However, in order to explain electric and magnetic fields generated by electric circuits, Alternative-A is required; and even then, many aspects remain unexplained. So, let's next consider the positive and negative **electric field** created and maintained at the cut wire tips when a wire conductor of an active electric circuit is cut.

When the power source is a battery, the concentration of available electrons at the negative terminal side is used to explain the negative field at the cut wire tip on the negative terminal side, which is more compatible with Alternative-A. However, with there allegedly being an equal number of electrons within the circuit wire and resistor itself as per Alternative-B, there is no adequate explanation of why and how this negative electric field is generated when the wire is cut.

The positive field at the other side of the cut wire is allegedly due to the net positive charge of the protons of atoms that are deficient in outer orbital electrons at the positive terminal, which is also more in line with Alternative-A. How and why a positive field is generated at the cut wire connected to the positive terminal, even when the cut is very close to the negative terminal (i.e. a significant distance from the positive terminal), would appear to remain unexplained without invoking Alternative-A.

When the cut wire ends are connected to a pair of flat metal plates that are held rigidly in place parallel and close to each other, we have a **capacitor**. Capacitors can store electric charge when the energy source is removed and which can generate an electric current in the opposite direction to the charging current. But how is that charge stored? Although there are two schools of thought, this is a simple basic question has no real answer. One rationale is that the charge is stored as a concentration of electrons on the negative plate (and a corresponding depletion of electrons on the positive plate) along the lines of Alternative-A. The other possibility is that charge is stored as the electric field between the plates, which is the only option possible for Alternative-B: but with this option, there is no adequate explanation of how and why the electric field is generated in the first place.

When an electric current passes through a wire conductor, a **circular magnetic field** is generated as determined by the direction of the current flow. Should the direction of the current be known then the direction of the magnetic field can be determined using **Maxwell's Right-Hand Grip Rule**; or should the direction and strength of the circular magnetic field then the electric current direction and strength can be determined. Although the relationship between the circular magnetic field and the electric current are well established, Scientists provide no feasible explanation for the phenomena itself.

It would seem that explanations for the basic concepts related to electromagnetism and electric current are often contradictory and certainly far from complete or convincing. One of the main problems would seem to be that, for all of the mainstream atomic theories and related models, the only way that a positive charge can be generated within 'normal' matter is by the removal of orbital electrons from electrically neutral atoms. So, although electrons are the obvious choice for mobile negative charge carriers, there is no corresponding provision for mobile positive charge carriers. But then, before the 1950's, there was no perceived need for a mobile positive charge within matter to explain electric currents.

All that changed with the development of semiconductor technologies in the 1950's, when it became abundantly clear that, in order to explain how semiconductor-based electric currents and the newly discovered Hall Effect worked, there was a need for mobile positive charge carriers. The Science community's work-around to overcome the lack of an appropriate mobile positive charge carrier focused upon **temporal cations**. Temporal cations are static atoms (i.e. atoms with a fixed location within an atomic lattice) that can be toggled between an electrical neutral state into a positive state (i.e. become a **cation**) by the removal of one or more electrons; and then back into the neutral state by the cation acquiring the require number of electrons.

These temporal cations are called '**positive holes**'. However, the positive charge of a positive hole does not move: the charge simply is toggled between its 'on' and 'off' states. The assertion that positive holes can represent and move as mobile positive charge carriers is misleading and represents a convenient, but crude, sleight of hand that is a total nonsense. The 'positive holes' concept has been mindlessly adopted and presented as a fact from within Physics courses, and supported by misleading diagrams and clever

animated-gifs (e.g. [this simple gif](#) or this [diagram of the Hall Effect](#)) that purport to show positive holes moving in the opposite direction to electrons to form an electric current.

A much more likely contender for the much needed mobile positive charge carrier would appear to be the **positron**, the anti-particle of the electron. However, this option is rarely considered because, according to the mainstream atomic theories and related models, positrons do not and cannot exist within 'normal' matter. So we are left with the unsatisfactory 'positive holes' explanation that is under-pinned by the LWL (little white lie) that static temporal cations can act as positive charge carriers.

To explore the possibility that **positrons**, rather than 'positive holes', might be the much needed positive charge carriers, we need to know more about positrons. Positrons were first observed by Ernest Rutherford in 1898 from Beta Plus (β^+) decay, but they were called **positive beta particles** and were considered to be a form of weird radiation from the radioactive decay of Uranium. Electrons from Beta Minus (β^-) decay were similarly called **negative beta particles**. However, in 1932, 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 existence of the positron, the **anti-particle** of the electron. So, although the official story is that positrons were first discovered by Carl Anderson in 1932, he really only discovered a different natural source of positrons some 34 years after Rutherford originally discovered them.

Whereas Beta plus decay and cosmic radiation are 'natural' sources of positrons, from 1989 onwards, the Large Electron-Positron (LEP) Collider at CERN could 'synthetically' generate positrons via high energy impact for use in particle collision experiments. And since about 2012, it has been possible to generate positrons synthetically by the bombardment of metallic targets such as nickel or gold film with high energy (petawatt) lasers. However, it still remains that, although the Science community describes the Beta decay process in detail, it cannot provide feasible explanations for how or why positrons are generated either naturally or synthetically.

The lack of an explanation for the generation of positrons leaves the unanswered question as to whether positrons already pre-exist within matter and require high-energy impact to release them; or whether they are both created and released by high-energy impact processes. Should they pre-exist within matter, which is the simplest and most logical explanation by far, then they would potentially qualify as the positive charge carriers much needed to fully explain the nature of electric currents and related electromagnetic phenomena. If they do not pre-exist, then a feasible explanation of exactly how and why are they created is needed.

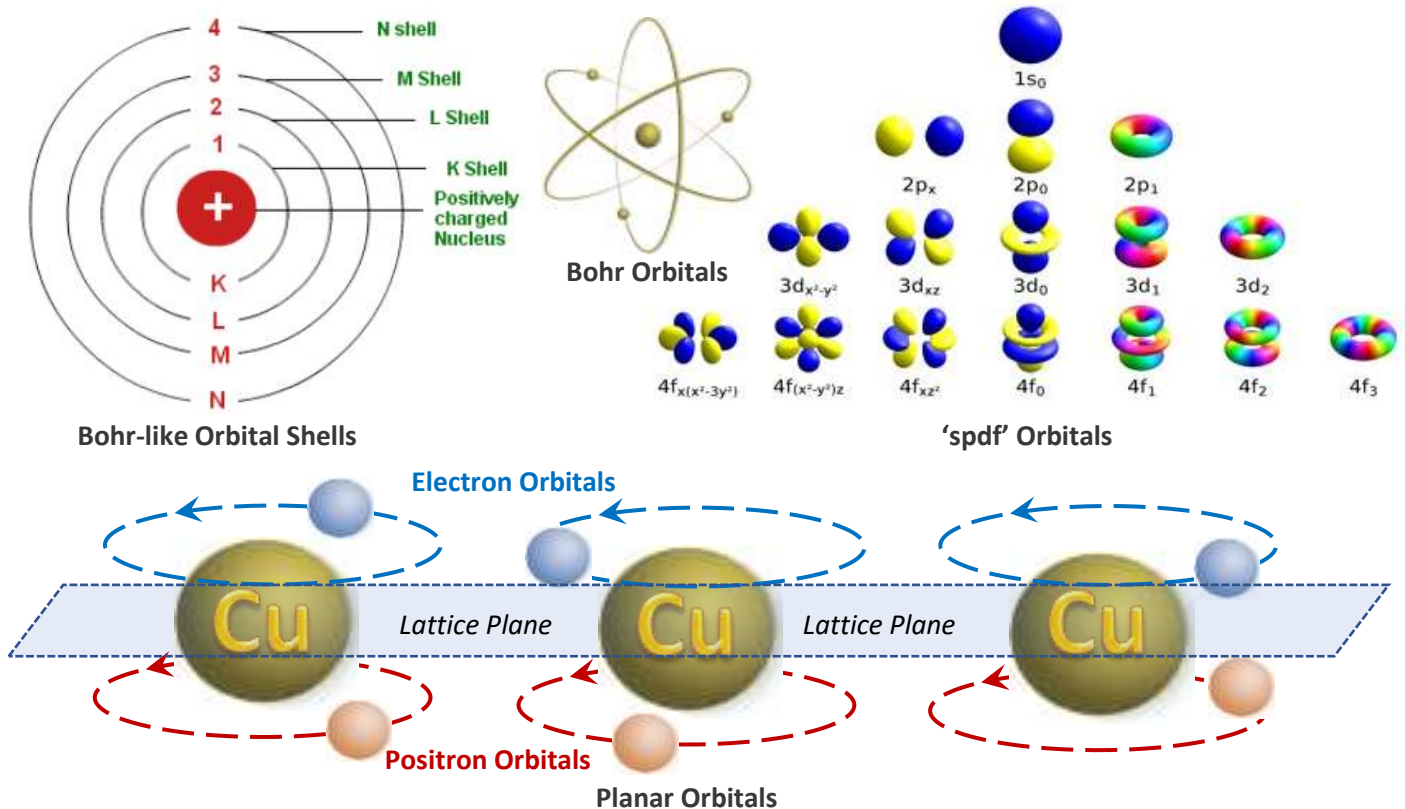
Should positrons pre-exist naturally within matter, an obvious question is: why haven't Scientists identified their existence within matter (i.e. in situ)? The most likely reason for this is that positrons and electrons are very similar to each other, only differing by the sign of their electric charge (electrons having a charge of $-1 e$, and positrons a charge of $+1 e$), and Scientists have been quite happy to consider any positive charge within 'normal' matter to be attributable to nucleus-based protons. Consequently Scientists have not been actively looking for positrons within matter, let alone within electrical conductors.

Another factor is that, although electrons can readily be released from their host medium by low level energy processes such as via heat or exposure to radiation in the visible light spectrum range, whereas the release (and possible creation) of positrons from a host media requires high-energy laser or collider bombardment techniques that have only been available since 1989 in a few specialised high-tech facilities.

Once released from their host medium, free electrons and positrons are easy to separate by an electric field, wherein they are deflected in opposite directions. Alternatively, should an electron and a positron meet each other head-on, they are highly likely to mutually self-destruct generating **gamma radiation**: this process is called **electron-positron annihilation**.

Should positrons pre-exist within matter rather than being dynamically created, they would need to be able to co-exist with electrons that are also present. For a good electrical conductor such as copper, which contains a ready supply of mobile electrons, the electrons and positrons would need to be kept well separated to avoid widespread electron-positron annihilation.

One possible way that electrons could be kept apart from positrons within an atom is if they populated different **planar orbitals** located on opposite sides of the atomic nucleus. Planar orbitals are not as unreasonable as they might first seem: they represent a feasible orbital configuration that is far less complicated than the 'spdf' or the planet-like Bohr orbital shells (as shown below) which are strongly promoted by various mainstream Atomic theories. Discrete and waveform electron orbitals that fully encircle the atomic nucleus are selectively adopted to help explain various phenomena but with mixed success: they still are controversial and unproven theoretical concepts and, although both approaches have been quantified mathematically, their existence and configurations have not yet been physically confirmed.



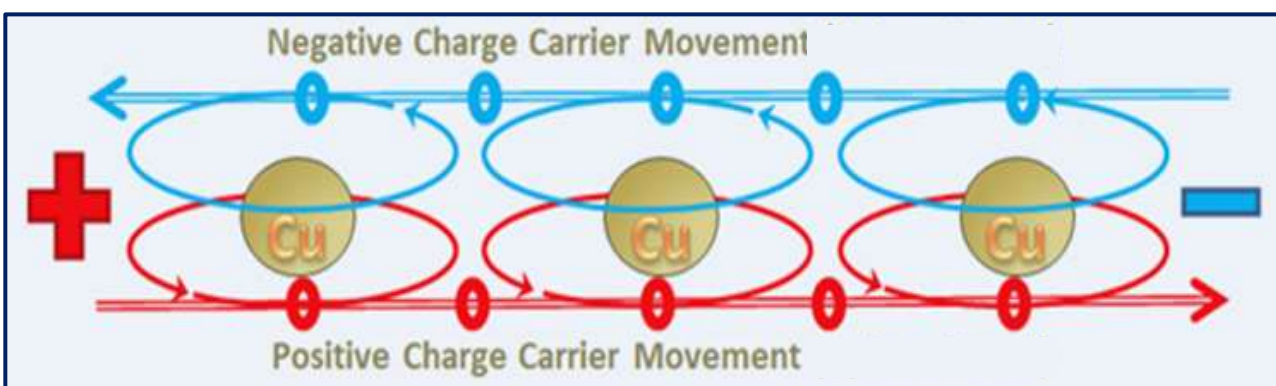
The planar orbitals would mean that, for atoms appropriately aligned within a lattice-like structure (e.g. copper atoms within a metallic conductor), their electrons and positrons would have separate orbitals above or below an atom group's lattice plane, and thus be well separated from each other as shown in the diagram above. This would also mean that they would have the ability to readily move or stream in opposite directions to each other under the influence of an applied or induced emf. Certainly the existence of such planar orbitals would mean that positrons, rather than the dubious 'positive holes', could be the elusive positive charge carriers required to fully explain electric current within semiconductors and the Hall Effect.

Traditionally, electrons have been physically represented as spheres but, to satisfy the **Wave equations** that underpin Quantum Mechanics and generate the 'spdf' orbital patterns, the spheres are reduced to dimensionless dots to allow a **point definition** to be used to mathematically define electrons. An alternative approach is to consider that, physically, electrons and positrons to have a **toroidal** (or doughnut) shaped structure consisting of a primitive material that generates the work-related effects that we attribute to 'energy', including interactions such as mutual electromagnetic attraction and repulsion. For want of a better name, this primitive material has been called **energen**. Unlike the spherical representation, the **toroidal electron model** has nothing at its toroidal centre-point except for a negligible amount of energen: it

can thus validly be treated as a dimensionless point source with energen-based electric field characteristics and **angular momentum** (or **spin**) that doesn't need to be considered **intrinsic** (i.e. an inexplicable property).

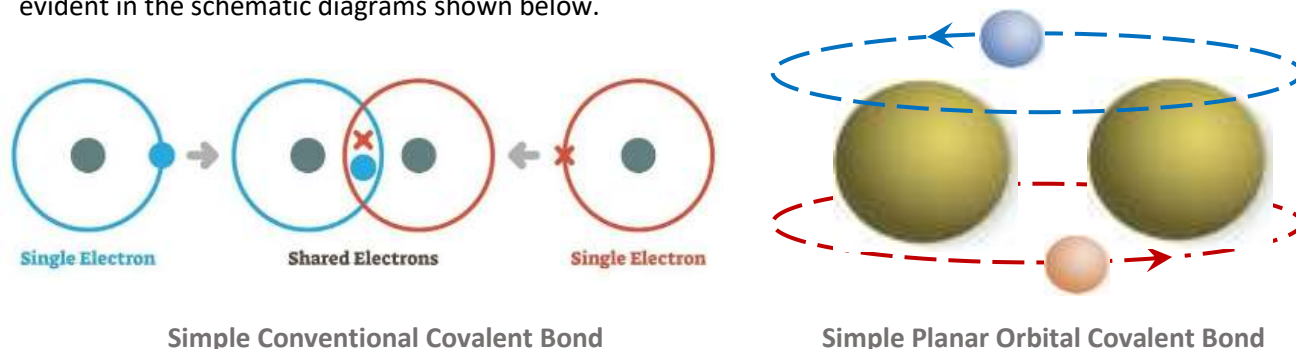
With the energen-based toroidal model of the electron, the only difference between an electron and a positron is the chiral flow direction of their energen-based **field energy**, with electrons having a **left-handed chiral** flow pattern which is perceived as a **negative** electric field; and positrons a **right-handed chiral** pattern which is perceived as a **positive** electric field. Such a simple model for the electron and positron can explain much about what we know about electromagnetism and the creation and characteristics of electric currents whilst still satisfying the Wave equations.

The diagram below shows how toroidal shaped electrons, acting as negative charge carriers, would stream in one direction and toroidal shaped positrons, acting as positive charge carriers, would stream in the opposite direction under the influence of an applied emf. As electrons and positrons stream, their electromagnetic field energy (shown as arrowed double lines) would align and combine to produce circuit activation at close to the speed of light although the average stream-speed of electrons and positrons themselves would be significantly slower.



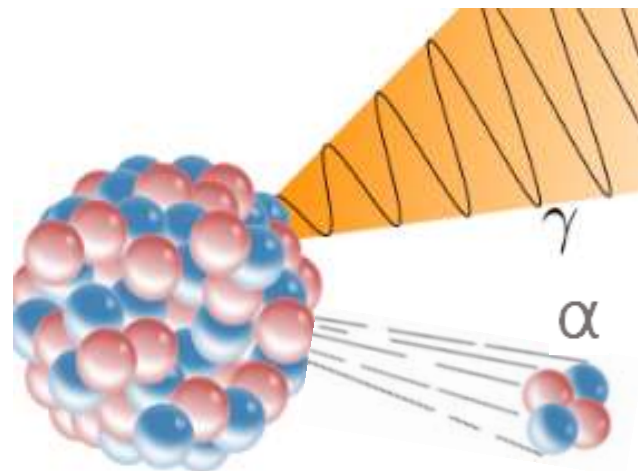
The **energen-based toroidal model** of the electron and positron supports the notion that electrical and magnetic fields consist of the same material (i.e. energen), but with different energen flow patterns that generate similar but subtly different interactions with each other. This approach readily provides a simple explanation for why and how negative and positive electric fields are different; how magnetic fields differ from electric fields; the almost instantaneous activation speed of an electrical circuit; the strength and direction of the circular magnetic field around a wire conductor carrying an electric current; and it leads to a logical explanation of electromagnetic induction and motor force generation phenomena. These are bold claims indeed, which can be explored in more detail in the STEM Development Group (**SDG**) paper titled [‘The Duplicit Electron’](#).

SDG also suggests that the planar orbital model makes much more sense when attempting to explain **covalent bonding** than do the conventional orbital approaches because planar orbitals do not involve mystical electron cross-overs between the bonded nuclei. The differences between the two approaches are evident in the schematic diagrams shown below.



For radioactively-stable elements (e.g. copper), SDG suggests that their crystal structure keep the electron and positron well separated. For **radioactive elements** and compounds, it is claimed that the separation of electrons and positrons is poor, resulting in random electron-positron annihilation events that produce [gamma radiation](#), which in turn initiates a range of radioactive decay processes such as [alpha radiation](#), [beta radiation](#), more gamma radiation (via [Bremsstrahlung](#)), and neutrinos.

SDG thus contends that random electron-positron annihilation events release gamma rays, which leads to a range of other forms of radioactive emissions. Although conventional Science documents the sources and effects of radiation quite well, the three basic forms of radiation (i.e. gamma, alpha and beta) remain mystical phenomena, with a feasible explanation either being non-existent or over-simplistic (e.g. the diagram right).



Gamma ray (γ) and Alpha (α) emission from an atomic nucleus (Conventional view)

Summary

The existence of a positron-like positive charge carrier fits in neatly with conventional DC and AC current generation theory and practice. And although, particularly for some photovoltaic cell applications, small or micro electric currents can be in terms of just negative or positive charge carrier movement, SDG contends that for all commercial DC and AC electrical applications, electric current consists of the simultaneous duplex movement of electrons and positrons in opposite directions to each other.

With electrons and positrons moving in opposite directions in equal numbers, the result is neutral charge within all sections of an electric circuit, whereas the one-way movement explanation of electrons leads to problems such as the Alternative-A and Alternative-B options, with detailed explanations of electric current requiring the far from acceptable use of positive charge carrying pseudo-particles called 'positive holes'.

An assumption that positrons (or their equivalent) already pre-exist within matter, rather than being created by unspecified high-energy interactions, results in logical explanations of all aspects of electromagnetic fields and the formation of electric currents, and leads to simpler models of covalent bonding and feasible explanations for the radioactive decay of unstable elements and compounds. However, to accommodate the concept that positrons pre-exist within matter would require a major revision of and, possibly, quite unwelcome radical changes to the atomic models currently embraced by the Science community.