Electricity is not what we think it is.

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Abstract: The mid 19th century natural philosophers pondered about the nature of the electric phenomenon, and used the term electric fluid. After the electron was discovered by Thomson, Drude shortly afterwards presented his theory of electric current as a drift of electrons; that theory, albeit with modifications, still holds today. Here I present a thought experiment that challenges Drude's theory.

Keywords: Coulomb force, Lorenz force, electrons, electricity

The 18th and 19th century Natural philosophers pondered about the electric fluid, they had no better means to describe electric phenomena; Thomson's [1] 1897 discovery of the electron changed that. Today, Drude's [2] 1900 postulate with the Sommerfeld's [3] 1928 modification, remains the accepted explanation for electric current. It is thought that electrons, as carriers of charge, drift to form an electric current. For example, assuming a 1mm diameter copper wire carrying an electric current of 1 amp, the electron drift is calculated at about 0.1 mm per second. Consequently according to Drude, when charging a capacitor, the positive charged plate will have a deficiency, and the negative charged plate an equal surplus of electrons.

Maxwell, showed us that there is another form of an electric current, the displacement current equal to the rate of change of an electric field. The displacement current and electric current in a copper wire are equivalent in dimensionality and both are sources of a magnetic field. The discovery of the displacement current is heralded as a historic landmark in physics because with it the magnetic and electric domains were unified into one set of equations, the Maxwell equations.

The Maxwell equations are fundamental to Nature. In this paper [4] I derive purely mathematically and purely generically the Maxwell equations. Therefore, the displacement current is a mathematical necessity, or rather it is fundamental to the electromagnetic phenomena. On the other hand, Drude's model has no equivalent in fundamental mathematical description. This now raises the question whether Drude's model really describes the electric current in conductors.

Drude's model does satisfy the dimensioning of electric current; the ampere is the flow of charge and is dimensioned as coulombs per second. I know of no experiment that confirms electric current in conductors as a drift of electrons.

Particle beams are parameterised by a beam current which is measured, among other ways, by the beam's magnetic field, which is identical to that generated by an equivalent electric current. But a particle beam differs from an electric current insofar as it carries kinetic energy and not electric energy. Van de Graaff in the midst of cutting edge technology at MIT would have known about Drude's theory but seemingly ignored it, as he wrote [5] "*When connected as shown, one point sprays positive and the other sprays negative electricity onto its adjacent belt.*" (see Figure-1) and we note that he does not attribute the high voltages of his generators to a lack or surplus of electrons on the domes.

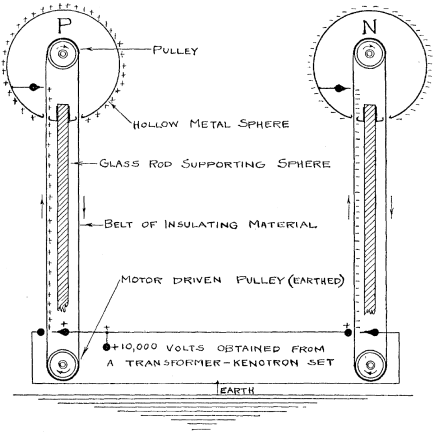

Figure 1: Van de Graaff Generator; extracted from [5]

The real question to ask is: "*Is the electrostatic charge field which is responsible for the Coulomb force the same phenomenon as the electric field (or electromotive field) responsible for the Lorentz force?*" To find an answer, I devised a thought experiment, which could be easily implemented by any competent research facility. The required apparatus is sketched in Figure-2.

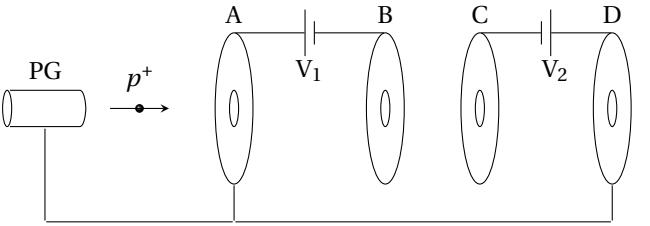

Figure 2: Thought experiment: Electrodynamic vs. static charge

High energy charged particles are emitted from the particle gun (PG) at

ground potential. The particles do not gain, nor lose, any kinetic energy on the path PG–A, as A is at the same potential as PG. On the path A–B the particles gain kinetic energy as the electromotive field $\mathbf{E}_{AB}$ accelerates the particles, causing an electric current to flow in the battery V_1 which is discharged accordingly. Anything else would violate energy conservation laws.

On the path B–C there is no potential difference and the kinetic energy of the particles remains unchanged in this section. The purpose of B and C is to electrically isolate batteries V_1 and V_2.

From C to D the particles lose kinetic energy as the electromotive field $\mathbf{E}_{CD} = -\mathbf{E}_{AB}$, and here the battery V_2 is charged; anything else would violate energy conservation laws. This is the symmetrical opposite of the physics that described B–C.

The particles leave the apparatus with its original energy, and the sum of the energies stored in batteries V_1 and V_2 also has not changed, although one has gained and the other has lost energy.

The particle beam can be maintained indefinitely, meaning that the electric currents which discharge and charge the batteries can be maintained indefinitely. We can now reasonably conclude that electric current is not an electron drift as postulated by Drude, because the question: "Where do the infinite electrons to support the electric current originate from?" cannot be answered for the experimental setup.

The thought experiment does not contradict Kirchhoff's current law. My interpretation/explanation is: The electric circuit A–V_1–B is a charged capacitor, the capacitor's energy is the electromotive field energy between A and B. A charged particle interacts with a partial volume of space and discharges its electric field, (the field energy is converted to kinetic energy hence the Lorentz force) which results in a Maxwell displacement current $\mathbf{j} = \partial\mathbf{E}/\partial t$ to restore the electric equilibrium of the field. This displacement current is the same current that discharges the battery. Therefore, electric charge does flow between A and B but requires a charge carrier other than the electron. (a massless '*voltron*' that carries electric energy?)

I have shown by logical thought that the electromotive fields $\mathbf{E}_{AB}$ and $\mathbf{E}_{CD}$ cannot be the result of a differential in free electrons on A and B, and on C and D, respectively. Therefore, I conclude that the electromotive field that accelerates atomic nuclei, electrons and ionised particles is a fundamental phenomenon that is not the same as the electrostatic fields that govern atomic matter, and particle–particle interactions.

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