ON THE PROPAGATION SPEED OF ELECTRIC CURRENT

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Introduction.

There are many contradictions in the modern theory of electric current. It is impossible to name some other branch of physics without having definition of its major subject. Yes, it is true; there is no definition of electric current in modern physics.

Electric current defined in the textbooks as the “rate of flow of electric charges”. The theory then stops and does not provides any more detailed information. However, thoughtful reader could find out that there are at least three different kinds of electric current:

1. Current in metals. In this case, electric current equals to NET flow of charge. Without “net” part, it is not possible to explain magnetic phenomenon. Ampere found that parallel currents attract or repel each other depending on the direction of the currents. When we changing our reference frame to the one which moving along with the electrons, magnetic force from moving electrons disappeared. The theory failed at this point without involving positively charged atomic nucleus. Indeed, the electrons are not moving now, but nucleus are moving in the opposite direction and the magnetic force between wires remains the same.

2. Current in electrolytes. Calculation of NET flow will produce zero result. However, electric current is not zero – the bulb in the circuit still glowing! The theory simply omit the “net” part and electric current in electrolytes calculated using charge carriers of one sign only. Since the “charge carries” of different signs moving in opposite direction, there is no magnetic field around such current and Ampere law does not holds for electrolytes.

3. Charged particles beam. Electron beam, for example is electric current according to physics textbooks. The huge difference from two previous cases is that the all moving particles have the same electric charge. On the first look, there are no differences with electric current in metals. In contrary to the metals, magnetic force should disappeared when reference frame is moving along with electrons. Does Ampere law holds for the two beams of electrons?

   If electron beam is indeed the electric current, then the single electron is an example of simplest kind of electric current. Let us calculate the value of such current. At a glance, it is easy. We just take the charge, which is equals to the charge of electron and divide it by time, which is… is… What it is? One second? One hour? Exactly one electron will cross the surface at any given time!

All of those three types of the flow of charges are electric currents. However, the calculations of the value of current are different. Magnetic field manifestations are also different.

The Speed of Electric Current in Metals

What is the speed of electric current in metal conductors? I am not talking here about the average drift speed of electrons. There is a switch on one end of the circuitry and the bulb on the other end. What is the time between turning switch on and lamp start to glow? The answer to this simple question is not that easy. The physics tried to avoid direct answer. The search on internet refer mostly to the drift velocity of electrons. Talking about the speed of electricity in conductors, the physics talking about electromagnetic wave propagation in the media. Wikipedia for example giving us some formula (https://en.wikipedia.org/wiki/Speed_of_electricity), which depend on frequency and magnetic property. However, our circuitry contains a DC battery. There is no any frequency. Talking about electromagnetic wave speed, we have well known formulae:

$$c = \frac{1}{\sqrt{\varepsilon\mu}}$$

where ε is dielectric constant and μ is permeability.

What the dielectric constant of the metals is equals to? There are no such thing exist and no tables could be found somewhere in the literature. Moreover, there is no electric field inside metals. Nevertheless, there are numerous references that such speed is very close to the speed of light.

Where Electricity Flows?

How the electricity propagates inside the wire? There are no clear answer provided by modern theory. You could find something like Fermi surface and Pauli exclusion.

Numerous experiments were conducted in order to measure the speed of electricity in coaxial cables. For some strange reason this speed depend on the dielectric which is the part of cable construction. There are explanations for this, one of such explanation is that the energy transferred not by electrons, but by electric field.

Let's take a second look at our simple electric circuitry. There are battery, two wires and light bulb, which dissipate the energy. Incoming and out coming wires have the same value of current, same value of electric field, same value of magnetic field, same value for kinetic energy of electrons, same everything. We should expect that there should be less energy in out coming wire, because the bulb is generating some heat, which could be measured. However, the energies inside and outside of the wires are the same.

Also there is no conservation energy law for electric current. Imagine the ball falling from some height. Potential energy of the ball in the beginning of experiment is equals to the kinetic energy at the end of experiment. For out circuitry we know the energy dissipated on the bulb. And this energy will be equals to the battery energy. What is battery energy? The energy of the battery equals to the value, which is written on battery. No other formulas or theory exist. And the final law sounds like this – "current squared times resistance times time is equals to the value written on battery".

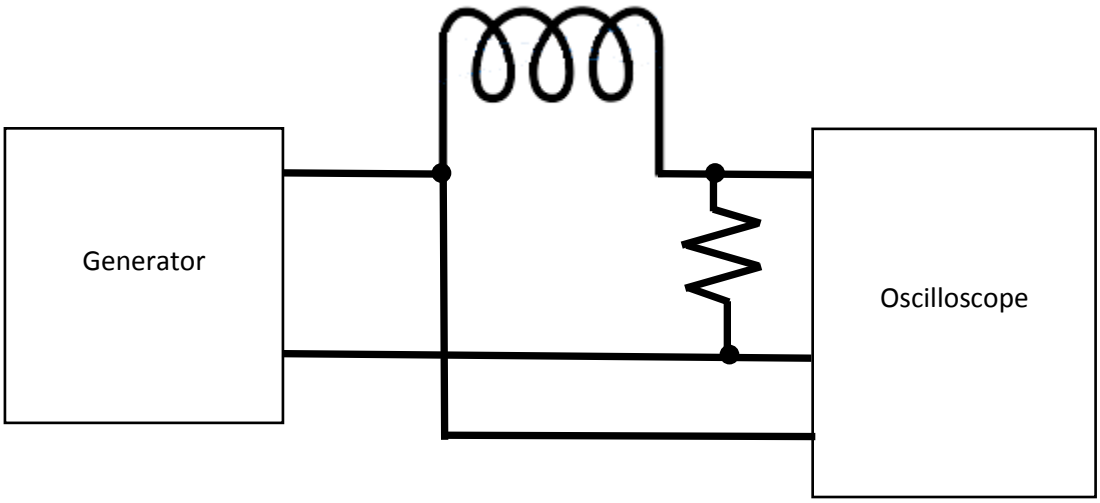
Here the different mechanism suggested. Electricity is something, which travels in between the wires from the battery to the load. The wires are just a guides for that "something". That "something" travels in the media and propagation speed depends on the property of this media.

Experiment

The following experiment was conducted:

We have 100 meters of copper wire. All our sources agreed on the fact that propagation speed of electricity in copper should be close to the speed of light. Calculation giving us: 100/3e8 = 330 nanoseconds.

The wire was formed in a coil. The half of this coil winded in the opposite direction to the other half. The coil inductance therefore is almost zero and there was no signal distortion. Signal from square wave generator applied to the one side of this coil. The other side of coil was connected to the load resistor. The delayed signal from load resistor was investigated using oscilloscope.



Although the wire was pretty long, the distance from the generator to the load resistor was not longer than 0.1 meter.

Time delay was measured with precision of one nanosecond and the value of delay was less than one nanosecond.

300 times fold between experiment and theory could not be explained by measurement precision. If electricity flow between wires, predicted value is in good accordance with experiment.