Ferroelectric Switching in 2-D Material

The 2-D realm exposes properties predicted by quantum mechanics—the probability-wave-based rules that underlie the behavior of all matter. [8]

Electron behaviour is governed by two major theories—the Coulomb's law and the Fermi liquid theory. [7]

This paper explains the magnetic effect of the electric current from the observed effects of the accelerating electrons, causing naturally the experienced changes of the electric field potential along the electric wire. The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the wave particle duality and the electron's spin also, building the bridge between the Classical and Quantum Theories.

The changing acceleration of the electrons explains the created negative electric field of the magnetic induction, the changing relativistic mass and the Gravitational Force, giving a Unified Theory of the physical forces. Taking into account the Planck Distribution Law of the electromagnetic oscillators also, we can explain the electron/proton mass rate and the Weak and Strong Interactions.

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Preface

Surprisingly nobody found strange that by theory the electrons are moving with a constant velocity in the stationary electric current, although there is an accelerating force **F = q E**, imposed by the **E** electric field along the wire as a result of the **U** potential difference. The accelerated electrons are creating a charge density distribution and maintaining the potential change along the wire. This charge distribution also creates a radial electrostatic field around the wire decreasing along the wire. The moving external electrons in this electrostatic field are experiencing a changing electrostatic field causing exactly the magnetic effect, repelling when moving against the direction of the current and attracting when moving in the direction of the current. This way the **A** magnetic potential is based on the real charge distribution of the electrons caused by their acceleration, maintaining the **E** electric field and the **A** magnetic potential at the same time.

The mysterious property of the matter that the electric potential difference is self maintained by the accelerating electrons in the electric current gives a clear explanation to the basic sentence of the relativity that is the velocity of the light is the maximum velocity of the electromagnetic matter. If the charge could move faster than the electromagnetic field, this self maintaining electromagnetic property of the electric current would be failed.

More importantly the accelerating electrons can explain the magnetic induction also. The changing acceleration of the electrons will create a –**E** electric field by changing the charge distribution, increasing acceleration lowering the charge density and decreasing acceleration causing an increasing charge density.

Since the magnetic induction creates a negative electric field as a result of the changing acceleration, it works as a relativistic changing electromagnetic mass. If the mass is electromagnetic, then the gravitation is also electromagnetic effect. The same charges would attract each other if they are moving parallel by the magnetic effect.

For UW physicists, the 2-D form of tungsten ditelluride is full of surprises

The general public might think of the 21st century as an era of revolutionary technological platforms, such as smartphones or social media. But for many scientists, this century is the era of another type of platform: two-dimensional materials, and their unexpected secrets.

These 2-D materials can be prepared in crystalline sheets as thin as a single monolayer, only one or a few atoms thick. Within a monolayer, electrons are restricted in how they can move: Like pieces on a board game, they can move front to back, side to side or diagonally—but not up or down. This constraint makes monolayers functionally two-dimensional.

The 2-D realm exposes properties predicted by quantum mechanics—the probability-wave-based rules that underlie the behavior of all matter. Since graphene—the first monolayer—debuted in 2004, scientists have isolated many other 2-D materials and shown that they harbor unique physical and chemical properties that could revolutionize computing and telecommunications, among other fields.

For a team led by scientists at the University of Washington, the 2-D form of one metallic compound—tungsten ditelluride, or WTe_2—is a bevy of quantum revelations. In a paper published online July 23 in the journal *Nature*, researchers report their latest discovery about WTe_2: Its 2-D form can undergo "ferroelectric switching." They found that when two monolayers are combined, the resulting "bilayer" develops a spontaneous electrical polarization. This polarization can be flipped between two opposite states by an applied electric field.

"Finding ferroelectric switching in this 2-D material was a complete surprise," said senior author David Cobden, a UW professor of physics. "We weren't looking for it, but we saw odd behavior, and after making a hypothesis about its nature we designed some experiments that confirmed it nicely."

Materials with ferroelectric properties can have applications in memory storage, capacitors, RFID card technologies and even medical sensors.

"Think of ferroelectrics as nature's switch," said Cobden. "The polarized state of the ferroelectric material means that you have an uneven distribution of charges within the material—and when the ferroelectric switching occurs, the charges move collectively, rather as they would in an artificial electronic switch based on transistors."

The UW team created WTe_2 monolayers from its the 3-D crystalline form, which was grown by co-authors Jiaqiang Yan at Oak Ridge National Laboratory and Zhiying Zhao at the University of Tennessee, Knoxville. Then the UW team, working in an oxygen-free isolation box to prevent WTe_2 from degrading, used Scotch Tape to exfoliate thin sheets of WTe_2 from the crystal—a technique widely used to isolate graphene and other 2-D materials. With these sheets isolated, they could measure their physical and chemical properties, which led to the discovery of the ferroelectric characteristics.

WTe_2 is the first exfoliated 2-D material known to undergo ferroelectric switching. Before this discovery, scientists had only seen ferroelectric switching in electrical insulators. But WTe_2 isn't an electrical insulator; it is actually a metal, albeit not a very good one. WTe_2 also maintains the ferroelectric switching at room temperature, and its switching is reliable and doesn't degrade over time, unlike many conventional 3-D ferroelectric materials, according to Cobden. These characteristics may make WTe_2 a promising material for smaller, more robust technological applications than other ferroelectric compounds.

"The unique combination of physical characteristics we saw in WTe_2 is a reminder that all sorts of new phenomena can be observed in 2-D materials," said Cobden.

Ferroelectric switching is the second major discovery Cobden and his team have made about monolayer WTe_2. In a 2017 paper in *Nature Physics*, the team reported that this material is also a "topological insulator," the first 2-D material with this exotic property.

In a topological insulator, the electrons' wave functions—mathematical summaries of their quantum mechanical states—have a kind of built-in twist. Thanks to the difficulty of removing this twist, topological insulators could have applications in quantum computing—a field that seeks to exploit the quantum-mechanical properties of electrons, atoms or crystals to generate computing power that is exponentially faster than today's technology. The UW team's discovery also stemmed from theories developed by David J. Thouless, a UW professor emeritus of physics who shared the 2016 Nobel Prize in Physics in part for his work on topology in the 2-D realm.

Cobden and his colleagues plan to keep exploring monolayer WTe_2 to see what else they can learn.

"Everything we have measured so far about WTe_2 has some surprise in it," said Cobden. "It's exciting to think what we might find next." [8]

Scientists solve open theoretical problem on electron interactions

Yale-NUS Associate Professor of Science (Physics) Shaffique Adam is the lead author of a recent work that describes a model for electron interaction in Dirac materials, a class of materials that includes graphene and topological insulators, solving a 65-year-old open theoretical problem in the process. The discovery will help scientists better understand electron interaction in new materials, paving the way for developing advanced electronics such as faster processors. The work was published in the peer-reviewed academic journal *Science* on 10 August 2018.

Electron behaviour is governed by two major theories—the Coulomb's law and the Fermi liquid theory. According to Fermi liquid theory, electrons in a conductive material behave like a liquid—their "flow" through a material is what causes electricity. For Dirac fermions, the Fermi liquid theory breaks down if the Coulomb force between the electrons crosses a certain threshold—the electrons "freeze" into a more rigid pattern which inhibits the "flow" of electrons, causing the material to become non-conductive.

For more than 65 years, this problem was a mathematical curiosity, because Dirac materials where the Coulomb threshold was reached did not yet exist. Today, however, we routinely make use of quantum materials for applications in technology, such as transistors in processors, where the electrons are engineered to have desired properties, including those that push the Coulomb force past this threshold. But the effects of strong electron-electron interaction can only be seen in very clean samples.

In the work immediately following his Ph.D., Associate Professor Adam proposed a model to describe experimentally available Dirac materials that were "very dirty," meaning they contain a lot of impurities. However, in the years that followed, newer and cleaner materials have been made, and the older theory no longer worked.

In this latest work, titled "The role of electron-electron interactions in two-dimensional Dirac fermions," Associate Professor Adam and his research team have developed a model that explains electron interactions past the Coulomb threshold in all Dirac materials by using a combination of numerical and analytical techniques.

In this research, the team designed a method to study the evolution of physical observables in a controllable manner and used it to address the competing effects of short-range and long-range parts in models of the Coulomb interaction. The researchers discovered that the velocity of electrons (the "flow" speed) in a material could decrease if the short-range interaction that favoured the insulating, "frozen" state dominated. However, the velocity of electrons could be enhanced by the long-range component that favoured the conducting "liquid" state. With this discovery, scientists can better understand long-range interactions of electrons non-perturbatively—something that previous theories were not able to explain. The findings serve as useful predictors for experiments exploring the long-range-interaction divergence in Dirac electrons when they transition between conducting to insulating phases.

This improved understanding in the evolution of the electron velocity during the phase transition paves the way to help scientists develop low heat dissipation devices for electronics. Associate Professor Adam explains, "The higher the electron velocity, the faster transistors can be switched on and off. However, this faster processor performance comes at the price of increased power leakage, which produces extra heat, and this heat will counteract the performance increase granted by the faster switching. Our findings on electron velocity behaviour will help scientists engineer devices that are capable of faster switching but lower power leakage. Because the mechanism in our new model harnesses the Coulomb force, it would cost less energy per switch compared to mechanisms available currently. Understanding and applying our new model could potentially usher in a new generation of technology." [7]

Simple Experiment

Everybody can repeat my physics teacher's - Nándor Toth - middle school experiment, placing aluminum folios in form V upside down on the electric wire with static electric current, and seeing them open up measuring the electric potential created by the charge distribution, caused by the acceleration of the electrons.

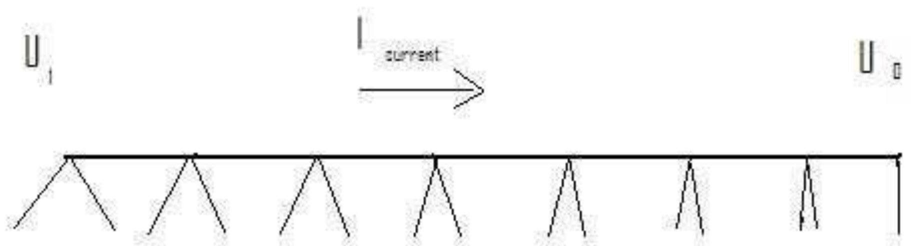

Figure 1.) Aluminium folios shows the charge distribution on the electric wire

He wanted to show us that the potential decreasing linearly along the wire and told us that in the beginning of the wire it is lowering harder, but after that the change is quite linear.

You will see that the folios will draw a parabolic curve showing the charge distribution along the wire, since the way of the accelerated electrons in the wire is proportional with the square of time. The free external charges are moving along the wire, will experience this charge distribution caused electrostatic force and repelled if moving against the direction of the electric current and attracted in the same direction – the magnetic effect of the electric current.

Uniformly accelerated electrons of the steady current

In the steady current **I= dq/dt**, the **q** electric charge crossing the electric wire at any place in the same time is constant. This does not require that the electrons should move with a constant v velocity and does not exclude the possibility that under the constant electric force created by the **E = - dU/dx** potential changes the electrons could accelerating.

If the electrons accelerating under the influence of the electric force, then they would arrive to the $\mathbf{x = 1/2\ at^2}$ in the wire. The $\mathbf{dx/dt = at}$, means that every second the accelerating q charge will take a linearly growing length of the wire. For simplicity if a=2 then the electrons would found in the wire at x = 1, 4, 9, 16, 25 …, which means that the dx between them should be 3, 5, 7, 9 …, linearly increasing the volume containing the same q electric charge. It means that the density of the electric charge decreasing linearly and as the consequence of this the U field is decreasing linearly as expected: $\mathbf{-dU/dx = E = const}$.

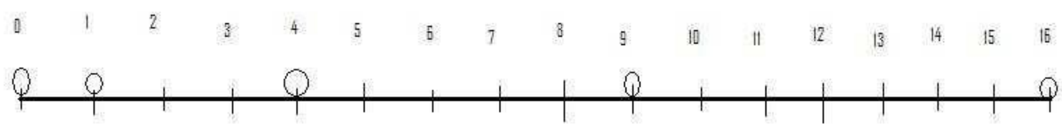

Figure 2.) The accelerating electrons created charge distribution on the electric wire

This picture remembers the Galileo's Slope of the accelerating ball, showed us by the same teacher in the middle school, some lectures before. I want to thank him for his enthusiastic and impressive lectures, giving me the associating idea between the Galileo's Slope and the accelerating charges of the electric current.

We can conclude that the electrons are accelerated by the electric **U** potential, and with this accelerated motion they are maintaining the linear potential decreasing of the **U** potential along they movement. Important to mention, that the linearly decreasing charge density measured in the referential frame of the moving electrons. Along the wire in its referential frame the charge density lowering parabolic, since the charges takes way proportional with the square of time.

The decreasing **U** potential is measurable, simply by measuring it at any place along the wire. One of the simple visualizations is the aluminum foils placed on the wire opening differently depending on the local charge density. The static electricity is changing by parabolic potential giving the equipotential lines for the external moving electrons in the surrounding of the wire.

Magnetic effect of the decreasing U electric potential

One **q** electric charge moving parallel along the wire outside of it with velocity v would experience a changing **U** electric potential along the wire. If it experiencing an emerging potential, it will repel the charge, in case of decreasing **U** potential it will move closer to the wire. This radial electric field will move the external electric charge on the parabolic curve, on the equipotential line of the accelerated charges of the electric current. This is exactly the magnetic effect of the electric current. A constant force, perpendicular to the direction of the movement of the matter will change its direction to a parabolic curve.

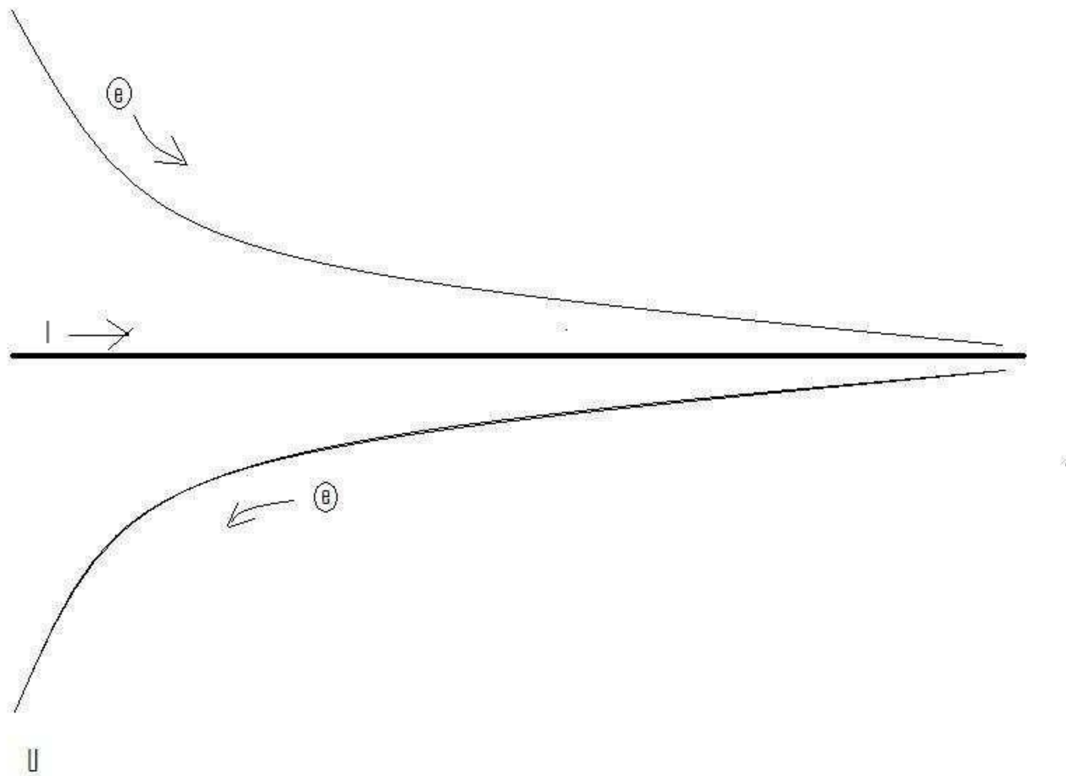

Figure 3.) Concentric parabolic equipotential surfaces around the electric wire causes the magnetic effect on the external moving charges

Considering that the magnetic effect is **F=q v x B**, where the **B** is concentric circle around the electric wire, it is an equipotential circle of the accelerating electrons caused charge distribution. Moving on this circle there is no electric and magnetic effect for the external charges, since **vxB=0**. Moving in the direction of the current the electric charges crosses the biggest potential change, while in any other direction – depending on the angle between the current and velocity of the external charge there is a modest electric potential difference, giving exactly the same force as the **v x B** magnetic force.

Getting the magnetic force from the **F = dp/dt** equation we will understand the magnetic field velocity dependency. Finding the appropriate trajectory of the moving charges we need simply get it from the equipotential lines on the equipotential surfaces, caused by the accelerating charges of the electric current. We can prove that the velocity dependent force causes to move the charges on the equipotential surfaces, since the force due to the potential difference according to the velocity angle – changing only the direction, but not the value of the charge's velocity.

The work done on the charge and the Hamilton Principle

One basic feature of magnetism is that, in the vicinity of a magnetic field, a moving charge will experience a force. Interestingly, the force on the charged particle is always perpendicular to the direction it is moving. Thus magnetic forces cause charged particles to change their direction of motion, but they do not change the speed of the particle. This property is used in high-energy particle accelerators to focus beams of particles which eventually collide with targets to produce new particles. Another way to understand this is to realize that if the force is perpendicular to the motion, then no work is done. Hence magnetic forces do no work on charged particles and cannot increase their kinetic energy. If a charged particle moves through a constant magnetic field, its speed stays the same, but its direction is constantly changing. [2]

In electrostatics, the work done to move a charge from any point on the equipotential surface to any other point on the equipotential surface is zero since they are at the same potential. Furthermore, equipotential surfaces are always perpendicular to the net electric field lines passing through it. [3]

Consequently the work done on the moving charges is zero in both cases, proving that they are equal forces, that is they are the same force.

The accelerating charges self-maintaining potential equivalent with the Hamilton Principle and the Euler-Lagrange equation. [4]

The Magnetic Vector Potential

Necessary to mention that the **A** magnetic vector potential is proportional with a, the acceleration of the charges in the electric current.

Also the **A** magnetic vector potential gives the radial parabolic electric potential change of the charge distribution due to the acceleration of electric charges in the electric current.

Since the magnetic field B is defined as the curl of A, and the by vector identity the curl of a gradient is identically zero, then any arbitrary function which can be expressed as the gradient of a scalar function may be added to A without changing the value of B obtained from it. That is, A' can be freely substituted for A where

$$\vec{A'} = \vec{A} + \vec{\nabla}\phi$$

Such transformations are called gauge transformations, and there have been a number of "gauges" that have been used to advantage is specific types of calculations in electromagnetic theory. [5] Since the potential difference and the vector potential both are in the direction of the electric current, this gauge transformation could explain the self maintaining electric potential of the accelerating electrons in the electric current. Also this is the source of the special and general relativity.

The Constant Force of the Magnetic Vector Potential

Moving on the parabolic equipotential line gives the same result as the constant force of gravitation moves on a parabolic line with a constant velocity moving body.

Electromagnetic four-potential

The electromagnetic four-potential defined as:

SI units	cgs units
$A^\alpha = (\phi/c, \mathbf{A})$	$A^\alpha = (\phi, \mathbf{A})$

in which ϕ is the electric potential, and **A** is the magnetic vector potential. [6] This is appropriate with the four-dimensional space-time vector (T, **R**) and in stationary current gives that the potential difference is constant in the time dimension and vector potential (and its curl, the magnetic field) is constant in the space dimensions.

Magnetic induction

Increasing the electric current I causes increasing magnetic field **B** by increasing the acceleration of the electrons in the wire. If the acceleration of electrons is growing, than the charge density **dQ/dl** will decrease in time, creating a **–E** electric field. Since the resistance of the wire is constant, only increasing U electric potential could cause an increasing electric current **I=U/R=dQ/dt**.

Necessary to mention that decreasing electric current will decrease the acceleration of the electrons, causing increased charge density and **E** positive field.

The electric field is a result of the geometric change of the **U** potential and the timely change of the **A** magnetic potential:

E = - dA/dt - dU/dr

$$\mathbf{B} = \nabla \times \mathbf{A}, \quad \mathbf{E} = -\nabla\phi - \frac{\partial \mathbf{A}}{\partial t},$$

The acceleration of the electric charges proportional with the A magnetic vector potential in the electric current and also their time dependence are proportional as well. Since the A vector potential is appears in the equation, the proportional **a** acceleration will satisfy the same equation.

Since increasing acceleration of charges in the increasing electric current the result of increasing potential difference, creating a decreasing potential difference, the electric and magnetic vector potential are changes by the next wave - function equations:

$$\frac{1}{c^2}\frac{\partial^2\varphi}{\partial t^2} - \nabla^2\varphi = \frac{\rho}{\varepsilon_0}$$

$$\nabla^2\mathbf{A} - \frac{1}{c^2}\frac{\partial^2\mathbf{A}}{\partial t^2} = -\mu_0\mathbf{J}$$

The simple experiment with periodical changing **U** potential and **I** electric current will move the aluminium folios with a moving wave along the wire.

The Lorentz gauge says exactly that the accelerating charges are self maintain their accelerator fields and the divergence (source) of the A vector potential is the timely change of the electric potential.

$$\nabla\cdot\vec{A} + \frac{1}{c^2}\frac{\partial\varphi}{\partial t} = 0.$$

Or

$$\vec{E} = -\nabla\,\varphi - \frac{\partial\vec{A}}{\partial t}.$$

The timely change of the A vector potential, which is the proportionally changing acceleration of the charges will produce the negative electric field.

Lorentz transformation of the Special Relativity

In the referential frame of the accelerating electrons the charge density lowering linearly because of the linearly growing way they takes every next time period. From the referential frame of the wire there is a parabolic charge density lowering.

The difference between these two referential frames, namely the referential frame of the wire and the referential frame of the moving electrons gives the relativistic effect. Important to say that the moving electrons presenting the time coordinate, since the electrons are taking linearly increasing way every next time period, and the wire presenting the geometric coordinate.

The Lorentz transformations are based on moving light sources of the Michelson - Morley experiment giving a practical method to transform time and geometric coordinates without explaining the source of this mystery.

The real mystery is that the accelerating charges are maintaining the accelerating force with their charge distribution locally. The resolution of this mystery that the charges are simply the results of the diffraction patterns, that is the charges and the electric field are two sides of the same thing. Otherwise the charges could exceed the velocity of the electromagnetic field.

The increasing mass of the electric charges the result of the increasing inductive electric force acting against the accelerating force. The decreasing mass of the decreasing acceleration is the result of the inductive electric force acting against the decreasing force. This is the relativistic mass change explanation, especially importantly explaining the mass reduction in case of velocity decrease.

Heisenberg Uncertainty Relation

In the atomic scale the Heisenberg uncertainty relation gives the same result, since the moving electron in the atom accelerating in the electric field of the proton, causing a charge distribution on delta x position difference and with a delta p momentum difference such a way that they product is about the half Planck reduced constant. For the proton this delta x much less in the nucleon, than in the orbit of the electron in the atom, the delta p is much higher because of the greater proton mass.

This means that the electron and proton are not point like particles, but has a real charge distribution.

Wave – Particle Duality

The accelerating electrons explains the wave – particle duality of the electrons and photons, since the elementary charges are distributed on delta x position with delta p impulse and creating a wave packet of the electron. The photon gives the electromagnetic particle of the mediating force of the electrons electromagnetic field with the same distribution of wavelengths.

Atomic model

The constantly accelerating electron in the Hydrogen atom is moving on the equipotential line of the proton and it's kinetic and potential energy will be constant. Its energy will change only when it is changing its way to another equipotential line with another value of potential energy or getting free with enough kinetic energy. This means that the Rutherford-Bohr atomic model is right and only the changing acceleration of the electric charge causes radiation, not the steady acceleration. The steady acceleration of the charges only creates a centric parabolic steady electric field around the charge, the magnetic field. This gives the magnetic moment of the atoms, summing up the proton and electron magnetic moments caused by their circular motions and spins.

Fermions' spin

The moving charges are accelerating, since only this way can self maintain the electric field causing their acceleration. The electric charge is not point like! This constant acceleration possible if there is a rotating movement changing the direction of the velocity. This way it can accelerate forever without increasing the absolute value of the velocity in the dimension of the time and not reaching the velocity of the light.

The Heisenberg uncertainty relation says that the minimum uncertainty is the value of the spin: **1/2 h = dx dp** or **1/2 h = dt dE**, that is the value of the basic energy status, consequently related to the m_o inertial mass of the fermions.

The photon's 1 spin value and the electric charges 1/2 spin gives us the idea, that the electric charge and the electromagnetic wave two sides of the same thing, 1/2 – (-1/2) = 1.

Fine structure constant

The Planck constant was first described as the proportionality constant between the energy ***E*** of a photon and the frequency ***ν*** of its associated electromagnetic wave. This relation between the energy and frequency is called the Planck relation or the Planck–Einstein equation:

$$E = \hbar\nu$$

Since the frequency ***ν*,** wavelength ***λ***, and speed of light ***c*** are related by ***λν* = *c***, the Planck relation can also be expressed as

$$E = \frac{\hbar c}{\lambda}.$$

Since this is the source of the Planck constant, the e electric charge countable from the Fine structure constant. This also related to the Heisenberg uncertainty relation, saying that the mass of the proton should be bigger than the electron mass because of the difference between their wavelengths, since **E = mc²**.

The expression of the fine-structure constant becomes the abbreviated

$$\alpha = \frac{e^2}{\hbar c}$$

This is a dimensionless constant expression, 1/137 commonly appearing in physics literature.

This means that the electric charge is a result of the electromagnetic waves diffractions, consequently the proton – electron mass rate is the result of the equal intensity of the corresponding electromagnetic frequencies in the Planck distribution law.

Planck Distribution Law

The Planck distribution law explains the different frequencies of the proton and electron, giving equal intensity to different lambda wavelengths! The weak interaction transforms an electric charge in the diffraction pattern from one side to the other side, causing an electric dipole momentum change, which violates the CP and time reversal symmetry.

The Planck distribution law is temperature dependent and it should be true locally and globally. I think that Einstein's energy-matter equivalence means some kind of existence of electromagnetic oscillations enabled by the temperature, creating the different matter formulas, atoms, molecules, crystals, dark matter and energy.

One way dividing the proton to three parts is, dividing his oscillation by the three direction of the space. We can order 1/3 **e** charge to each coordinates and 2/3 **e** charge to one plane oscillation, because the charge is scalar. In this way the proton has two +2/3 **e** plane oscillation and one linear oscillation with -1/3 **e** charge. The colors of quarks are coming from the three directions of coordinates and the proton is colorless. [1]

Electromagnetic inertia and Gravitational attraction

Since the magnetic induction creates a negative electric field as a result of the changing acceleration, it works as an electromagnetic changing mass.

It looks clear that the growing acceleration results the relativistic growing mass - limited also with the velocity of the electromagnetic wave.

The negatively changing acceleration causes a positive electric field, working as a decreasing mass.

Since $E = hv$ and $E = mc^2$, $m = hv / c^2$ that is the m depends only on the v frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the m_o inertial mass is the result of the spin, since this is the only accelerating motion of the electric charge. Since the accelerating motion has different frequency for the electron in the atom and the proton, they masses are different, also as the wavelengths on both sides of the diffraction pattern, giving equal intensity of radiation.

If the mass is electromagnetic, then the gravitation is also electromagnetic effect caused by the magnetic effect between the same charges, they would attract each other if they are moving parallel by the magnetic effect.

The Planck distribution law explains the different frequencies of the proton and electron, giving equal intensity to different lambda wavelengths. Also since the particles are diffraction patterns they have some closeness to each other – can be seen as the measured effect of the force of the gravitation, since the magnetic effect depends on this closeness. This way the mass and the magnetic attraction depend equally on the wavelength of the electromagnetic waves.

Conclusions

Needless to say that the accelerating electrons of the steady stationary current are a simple demystification of the magnetic field, by creating a decreasing charge distribution along the wire, maintaining the decreasing U potential and creating the **A** vector potential experienced by the electrons moving by **v** velocity relative to the wire. This way it is easier to understand also the time dependent changes of the electric current and the electromagnetic waves as the resulting fields moving by c velocity.
There is a very important law of the nature behind the self maintaining **E** accelerating force by the accelerated electrons. The accelerated electrons created electromagnetic fields are so natural that they occur as electromagnetic waves traveling with velocity c. It shows that the electric charges are the result of the electromagnetic waves diffraction.
One of the most important conclusions is that the electric charges are moving in an accelerated way and even if their velocity is constant, they have an intrinsic acceleration anyway, the so called spin, since they need at least an intrinsic acceleration to make possible they movement . The bridge between the classical and quantum theory is based on this intrinsic acceleration of the spin, explaining also the Heisenberg Uncertainty Principle. The particle – wave duality of the electric charges and the photon makes certain that they are both sides of the same thing. Basing the gravitational force on the magnetic force and the Planck Distribution Law of the electromagnetic waves caused diffraction gives us the basis to build a Unified Theory of the physical interactions.

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