Magnetic Anisotropy

There is a big effort in industry to produce electrical devices with more and faster memory and logic. Magnetic memory elements, such as in a hard drive, and in the future in what is called MRAM (magnetic random access memory), use electrical currents to encode information. However, the heat which is generated is a significant problem, since it limits the density of devices and hence the performance of computer chips. [11]

The National High Magnetic Field Laboratory, with facilities in Florida and New Mexico, offers scientists access to enormous machines that create record-setting magnetic fields. The strong magnetic fields help researchers probe the fundamental structure of materials to better understand and manipulate their properties. Yet large-scale facilities like the MagLab are scarce, and scientists must compete with others for valuable time on the machines. [10]

By showing that a phenomenon dubbed the "inverse spin Hall effect" works in several organic semiconductors - including carbon-60 buckyballs - University of Utah physicists changed magnetic "spin current" into electric current. The efficiency of this new power conversion method isn't yet known, but it might find use in future electronic devices including batteries, solar cells and computers. [9]

Researchers from the Norwegian University of Science and Technology (NTNU) and the University of Cambridge in the UK have demonstrated that it is possible to directly generate an electric current in a magnetic material by rotating its magnetization. [8]

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.

Contents

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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.

Controlling magnetism with an electric field

Scientists are now proposing a novel approach to achieve greater memory density while producing less heat: by using an electric field instead of a current to turn magnetism on and off, thereby encoding the electrical devices.

The University of Miami (UM) researcher and colloborators did not discover electrical control of magnetism, but a new understanding of the phenomenon. The study shows how the electric

field, and not the change in the electron density in the film (called doping), leads to control of magnetism in current experiments. The findings are published in the journal Scientific Reports.

"Our work shows a new path to using a magnetic capacitor which uses electric field to control magnetism," says Stewart Barnes, physicist at the UM College of Arts and Sciences, and corresponding author of the study. "The energy dissipation involved is much lower than produced with an electric current, drastically reducing the heat."

Electricity and magnetism are two aspects of the electromagnetic force. Ampère's law says that when charged particles flow in a conductor, they produce a magnetic field. The intensity of an electric current flowing in a wire determines the intensity of this field near the wire. On the other hand, an electric field in the space around a given charge is given by Coulomb's law. It determines the force on a second nearby charged particle. There is no charge flow.

Traditionally, magnetism is activated in an electromagnet by passing a current through a coil around a magnetic material. This coil generates a magnetic field. The new method uses a capacitor, a device used to generate an electric field, to control the magnetism of a magnetic material.

"With the electrical control of magnetism, you use a capacitor in which one element is magnetic and, simply by charging the capacitor, you change the direction of the magnetism, say from being in the plane of the film to being perpendicular," says Barnes.

This property of magnetic materials, where the magnetization is oriented in a preferred direction, is called anisotropy. The new approach developed by the researchers is founded on a relativistic effect called Rashba spin-orbit coupling. The effect arises from the interaction between the spin of an electron and an electric field.

"We use this Rashba effect to produce a magnetic anisotropy, which leads to our control of magnetism," says Barnes. "We produce the electric field, in part, by a proper choice of the magnetic and non-magnetic elements in our bi-layer and by generating an electric field with a capacitor."

The new mechanism has been studied, theoretically, in sandwiches of magnetic materials and non-magnetic metals or semi-conductors. The analysis of a number of such sandwiches helps answer technical questions associated with the control of magnetism of thin ferromagnetic films, as might be used in memory and logic devices.

Thin magnetic films with a controllable perpendicular magnetic anisotropy (PMA) have important applications, not only for MRAM and logic, but also for electromechanical devices, such as actuators, which are devices that transform an electrical signal into motion. For that reason, an internal electric field that can be used to engineer such a PMA is of great interests.

The researchers are planning experiments which verify the basic principles of the current study and to simulate the materials involved using a computer. The study is called "Rashba Spin-Orbit

Anisotropy and the Electric Field Control of Magnetism" Co-authors are Jun'ichi Ieda and Sadamichi Maekawa, from the Advanced Science Research Center of the Japan Atomic Energy Agency, in Tokai, and CREST, Japan Science and Technology Agency, Sanbancho in Tokyo. [11]

New tabletop instrument tests electron mobility for next-generation electronics

The National High Magnetic Field Laboratory, with facilities in Florida and New Mexico, offers scientists access to enormous machines that create record-setting magnetic fields. The strong magnetic fields help researchers probe the fundamental structure of materials to better understand and manipulate their properties. Yet large-scale facilities like the MagLab are scarce, and scientists must compete with others for valuable time on the machines.

Now researchers from the United Kingdom, in collaboration with industry partners from Germany, have built a tabletop instrument that can perform measurements that were only previously possible at large national magnet labs. The measurements will help in the development of next generation electronic devices employing 2-D materials, said Ben Spencer, a post-doctoral research associate working in Darren Graham's group at the University of Manchester's Photon Science Institute, who helped develop the new instrument.

The researchers describe their work in a paper in the journal Applied Physics Letters.

Since the 1950s, experiments conducted with magnetic fields have played a pivotal role in the development of semiconductors devices—like transistors and light-emitting diodes—that have changed the world.

One magnetic field technique is called cyclotron resonance. In a magnetic field, the charged particles in a material start to move in circles around the magnetic field lines. The orbiting particles interact with light differently depending on properties like their mass, concentration, and on how easily they move through the material. By shining light on the material in the magnetic field and recording what frequency and how much light is absorbed, scientists can learn important information about how easily charged particles move, a critical property in electronic devices.

 New tabletop instrument tests electron mobility for next-generation electronics

The magnetic coil at the heart of the system was developed by Professor Hiroyuki Nojiri at the Institute of Materials Research, Tohoku University (Japan). It produces a pulsed magnetic field of up to 30 Tesla. Credit: S. Hammersley, The University of Manchester

One of the main obstacles to wide-spread use of cyclotron resonance is that some materials require an extremely high magnetic field to get the charged particles to move fast enough to interact with the light.

Recently researchers created a small, high-powered magnet that can generate fields of around 30 Tesla, about 600,000 times stronger than the Earth's magnetic field and 20 times stronger than the MRI scanners typically used in hospitals.

The new magnet is compact enough for a tabletop machine, yet the magnet can only generate a field in short pulses that each last for a fleeting one-hundredth of a second.

"The challenge in doing cyclotron resonance with these pulsed magnets is being able to record your data within the brief time period that the magnet is on," Spencer said. "The breakthrough we have made is in the measurement technique."

Spencer and his colleagues used an approach called an asynchronous optical sampling technique to increase the number of measurements during one pulse to around 100. Previous experiments with a similar magnet system were limited to four measurements per pulse.

The team worked with researchers from Laser Quantum, a laser manufacturer, to incorporate ultrafast lasers into the new instrument. The "Taccor" lasers they used run at repetition rates of 1 billion cycles per second, more than 10 times higher than the typical repetition rates for ultrafast laser systems, Spencer said. The fast laser allowed data acquisition times on the order of one ten-thousandth of a second, which meant up to a hundred measurements could be taken during the transient magnet pulse.

"It is this leap forward that will now enable routine cyclotron resonance measurements on a tabletop in a laboratory environment," Spencer said.

The team tested their system by measuring the properties of electrons at the interface of the two semiconductors AlGaN and GaN. Such interfaces could form an important part of new, energy-saving transistors.

"This work is feeding into a programme of work at Cambridge University on developing AlGaN/GaN-based high electron mobility transistors. These promise much lower power consumption than current devices, which will ultimately lead to energy savings in a wide range of consumer electronic devices. We are also starting to investigate a range of other two-dimensional materials using this instrument, including the new wonder 2-D material graphene," Graham said.

Ultimately, the team hopes their new instrument could facilitate rapid progress in many areas of semiconductor device development. The system can be easily moved to different universities, and it makes it easy to think of a measurement, and simply perform it the next day, without having to apply for time at a national magnet facility, the researchers say.

"We're sure that when people realise that we can do such measurements in the lab they will be lining up to use our instrument. We've already been contacted by several groups interested in having measurements made on their samples," Graham said. [10]

Inverse spin Hall effect: A new way to get electricity from magnetism

By showing that a phenomenon dubbed the "inverse spin Hall effect" works in several organic semiconductors - including carbon-60 buckyballs - University of Utah physicists changed magnetic "spin current" into electric current. The efficiency of this new power conversion method isn't yet known, but it might find use in future electronic devices including batteries, solar cells and computers.

"This paper is the first to demonstrate the inverse spin Hall effect in a range of organic semiconductors with unprecedented sensitivity," although a 2013 study by other researchers demonstrated it with less sensitivity in one such material, says Christoph Boehme, a senior author of the study published April 18 in the journal Nature Materials.

"The inverse spin Hall effect is a remarkable phenomenon that turns so-called spin current into an electric current. The effect is so odd that nobody really knows what this will be used for eventually, but many technical applications are conceivable, including very odd new power-conversion schemes," says Boehme, a physics professor.

His fellow senior author, distinguished professor Z. Valy Vardeny, says that by using pulses of microwaves, the inverse spin Hall effect and organic semiconductors to convert spin current into electricity, this new electromotive force generates electrical current in a way different than existing sources.

Coal, gas, hydroelectric, wind and nuclear plants all use dynamos to convert mechanical force into magnetic-field changes and then electricity. Chemical reactions power modern batteries and solar cells convert light to electrical current. Converting spin current into electrical current is another method.

Scientists already are developing such devices, such as a thermoelectric generator, using traditional inorganic semiconductors. Vardeny says organic semiconductors are promising because they are cheap, easily processed and environmentally friendly. He notes that both organic solar cells and organic LED (light-emitting diode) TV displays were developed even though silicon solar cells and nonorganic LEDs were widely used.

A new way to get electricity from magnetism

Vardeny and Boehme stressed that the efficiency at which organic semiconductors convert spin current to electric current remains unknown, so it is too early to predict the extent to which it might one day be used for new power conversion techniques in batteries, solar cells, computers, phones and other consumer electronics.

"I want to invoke a degree of caution," Boehme says. "This is a power conversion effect that is new and mostly unstudied."

Boehme notes that the experiments in the new study converted more spin current to electrical current than in the 2013 study, but Vardeny cautioned the effect still "would have to be scaled up many times to produce voltages equivalent to household batteries."

The new study was funded by the National Science Foundation and the University of Utah-NSF Materials Research Science and Engineering Center. Study co-authors with Vardeny and Boehme were these University of Utah physicists: research assistant professors Dali Sun and Hans Malissa, postdoctoral researchers Kipp van Schooten and Chuang Zhang, and graduate students Marzieh Kavand and Matthew Groesbeck.

From spin current to electric current

Just as atomic nuclei and the electrons that orbit them carry electrical charges, they also have another inherent property: spin, which makes them behave like tiny bar magnets that can point north or south.

Electronic devices store and transmit information using the flow of electricity in the form of electrons, which are negatively charged subatomic particles. The zeroes and ones of computer binary code are represented by the absence or presence of electrons within silicon or other nonorganic semiconductors.

Spin electronics - spintronics - holds promise for faster, cheaper computers, better electronics and LEDs for displays, and smaller sensors to detect everything from radiation to magnetic fields.

The inverse spin Hall effect first was demonstrated in metals in 2008, and then in nonorganic semiconductors, Vardeny says. In 2013, researchers elsewhere showed it occurred in an organic semiconductor named PEDOT:PSS when it was exposed to continuous microwaves that were relatively weak to avoid frying the semiconductor. [9]

New electron spin secrets revealed: Discovery of a novel link between magnetism and electricity

The findings reveal a novel link between magnetism and electricity, and may have applications in electronics.

The electric current generation demonstrated by the researchers is called charge pumping. Charge pumping provides a source of very high frequency alternating electric currents, and its magnitude and external magnetic field dependency can be used to detect magnetic information.

The findings may, therefore, offer new and exciting ways of transferring and manipulating data in electronic devices based on spintronics, a technology that uses electron spin as the foundation for information storage and manipulation.

The research findings are published as an Advance Online Publication (AOP) on Nature Nanotechnology's website on 10 November 2014.

Spintronics has already been exploited in magnetic mass data storage since the discovery of the giant magnetoresistance (GMR) effect in 1988. For their contribution to physics, the discoverers of GMR were awarded the Nobel Prize in 2007.

The basis of spintronics is the storage of information in the magnetic configuration of ferromagnets and the read-out via spin-dependent transport mechanisms.

"Much of the progress in spintronics has resulted from exploiting the coupling between the electron spin and its orbital motion, but our understanding of these interactions is still immature. We need to know more so that we can fully explore and exploit these forces," says Arne Brataas, professor at NTNU and the corresponding author for the paper.

An electron has a spin, a seemingly internal rotation, in addition to an electric charge. The spin can be up or down, representing clockwise and counterclockwise rotations.

Pure spin currents are charge currents in opposite directions for the two spin components in the material.

It has been known for some time that rotating the magnetization in a magnetic material can generate pure spin currents in adjacent conductors.

However, pure spin currents cannot be conventionally detected by a voltmeter because of the cancellation of the associated charge flow in the same direction.

A secondary spin-charge conversion element is then necessary, such as another ferromagnet or a strong spin-orbit interaction, which causes a spin Hall effect.

Brataas and his collaborators have demonstrated that in a small class of ferromagnetic materials, the spin-charge conversion occurs in the materials themselves.

The spin currents created in the materials are thus directly converted to charge currents via the spin-orbit interaction.

In other words, the ferromagnets function intrinsically as generators of alternating currents driven by the rotating magnetization.

"The phenomenon is a result of a direct link between electricity and magnetism. It allows for the possibility of new nano-scale detection techniques of magnetic information and for the generation of very high-frequency alternating currents," Brataas says. [8]

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.
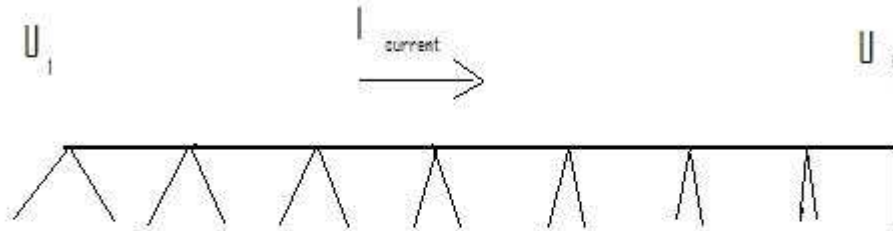

Figure 1.) Aluminium folios shows the charge distribution on the electric wire

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 $x = 1/2 \, at^2$ in the wire. The **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: **-dU/dx = E = const**.
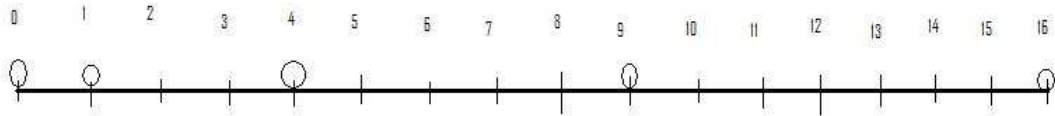
Figure 2.) The accelerating electrons created charge distribution on the electric wire

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.
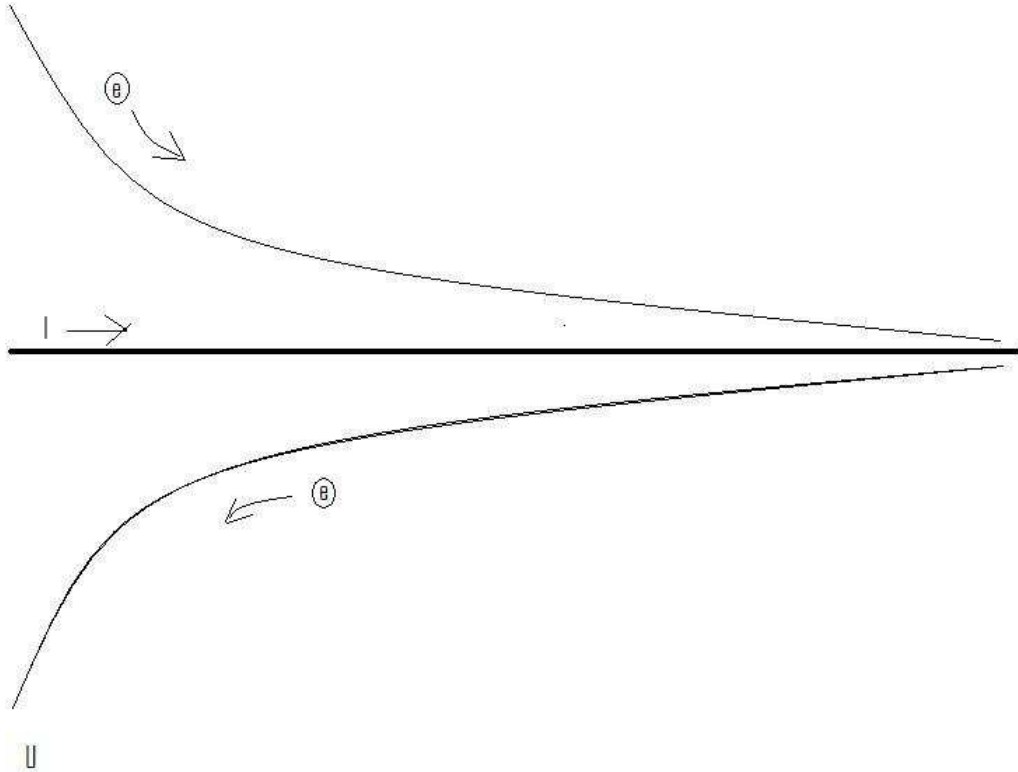

Figure 3.) Concentric parabolic equipotential surfaces around the electric wire causes the magnetic effect on the external moving charges

Considering that the magnetic effect is **F=q $\underline{v}$ 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 **$\underline{v}$x$\underline{B}$=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 **$\underline{v}$ x $\underline{B}$** 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

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.

Necessary to mention that the **A** magnetic vector potential is proportional with a, the acceleration of the charges in the electric current although this is not the only parameter.

The **A** magnetic vector potential is proportional with I**=dQ/dt** electric current, which is proportional with the strength of the charge distribution along the wire. Although it is proportional also with the U potential difference I=U/R, but the R resistivity depends also on the cross-sectional area, that is bigger area gives stronger I and **A**. [7] This means that the bigger potential differences with smaller cross-section can give the same **I** current and **A** vector potential, explaining the gauge transformation.

Since the magnetic field B is defined as the curl of **A**, and 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

$$A^\alpha = (\phi/c, \mathbf{A}) \quad A^\alpha = (\phi, \mathbf{A})$$

in which ϕ is the electric potential, and $\mathbf{A}$ 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. Since I=at, 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**. The charge density in the static current changes linear in the time coordinates. Changing its value in time will causing a static electric force, negative to the accelerating force change. This explains the relativistic changing mass of the charge in time also.

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 **v** of its associated electromagnetic wave. This relation between the energy and frequency is called the Planck relation or the Planck–Einstein equation:

$$E = h\nu .$$

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

$$E = \frac{hc}{\lambda}.$$

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 $E = h\nu$ and $E = mc^2$, $m = h\nu /c^2$ that is the m depends only on the ν 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

The generation and modulation of high-frequency currents are central wireless communication devices such as mobile phones, WLAN modules for personal computers, Bluetooth devices and future vehicle radars. [8]
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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