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Physics and Space Science

Theory of Everything

Measurement of Verdet Constant

Highlights

Evaluation of General Relativity

New Ideas in Classical Electrodynamics

Discovering Thoughts, Inventing Future

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Evaluation of General Relativity

By Kexin Yao

Abstract- According to the fact that electric quantity and elastic force are unrelated to velocity, as well as the properties of gravitational field, it is proved that the gravitational mass of an object is inevitably unrelated to the velocity, while the inertial mass of an object is undoubtedly related to the velocity, so it can be concluded that the gravitational mass is not possibly equal to the inertial mass, and the equivalence principle is not tenable. The equivalence principle is the theoretical basis of general relativity. Now that the basis is untenable, according to the principle of physics, the general relativity will naturally be untenable. By analyzing the conditions under which the general relativity is approximately tenable and the conditions under which it is untenable, and combining with the fact that Black Hole is the analysis result of general relativity under the condition that equivalence principle is not tenable, the Black Hole is not considered to be possibly existent. Besides, the spacecraft rotates around the Black Hole, which is the only way for humans to travel through time. Now that the Black Hole does not exist, time travel will be impossible.

Keywords: general relativity; special relativity; gravitational mass; inertial mass, equivalence principle; electric quantity; elastic force; gravitational field; velocity; black hole.

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EVALUATIONOFGENERALRELATIVITY

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Evaluation of General Relativity

Kexin Yao

Abstract- According to the fact that electric quantity and elastic force are unrelated to velocity, as well as the properties of gravitational field, it is proved that the gravitational mass of an object is inevitably unrelated to the velocity, while the inertial mass of an object is undoubtedly related to the velocity, so it can be concluded that the gravitational mass is not possibly equal to the inertial mass, and the equivalence principle is not tenable. The equivalence principle is the theoretical basis of general relativity. Now that the basis is untenable, according to the principle of physics, the general relativity will naturally be untenable. By analyzing the conditions under which the general relativity is approximately tenable and the conditions under which it is untenable, and combining with the fact that Black Hole is the analysis result of general relativity under the condition that equivalence principle is not tenable, the Black Hole is not considered to be possibly existent. Besides, the spacecraft rotates around the Black Hole, which is the only way for humans to travel through time. Now that the Black Hole does not exist, time travel will be impossible.

Keywords: general relativity; special relativity; gravitational mass; inertial mass, equivalence principle; electric quantity; elastic force; gravitational field; velocity; black hole.

I. Introduction

The establishment of a scientific theory is derived from its correct theoretical basis. For example, the mechanics theory is derived from Newton's three laws, which have been proved by numerous experiments. Special relativity is derived from the principle of constancy of light velocity as well as the relativity principle. The principle of constancy of light velocity has also been proved by many experiments. However, the equivalence principle for the theoretical basis of general relativity, that is, the gravitation mass is equal to the inertial mass, has not been fully proved by experiments, because so far all equivalence principles have been verified at low velocity, and no experiment has been carried out at high velocity. At high velocity, experiments have shown that the inertial mass of an object increases with the increase of velocity, while no experiments have proved that the gravitational mass of an object also increases with the increase of velocity. Obviously, no experiment has proved that the gravitational mass of an object at high velocity has the same increase effect as the inertial mass, so it cannot be sure that the gravitational mass is completely equal to the inertial mass. It becomes necessary to study whether the gravitational mass of an object increases significantly during high velocity motion, so as to determine whether the equivalence principle is tenable or not.

At present, there is no experimental method to verify whether the gravitational mass of an object increases at high velocity. However, if we can determine that the gravitational mass of an object is unrelated to the motion velocity by using reasonable physical analysis methods, we will be able to deny that the gravitational mass is related to the velocity, which is equivalent to determining the relationship between the gravitational mass and the velocity at high velocity.

As we all know, there are many physical quantities unrelated to the motion velocity, such as the electric charge of an object, the elastic force of a deformed object and gas pressure. We can compare the relationship between gravitational mass and these physical quantities under the same conditions, so as to analyze and determine the relationship between gravitational mass and velocity. In addition, gravitational mass will inevitably generate gravitational field. We can also obtain this relationship by analyzing the basic properties of the gravitational field. In this case, we can finally determine whether or not the equivalence principle is tenable, so that the general relativity can be correctly evaluated.

II. Determining that Gravitational Mass Shall also be Unrelated to Velocity based on the Fact that Electric Quantity is not Related to Velocity

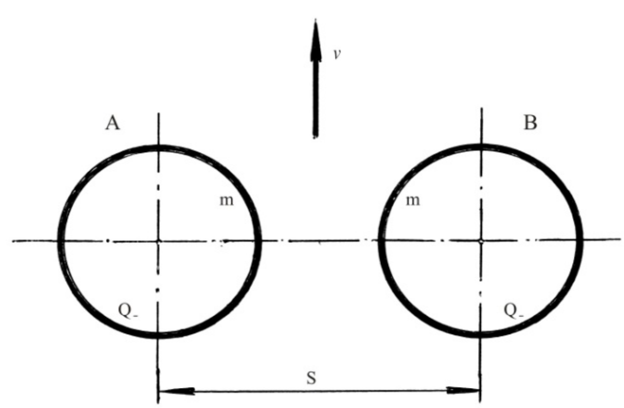

Fig. 1: Universal Gravitation is Equal in Magnitude to Electrostatic Repulsion

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Fig. 1 indicates that the two objects A and B, with the same mass m and the same distance from the center S, have the equal negative charge Q_-. If the electrostatic repulsion between A and B happens to be equal to the universal gravitation between them due to the electric quantity Q_- , A and B shall be in equilibrium, and the distance S shall not change.

When the observer moves at velocity V relative to A and B, the inertial mass of A and B shall increase with the increase of V. If the gravitational mass of A and B is equal to their inertial mass, the gravitational mass of A and B shall also increase with the increase of V. With the increase of gravitational mass, the universal gravitation between A and B shall also inevitably increase. However, experiments have proved that the electric quantity Q_- of A and B is unrelated to the motion velocity of A and B, that is to say, the electrostatic repulsion between A and B shall be constant. The electrostatic repulsion remains unchanged, while the universal gravitation increases. The inevitable result is that the universal gravitation is greater than the electrostatic repulsion and the imbalance between A and B will cause them to collide together. Obviously, this result is impossible since any observer can see that A and B are always in equilibrium. This suggests that the universal gravitation between A and B must be equal to the electrostatic repulsion, but they are in the opposite direction. Both of them are unrelated to the velocity of A and B, that is, the gravitational mass of A and B must be unrelated to their motion. In other words, the gravitational mass of an object is a constant unrelated to the motion velocity of the object.

III. Determining that Gravitational Mass shall be also Unrelated to Velocity based on the Fact that Elastic Force is not Related to Velocity

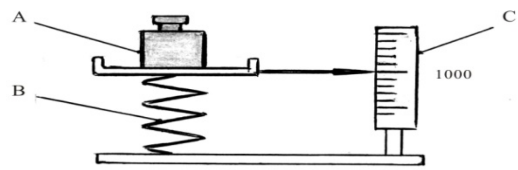

Fig. 2: Universal Gravitation is Equal in Magnitude to Elastic Force of a Deformed Spring

Fig. 2 is a schematic diagram of the spring scale. A represents the 1,000g weight, B represents the spring scale, and C represents the dial of the spring scale. The pointer of the spring scale stops at 1,000g on the dial when the weight in Fig. 2 is placed on the spring scale. This indicates that the pointer of spring scale will stop at 1,000g when the earth's universal gravitation on the weight is in equilibrium with the elastic force generated by the deformed spring. Obviously, the observer moving at any velocity relative to the spring scale will see the pointer stop at the same 1,000g position. Since the deformation of the spring is unrelated to its motion velocity, the only possibility for the spring scale pointer to stop at 1,000g position must be that the earth's universal gravitation on the weight is unrelated to the velocity of the weight, that is, the gravitational mass of the weight is unrelated to its velocity.

IV. Determining that Gravitational Mass Shall be Unrelated to Motion Velocity According to the Properties of Gravitational Field

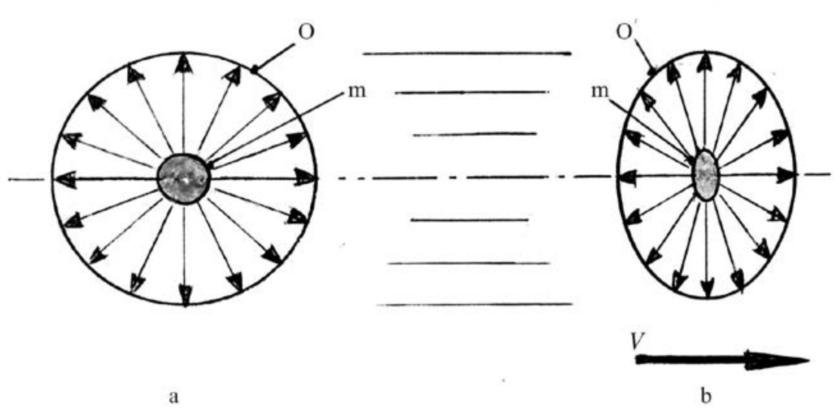

Fig. 3: The Flux of Gravitational Field on the Closed Surface is Unrelated to Velocity

Fig. 3a indicates that the gravitational mass m of an object generates a uniform gravitational field around it. In the figure, lines with arrows are used to represent the gravitational field. The smaller the distance between the lines, the greater the intensity of the gravitational field. O represents a closed surface surrounding m, and the number of gravitational field lines passing through O represents the intensity flux of gravitational field passing through O. Since the distribution of the gravitational field for gravitational

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mass is completely similar to that of electric field for electrified body, according to Gauss theorem on electric field, we can draw that the intensity flux of the gravitational field passing through arbitrary closed surface is equal to the total gravitational mass surrounded by the surface. The intensity flux for gravitational field of the closed surface O indicated in figure 3a is equal to the gravitational mass m. As shown in figure 3b, when m is moving at a high velocity relative to the observer, according to the special relativity, the length shall shrink in the direction of motion, O shall shrink to O', and the distribution of the gravitational line shall also change. However, it can be seen that although the distribution of gravitational field lines in figure 3b has changed, the total number of gravitational lines has not changed. That is to say, the intensity flux of gravitational field passing through O' is still the same as the flux passing through O, that is, the gravitational mass surrounded by O' is the same as that surrounded by O. This also indicates that the gravitational mass of an object is unrelated to its motion velocity, and the gravitational mass is the constant unrelated to the motion.

V. Evaluation on General Relativity

a) General relativity is not a scientific theory

The general relativity is derived from the equivalence principle, which assumes that the gravitational mass of an object is equal to the inertial mass. This assumption can be derived from the elevator effect. When the elevator suddenly rises, the people in the elevator feel that his weight has increased. This increase seems to be no different from the increase of the earth's gravitation. That is, inertial force is not essentially different from gravitation. Thus, the famous equivalence principle that the gravitational mass is equal to the inertial mass is generated.

Through further analysis on the force, we know that it is mostly one-sided to determine the inexorable law only by a feeling. Taking two equal forces as an example, if an airtight cabin is placed in deep water, the buoyancy of the water will accelerate the rise of the cabin, and the people in the cabin will inevitably feel that his weight has increased. He can naturally assume that the buoyancy of water is equal to the universal gravitation. Or under the action of strong updraft, the cabin rises with accelerated velocity, and the people inside the cabin will also assume that the updraft is equal to the universal gravitation. Obviously, buoyancy and updraft are completely different from universal gravitation in properties, so buoyancy and updraft shall not be regarded to be the same as universal gravitation. Therefore, it is not scientific to identify the two forces only by feeling without further discriminant analysis on their properties. Through further comparative analysis on universal gravitation and inertial force, we can find that the basic properties of these two forces are essentially different, and there are at least three essential differences. 1. Inertial force is energy transfer force, and the universal gravitation is unrelated to the energy transfer. This is because if the acting force F, generated by A, makes the object B move by distance S in time t, the energy transferred from A to B shall be FS, while if B moves with the acceleration a under the action of F, the velocity obtained by B in time t shall be $V=at$, and the energy obtained by B shall be $mV^2/2=ma^2t^2/2$. According to $S=at^2/2$, the energy that A transfers to B shall be $FS=Fat^2/2$, which is equal to the energy obtained by B. Accordingly the formula $Fat^2/2=ma^2t^2/2$ is generated, and after the elimination of $at^2/2$ on both sides, we get the inertial force equation $F=ma$. This shows that the existence of inertial force is inevitably accompanied by the acquisition of energy by the object, that is, the inertial force is an energy transfer force. However, the universal gravitation can act on the stationary object eternally, that is to say, the universal gravitation is not the energy transfer force. Obviously, the energy transfer force and the non-energy transfer force are fundamentally different in properties, that is, the energy transfer inertial force cannot be equal to the non-energy transfer universal gravitation. 2. The inertial force is the force that pushes the object to move, that is, the inertial force shall always be in motion, while the universal gravitation can always be at rest. 3. Universal gravitation is a field force. The magnitude and direction of the universal gravitation on any objects shall depend on the position of the object in the gravitational field, while the magnitude and direction of the inertial force on all objects can be unrelated to the position of the object.

The above is illustrated in terms of physical properties, which shows that the universal gravitation is different from the inertial force in nature. This difference also means that the gravitational mass is different from the inertial mass. Further determination to verify this undoubted difference is tested through experiments. Numerous experimental results now have confirmed that the inertial mass of an object will surely increase with the increase of its velocity, and the relation derived from special relativity is $m=m_0\Big/\sqrt{1-V^2/C^2}$ (where m_0 is rest mass and C is light velocity). Nevertheless, as already stated previously, the fact that the gravitational mass of an object is a constant unrelated to motion has been further proved beyond any doubt, so the inertial mass is definitely not equal to the gravitational mass. That is, the equivalence principle has been undoubtedly proved to be untenable in physics.

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In fact, any object has not only the two physical properties of inertial mass and gravitational mass, but also other properties such as the density, specific heat and electrical resistivity. All physical properties have their own characteristics and shall not be considered to be equivalent to each other. Even if the gravitational mass of the object is completely proportional to the density of the object, it cannot be considered that the two are equal by changing the dimension. This is because the density of an object is affected by temperature (generally, the density decreases with the increase of temperature), while the gravitational mass is unrelated to temperature.

The theoretical basis of all physical theories must be objective and realistic. This is the basic principle of physics. For example, the principle of constancy of light velocity, which is the theoretical basis of special relativity, has been proved by many experiments. It is certainly in line with this basic principle of physics. However, as stated previously, the equivalence principle for the theoretical basis of general relativity is untenable, that is, the theoretical basis of general relativity does not conform to the basic principle of physics. Therefore, according to the basic principle of scientific physics, it can be concluded that general relativity is not a scientific theory.

b) For all real objects in the universe, general relativity is approximately tenable

In order to analyze the problem simply and calculate the data easily, people often put forward some approximate calculation methods, such as the trigonometric function $y = A\sin x$, where y and x are not linearly correlated, and their values are not proportional. For example, when x is less than 10°, if we assume that $y = Ax$, the error shall not be greater than 0.5%; if we assume that $y = Ax$, the error shall not be greater than 0.07%. Therefore, in the actual calculation and analysis, if x is very small, it can be considered that $y \approx Ax$. In reality, there are lots of approximate formulas similar to $y \approx Ax$. Then, can the equivalence principle be approximately tenable under certain conditions? The analysis on the inertial mass expression $m = m_0 \big/ \sqrt{1 - V^2/C^2}$ shows that the approximate formula $m \approx m_0$ is tenable when the relative light velocity V is very low. According to the calculation, the error between m and m_0 is less than 10^{-5} even if V is as high as the fourth cosmic velocity of 120 km/s. While in the real universe, there are no celestial body or object with velocity of $V > 120km/s$ except particles. Therefore, it can be considered that the relation $m \approx m_0$ is tenable for all real objects in the universe. In other words, the inertial mass of all objects in the universe is approximately equal to the rest mass. That is, the inertial mass is approximately a constant unrelated to the motion. Obviously, under such condition, if the assumption that the inertia mass is the same as the gravitational mass is basically in line with the reality, the equivalence principle will be naturally and basically realistic. Since both equivalence principle and general relativity are tenable, we can obtain the conclusion that general relativity is approximately tenable for all real objects in the universe.

c) General relativity is not tenable when the motion velocity of an object is very high

It can be seen from the formula $m = m_0 \big/ \sqrt{1 - V^2/C^2}$ that as V increase, the difference between m and m_0 gets bigger. When $V > 0.1C$, the numerical error of m and m_0 will be greater than one thousandth. When $V > 0.5C$, the numerical error of m and m_0 will be greater than 86%. When V approaches the light velocity, the value of m will be ten times larger than m_0. Therefore, when V is high, $m \approx m_0$ will be untenable, m cannot be considered to be the constant m_0, the equivalence principle is not tenable naturally, and the general relativity analysis conclusion shall be incorrect. Therefore, our conclusion is that general relativity is not tenable when V is high. It can be consequently inferred that when V is unrestricted, some analysis results obtained by applying general relativity, such as Black Hole, White Hole, Worm Hole and so on, cannot be true.

VI. Black Hole cannot be a Material Existence

Experiments show that when V is quite high, the inertial mass will become significantly larger. According to the equivalence principle of general relativity, the gravitational mass shall also increase significantly. Therefore, when the motion velocity of an object reaches close to the light velocity, the gravitational mass of any object in the form of solid, liquid or gas can increase by several trillions of times, resulting in the formation of the Black Hole. Thus, according to the equivalence principle of general relativity, any object can become a Black Hole and the Black Hole is not fixed in structure. However, the previous 2, 3 and 4 have proved that gravitational mass is a constant unrelated to motion, that is, no matter what motion an object takes, it cannot become the Black Hole.

Let us assume that Black Hole exists and it is a moving object, then what kind of movement does the Black Hole take? Obviously it cannot be linear motion, because the object takes linear motion is the one that never returns, that falls into an infinite abyss, and that

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may collide with other celestial bodies on the way. Therefore, Black Hole can only take repeated circular motion, which will inevitably generate centrifugal force. However, there is no celestial body in the universe that can balance the huge centrifugal force of Black Hole, and the centrifugal force of the Black Hole shall not exist naturally, so the Black Hole cannot move. That is to say, the velocity of Black Hole must be zero. Thus, even if the equivalence principle is tenable, no one can deduce the existence of Black Hole according to general relativity under the prerequisite $V=0$, that is, the existence of Black Hole is theoretically impossible.

The analysis of material structure can also deny the existence of Black Holes. According to Black Hole theory, the mass of a Black Hole sphere with a diameter of 120m is equal to that of four suns, that is, it is equal to the mass of 1.32 million earths, and the volume of the earth is 10^{15} times larger than that of a Black Hole sphere with a diameter of 120m, which means that the density of Black Hole material is more than 10^{21} times that of the earth. According to this proportion, the mass of 6 trillion people is less than that of a Black Hole with the size of a grain of rice.

It is well known that all matter in the universe consists of several of 118 elements. However, according to the density of the above-mentioned Black Hole material, if the Black Hole is also made up of atoms, the size of the Black Hole atom is only $1/10^{21}$ of the size of the Earth's material atoms. So it's obviously impossible. According to Black Hole theory, Black Holes are made up of collapsed atoms, and we assume that all the electrons around the collapsed atoms fall onto protons and become neutrons, and that these neutrons are squeezed together and become one big neutron. Calculation shows that such large neutrons are more than one million times larger than the theoretical volume of Black Holes. It is obviously impossible to find the matter with a density of one million times larger than that of the neutron. Moreover, according to atomic physics, there is no possibility that all electrons around any atom will fall on protons, that is, there is no possibility of atomic collapse. And even if the atom did collapse, it would still fall far short of the density of a Black Hole. In this regard, we can conclude that Black Holes cannot be made up of real atoms, that is, Black Holes cannot be a real material existence.

As mentioned above, if the Black Hole exists, its velocity must be $V=0$. Under the prerequisite of $V=0$, it is impossible to deduce the existence of the Black Holes based on general relativity. Moreover, Black Holes can never be made of real atoms. For these two reasons, the only conclusion we can draw is that there can be no Black Hole in the universe, and in fact, there is no conclusive evidence to prove that the Black Hole exists. On April 10, eight astronomical observatories in the world jointly released a photograph of the black hole and also explained that the photo displays the black hole of 14 billion solar mass, which attracts surrounding gases and produce special astronomical phenomena. Such an explanation is too one-sided! Does it mean that the black hole can't attract solids but only gases? As indicated by the simple calculation of universal gravitation, this black hole has the same universal gravitation to the earth as the sun at a distance of 2 light-years. Its universal gravitation to the earth at a distance of 10 light-years is also 4% of that of the sun. Such a huge universal gravitation will inevitably make many celestial bodies around collide into the black hole quickly, releasing huge energy and producing strong light. However, to this day, no astronomical observatories have found that the black hole emits light when it is impacted by celestial bodies, which indicates that such a black hole don't exist at all. This photo of the black hole doesn't unveil the real black hole. What it puts before the public is only a special astronomical phenomenon. I believe that black holes that violate atomic physics cannot really exist

The denial of the existence of Black Holes makes time travel impossible. This is because if humans want to travel through time, the velocity of spacecraft must be close to the light velocity, and the spacecraft cannot take linear motion that will not return and that may collide with other celestial bodies. It can only rotate around a gravitationally powerful massive star in a circle, so as to balance the centrifugal force inevitably generated by its circular motion, such as the rotation of the earth around the sun, which achieves a rotation velocity of 29km per second. What kind of stars does the spaceship rotate around? According to current astronomical observations, the largest A1 star is 150 times the mass of the sun and 114 times the diameter of the sun. Calculation shows that the spacecraft can rotate around the surface of A1 star and only 510km/s rotation velocity can be achieved. At this velocity, the spacecraft has a delay of 271 seconds every year, and the lifespan of the passengers in the spacecraft can only be prolonged by less than one in ten thousand, which is not time travel at all. Calculation also shows that the velocity of spacecraft can approach the light velocity only when it rotates around the Black Hole. In this case, the passengers in the spacecraft can possibly travel through time with lifespan prolonged by several times. As we already explained, real Black Holes cannot exist, so it is impossible for humans to travel through time in spacecraft.

VII. Summary

One of the theoretical bases of general relativity is the equivalence principle, which assumes that gravitational mass is equal to inertial mass. However, up to now, there has been no evidence to prove that the gravitational mass of an object increases in the same

Global Journal of Science Frontier Research (A) Volume XIX Issue V Version I Year 2019

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pattern with the inertial mass when it moves at high velocity. Therefore, it is necessary to determine the relationship between gravitational mass and velocity in order to determine whether the equivalence principle is tenable. According to the fact that the electric charge as well as the elastic force generated by the deformed object is unrelated to the velocity, we analyze and prove in this paper that the gravitational mass of an object is inevitably unrelated to its motion. By analyzing the properties of the gravitational field that is inevitably generated by gravitational mass, we further determine that the gravitational mass of an object is a constant unrelated to its motion. By comparing the gravitational mass with the inertial mass, we point out that the two have three completely different physical properties, especially the property that the gravitational mass is a constant unrelated to the motion, while experiments have proved that the inertial mass of an object is definitely a variable related to the motion velocity. According to these completely different properties, it can be concluded that the gravitational mass of an object cannot be equal to its inertial mass, that is, the equivalence principle cannot be tenable. It is a basic principle of physics that the theoretical basis of physical theories must conform to the reality. The equivalence principle for the theoretical basis of general relativity does not conform to this basic principle, so we can conclude that general relativity is not a scientific physical theory.

By analyzing the expression $m = m_0 \big/ \sqrt{1 - V^2/C^2}$ for inertial mass, we find that when V is very low relative to the light velocity, the approximate expression $m \approx m_0$ will be surely tenable. Therefore, we can conclude that when the motion velocity is very low relative to the light velocity, the inertial mass of an object is very approximate to the rest mass. Under such condition, the inertial mass is approximately equal to the gravitational mass and both are constant, then the equivalence principle is basically tenable. Naturally, the general relativity is also basically tenable. Since in the real universe, all objects move at a velocity much lower than the light velocity, the inertial mass is approximately equal to the rest mass, and the equivalence principle is tenable, so general relativity is considered to be applicable to all cosmic celestial bodies. When the velocity of movement is quite high, the equivalence principle will not be tenable, and the analysis conclusion of general relativity becomes inevitably unrealistic. Black Holes are the analysis conclusion of general relativity when the velocity is not limited and the equivalence principle is not tenable, so the existence of Black Holes cannot be true. We put forward through analysis that if a Black Hole exists, its velocity must be $V = 0$, while when $V = 0$, it is impossible to obtain the analysis result of Black Hole through general relativity. Such contradictory analysis proves that general relativity analysis is not realistic. According to atomic physics, Black Hole cannot be atomic material, that is, Black Hole cannot be the real material existence. Finally, time travel is discussed. The only way for humans to travel through time is to be in spacecraft rotating around the Black Hole. Since Black Hole does not really exist, it becomes impossible for humans to travel through time.

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Theory of Everything

By Prince Jessii
Trasker Institute of Scientific Research

Abstract- After secretly working on several experiments and observations, Prince Jessii combines all the outcomes and results to present the "theory of everything" which is released this year ahead of the start of a new decade [2020] to open the eyes of everyone to the world of science [physics] and to release an urgent information. This theory tells the world what made them exist, how they existed, how they can still exist. It isn't fair if humans die every day with all the unfortunate events happening and still to come, when science [physics] is there to save them and prevent all unfortunate events from happening.

Keywords: GoD, dark energy, dark matter, energy, matter, space, dimension, universe.

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THEORYOFEVERYTHING

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Theory of Everything

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Abstract- After secretly working on several experiments and observations, Prince Jessii combines all the outcomes and results to present the "theory of everything" which is released this year ahead of the start of a new decade [2020] to open the eyes of everyone to the world of science [physics] and to release an urgent information. This theory tells the world what made them exist, how they existed, how they can still exist. It isn't fair if humans die every day with all the unfortunate events happening and still to come, when science [physics] is there to save them and prevent all unfortunate events from happening.

Keywords: GoD, dark energy, dark matter, energy, matter, space, dimension, universe.

I. Introduction

"The theory of everything" is written to avoid high technical language and soundness to enable everyone in the world to understand it. All the results and outcomes of my observations and experiments are [1], [2], [3] in the reference list, you have to read it according to the sequence [1-2-3] before proceeding to this theory. If not done, you won't understand this theory.

Dear Universe,

This theory is the summary of all the results of my experiments and observations conducted in the environment of our universe.

It all started when I got attached to the space around us which I started observing closely. With the nature of space around us being different from that which surrounds the planets, I began to wonder the cause of this, at that moment you might say that space can be split or be different, but i eventually realized that it was gravity which is also space, but in its opposite form. Gravity was not understood properly, but it was explained in a proper way in reference [3]. You can imagine why everything in free fall is attracted to the center of the earth, there's a space fabric at the center/core of a planet and it's also the strongest [original] form of space which can be found at the outer space and with the fact that space cannot be split i.e there's only one environment of space placed in the universe of a magnitude of [1.50×10^{10}], gravity can now arise to reduce this magnitude of space in certain areas but it's the same thing acting on itself [read reference [1] and [3]]. However, i started observing photons that comes from the sun which i can also see with my bare eyes with absolute focus but the light seems to out-shine my eyes which allows me to see it for few seconds/minutes, the details of this light where already discovered by great scientists/physicist in the past, so i didn't bother experimenting on it, i just trusted their details, so i took the constants related to them. But there was another light, and this one comes and goes, it required another type of focus to see this one, the mystery about this light is that you can never see it where the rays of the sun appear, it was like the light from the sun outshines the other and it's brightness depends on how dark a place is i.e a room without light. I'm sorry if you don't see this, but you'll eventually know why and howi saw the light, some other humans see it too but don't know what it is, but scientists in the past observed this light and gave it a name, I'll address it as that name. So there are two lights, one is visible to everyone; the other isn't yet visible to humans at this moment. By observations, i realized that both lights move at the same speed, so i took the speed of light constant (3×10^8) so serious. Now after several observations and experiments with these lights, coupled with the GOD factor, i present your theory of everything which originates from these two lights and space [gravity].

My experiment and observations might not be enough for most people outside the scientific environment, so I'll use some verses from the holy book to boost your understanding in order to explain our universe from the point of creation to its end.

II. Discussion

a) *The Big Bang*

All these, the reason you exist, everything around you, they all started from your creator and i can't tell you his face but i can say that he is made up of two lights and exist with both lights merged as shown in figure 1 below. His light is abundant and large enough to build a universe, as both lights are merged, it can also be unmerged. Surprisingly, he a scientist in a way and he wanted to create people [humans] who will serve and praise him all day and also be part of his light. But there one law, the ultimate law that governs this universe even he can't break or change. He knows that he is made up two lights and that one is superior and the other needs the superior to survive i.e. the life-span of the other depends on the superior. The superior is Dark-Energy and the other is Energy the inferior. Dark Energy is a pure bright white light and Energy is exactly the picture of light you see from the sun. Because his inferior light can fade, it was merged with the superior to

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make it exist forever and space is the point where these two lights merge, as shown in (figure 1). This means your creator is made up of the two lights with space.

He created everything [universe] under 7days beneath where he stays; he created earth first and then dropped it into the universe which he created later. From the holy book, he said "Let there be light" on the first day (Genesis 1), that light was dark-energy; this was done to obey the law. By creating a dimension made up of the inferior light, a dimension of the superior light must be created first and merged with it in order for the inferior dimension to exist forever. Besides creating new things every day for the 7days, the big bang of the universe happened on the third day where his inferior light was used to create the universe. By placing his superior light first, he allowed his inferior light to cool on top of the superior light thereby forming the universe which contains all planetary bodies, everything in the universe that you see at the moment are the solidified form of the inferior light. Because they are his light, this could be done just by him thinking of what to create, the placement of these two lights created both dimensions PS merged together. The humans was all he had in mind, he just wanted to create children [humans] which will be part of his light. However, he was just worried about the humans obeying the ultimate law.

The Ultimate Law says "To keep the inferior light, it must become the superior light, in other words, it must be merged with the superior light".

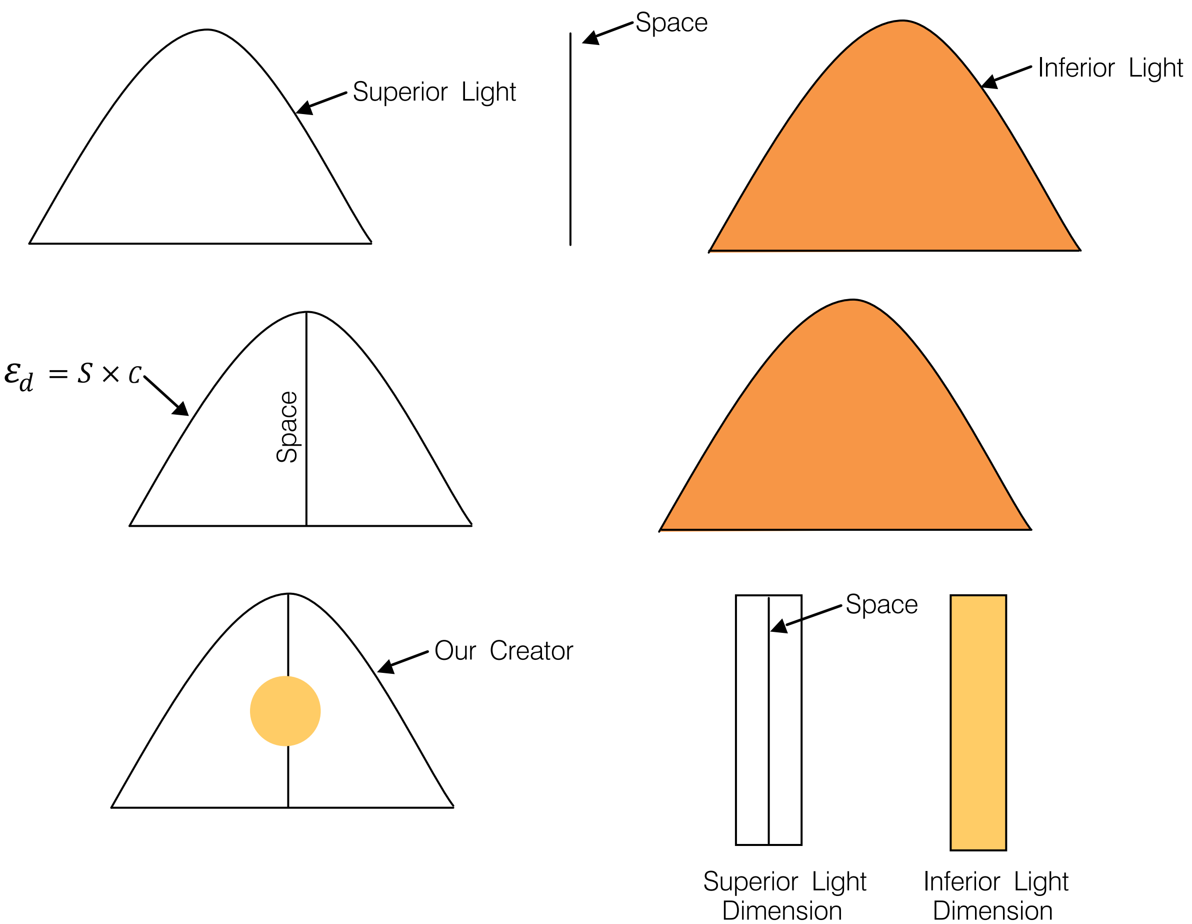

Figure I

Merging the two lights is a process to follow and because they are his lights, only he can provide a means which can be done automatically and also the means in which it can be reversed. But he wanted to test humans with a game; this was his thought at that moment.

"I want to test my creation [Humans], and I'll create them in my image [with the inferior light and superior light] and I'll provide them with a means of merging both lights automatically, but I'll also provide a means of unmerging both light dimensions as a distraction. If the first human I'll create decides to unmerge both dimensions, he and his generations have to figure out how to merge it back which means I'll have to provide a clue for them. I'll create the stars and they'll be the only body that will still possess my inferior light itself, the humans will have to figure out the puzzle early enough, else everything made of my inferior light will eventually fade and disappear in space, then i can start this creation process all-over again."

The creation of the first human was done on the sixth day and later the first man chose to unmerge both

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dimensions instead of merging his lights which he was created with. From the holy book [Genesis], he provided the means of merging as the tree of life and the means of unmerging the dimensions as the tree of knowledge of good and evil, when the first human ate from the tree of knowledge of good and evil, his eyes where opened, this was because both dimensions were unmerged and he was not yet merged with the superior light, so he could only see the light his body was made with and the other had to be invisible. Man can only see the superior light if he merges his body with the superior light.

The inferior light solidified to form land, air, water, vegetation, humans, animals etc. these were the essentials man needed to survive and increase the life-span of his body which is also a solidified form of the inferior light, to keep it to exist on a temporary basis. The land consists of natural resources which have been explored by man and are now used to produce more advanced type of matter to enhance living. Man advanced from local and natural means to a technological way, all with the help of the inferior light. Quantum mechanics, relativity, electromagnetism, waves, electricity, wind energy, etc, are all the physics of the inferior light with space. We've only succeeded in studying 50% of physics, the physics of the superior light was left out and sometimes when people or things [magic] defy the laws of physics, it feels like the laws aren't correct, but it wasn't known that those things that are done are also part of physics [the other 50%].

III. Methods

a) 137

After creating the universe, man is to multiply and fill the universe but wasn't aware of this game.

The code of the game he wanted humans to play was 137 which represents days in creation [read reference 3], another code similar to this is 666. From the Holy Book [Revelation 13;18], it says "this calls for wisdom, if anyone has insight, let him calculate the number of the beast for it is man's number, his number is 666".

The three spaces _ _ _ has to be filled to form a code with the days in creation. Before then, we couldn't answer this question, but this paper gives you the knowledge of this. It's 666 because man was created on the sixth day and because it talks about just a particular day, to form the code the three spaces had to be filled with 6, but 137 talks about two days, so after inserting the two days, the total number of days had to be inserted to express it properly.

Our universe is made up of both lights. Using the clue, the stars were made to play the game of 137 to light-up dimension P and man is expected to play the game and light-up dimension S so that both dimensions can merge and be one [Read reference 3], but man has refused to play the game ever since the first man made the mistake. Our creator [the only man to complete the game] had to be born in form of a man to teach us how to play and complete the game but we've still ignored him [John 1;9*…..["The true light that gives light to every man was coming into the world]*. We take it for granted but the fact is that, we think 13.7 billion years has passed and his inferior light has not faded completely.

Remember, space is related to time [Read reference 2] and the nature of space where he stays is not the same on earth, 1000 years on earth is equal to 1 day were he stays, this means that if he's depending on the days it'll take for it to fade, ours will extend to more years. Our creator might or will decide to force it to fade before its time resulting into the apocalypse.

The fact that people die every day is enough to prove that the light fades. What are we waiting for? *Do we want the apocalypse to take us?.*

NB; how to play the game is deeply religion but also science. I'll publish a book concerning that.

I present the summary of my experiments with the help of reference [1] [2] [3]

My experiment resulted into two fine structure constants with each representing each dimensions, I also discovered that the inverse of these fine structure constants is the visibility value of each of the dimensions at the point of unmerging PS and that one dimension "S" was lacking the game of 137. This is the visibility constant of the dimensions as regards to the electron [Matter]

However, let me lead you to some explanations before i use my experiments and calculations to present the theory of everything

We have two lights, Dark-Energy and Energy

We have two solidified form of the lights, Dark-Matter and Matter

We have space [gravity] which is associated with time to give space-time These 5 forms are everything in the universe i.e everything in the universe must be categorized or related as one of these forms.

Dark Energy and Dark Matter are for Dimension S and Energy and Matter are for Dimension P, Space [gravity] is the merging point of both dimensions

I presented Dark Energy as E_d and Energy as E, Dark-Matter as M_d and Matter as M, Space as S,

In reference [3], I presented the values of Dark-Energy and Dark-Matter as constants.

Matter and Energy cannot be defined as constants but their quantum state can be defined as constants. However, the constants of dark energy and dark matter are the same for both its higher state and quantum state.

IV. Results

a) Theory of Everything

From reference 3, our universe is all about the lights and the absorption of the lights by its

Global Journal of Science Frontier Research (A) Volume XIX Issue V Version I Year 2019 9

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corresponding solidified form, and the main explanation of the equation $1/\alpha_s + 137 = 1/\alpha_p$ i.e. $1.388 + 137 = 138.8$ is the clue itself.

The stars which are the bigger state of an electron are the clue and as many as they are, they've played their game making dimension P to be visible, man times the number of stars existing is expected to play the game to make dimension S visible. With that, both dimensions will merge and dimension P won't be able to fade.

However, the current value of our universe is 138.8/1.388 = 100 and the original value of our universe is 1 i.e. when both dimensions merge 138.8/138.8 = 1

Keep this in mind; you'll see the effect with this illustration.

NB; the values and details of the constants in the representation below are in reference [3] and also remember that a solidified form of a light can only absorb the light which it was made with, to absorb the other light, it has to be as an attachment with the other solidified form (Read Reference 3).

Hang on and gradually follow the illustration below, I'll explain after it.

The Universe

Dimension S	100	Dimension P
1. The Superior Light (E_d) = S x c = [$1.50 \times 10^{10} \times 3 \times 10^8$] $E_d = 4.5 \times 10^{18}$(Dark Energy) *Quantum state)*		The Inferior Light (E) = k/hc = $9 \times 10^9/[6.63 \times 10^{-16} \times 3 \times 10^8]$ $E = 4.5 \times 10^{16}$ (Energy) *(Quantum state)*
2. The superior light (E_d) = $M_d \times c^2$ $E_d = 50 \times (3 \times 10^8)^2$……… $E_d = 4.5 \times 10^{18}$ *(Higher State)*		The Inferior Light (E) = $M \times c^2$ NB; The energy and mass of matter should be inserted into this equation, they are not constant *(Higher State)*
3. The Solidified form of the Superior Light (dark Matter) $M_d(50) = S/c = 1.50 \times 10^{10}/3 \times 10^8$……. *(Quantum State)*		The Solidified form of Inferior Light (Matter) Electron (e) = 1.60×10^{-19}…………….*(Quantum State)*
4. The Solidified form of the Superior Light $M_d(50) = E_d/c^2$………*(Higher State)*		The Solidified form of the Inferior Light $M = E/c^2$……………….*(Higher State)*
5. Visibility value of the Superior Light dimension $K_s = (1.388)$	100	Visibility value of the Inferior Light dimension $K_p = 138.8$
6. Absorption of the superior light by its solidified form $M_d \times E_d = 50 \times (4.5 \times 10^{18}) = 2.25 \times 10^{20}$(Light Mode S) *(Quantum State)*	100	The tendency of the solidified form of the superior light to absorb the inferior light….. $M_d \times E = (50 \times 4.5 \times 10^{16})$ $= 2.25 \times 10^{18}$………. *(Quantum State)*
7. Absorption of the superior light by its solidified form $[M_d \times c]^2 = [50 \times 3 \times 10^8]^2 = 2.25 \times 10^{20}$ (Light mode S) *(Higher State)*		Absorption of the inferior light by its solidified form $[M \times c]^2$. …This is how to calculate the energy of a star by its mass…..(Light Mode P) *(Higher State)*
8. The tendency of the solidified form of the inferior light to absorb the superior light….. $e \times E_d = 1.60 \times 10^{-19} \times 4.5 \times 10^{18} = 0.72$ *(Quantum State)*	100	Absorption of inferior light by its solidified form $e \times E = 1.60 \times 10^{-19} \times 4.5 \times 10^{16} = 0.0072$(Light Mode P) *(Quantum state)*

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9. To solve the tendency issue; we use its fellow as an attachment.

$$e \xrightarrow{\cancel{M_d}} E_d$$

$1.60 \times 10^{-19} \times 50 \times 4.5 \times 10^{18} = 36$ *(Quantum State)*

Absorption of the superior light by the solidified form of the Inferior light.

10. The (Higher state) of the previous will be $M \times [M_d \times c]^2$

i.e $M \times [2.25 \times 10^{20}]$

$$M_d \xrightarrow{\cancel{e}} E$$

100 $50 \times 1.60 \times 10^{-19} \times 4.5 \times 10^{16} = 0.36$ *(Quantum State)*

Absorption of the inferior light by the solidified form of the superior light.

The (Higher state) will be $M_d \times [M \times c]^2$

i.e $50 \times [M \times (3x\ 10^8)]^2$

V. Explanation

Think of the theory of everything as the brain and heart of science [physics], you just have to connect all branches to link with it. When i talk about light in this paper or previous, it means the original lights used in creation and they are just two. Let's start with their solidified forms.

In physics, matter is expressed as a constant in quantum states, the higher states are combination of the different quantum states which results in higher states not been expressed as constants. For example, your body is made up of electrons; your body (matter) can't be expressed as a constant because the amount of electrons in your body is not the same in another body. As a result, we use the mass of the particular matter as a higher state but it is not constant because it changes and differs from other matter. The mass of the matter will now replace the "M" which represents matter in the equations it appeared in the illustration above. But it's the reverse in the case of dark matter; it is constant in both quantum and higher state, e.g. the dark matter that gives life to ants is the same value in humans, this is one of the properties that makes it superior. The value of dark matter at higher state will now be used for its quantum state. As a result, both solidified forms can't have similar values at both quantum and higher states but their lights itself can have similar values at quantum state. However, from the illustration above, the value of dark energy is gotten from a higher state as 4.5×10^{18} and it has this same value for its quantum state. Therefore we use its value at higher state for its quantum state. During the big bang, the inferior light solidified mainly into planetary bodies that contained the combination of any of these; land, water, gases, vegetation, creatures. The land contains natural resources including chemical elements. Man has now experimented on these things to produce more matter. Speaking about the process of the big bang and also production of matter by man, the photons from the light solidified into electrons, but as a result of forming different kinds of matter, electrons will have to deviate from the original solidified form to adjust to the requirements for forming a particular matter. This is the reason why some kinds of electron would not absorb the inferior light on their own. But some electrons deviate and still tend to absorb the light. This is where the photoelectric effect comes in to explain; electrons have deviated, which means to absorb the light, the light has to adjust and impart at least the required amount of energy for the electron to be liberated to ensure absorption. It's the reverse in the case of dark-matter and the superior light (dark energy). In this case, the light can't be adjusted, only the dark matter, this is one of the properties that makes it superior.

However, these electrons can go as far as deviating to form an anti-electron (positron) which is the limit for deviation; to deviate to the opposite form of the exact value of (1.60×10^{-19}C) but this time it is positive, its higher state is the anti-matter. In this case, a minus sign (-) can be put into the equations of energy and matter e.g. ($E=-Mc^2$) in the case were an anti-matter is involved. On the other hand, dark matter can go as far as deviating to the opposite form of (50), this is where i'll have to bring religion which is also science. For your information, in every game, there are obstacles to prevent your mission/aim. In the game of 137, the fallen angels are here in this world to stop our dark matter from absorbing the superior light resulting into "not playing the game". During their era, they were made to become part of the superior light automatically making them positive angels and were eventually given power to cause negative effects while absorbing the superior light which is a positive process just for the purpose of preventing man from playing the game. They are the only reason why one's dark-matter will deviate to the exact opposite form. If they or their effect collides with your dark-matter, dark-matter starts deviating to a negative form and the only way to absorb the superior light is to adjust back to the original form of your dark-matter, else it will remain in an opposite state which is negative and the absorption will not count.

NB; The elementary particles (quarks, leptons, mesons, neutrinos etc.) are all related to the [electron, proton and neutron]. This theory accounts for quantum state of matter as the electron which is the approved limit, this is why its brother [proton] also has the same charge

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[1.60×10^{-19}) and its other (neutron) has no charge. The electron, proton, neutron are the approved quantum state, splitting further is not necessary in explaining TOE, it's just for the fun and enjoying physics.

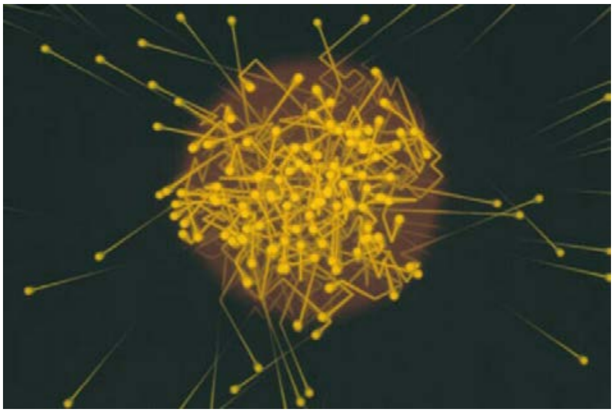

Figure 2

Figure 2 is a star, its energy causes radiation which consists of photons, and each photon has an energy constant of 4.5×10^{16}. However, there are literally filters [ozone layer] at the surface of planets and these filters were created to reduce the intensity of the energy [radiation] from these photons by filtering to produce different rays [with wavelengths and frequencies] to build the electromagnetic spectrum.

Furthermore, without going deeply into electromagnetism, we have already discovered forms of energy [light] and they are made from the inferior light, the different kinds of energy [lights] also move as a collection of discrete wave packets (photons) and their energy will still be represented as "E" and this energy of a single photon is given as [E=hf] and f, frequency is given as the speed of light/wavelength [c/ƛ] according to Planck-Einstein. But it is not referring to the original inferior light, each photon from the original inferior light in which the stars possess has energy of a value of E= [4.5×10^{16}] as a constant, i.e. the photon energy from the inferior light itself is constant. Also, when an electron emits a photon, the photon energy can be calculated as [E=hf].

Discovering dark energy as the "light of God" and also "the superior", the energy from each photon has a constant of $E_d = 4.5 \times 10^{18}$ and just like matter can be transformed back to its inferior light [energy] as $E= Mc^2$, dark matter [quantum and higher] transforming into its light [dark energy] as $E_d= M_dc^2$ will still result into a constant [4.5×10^{18}]. This is why dark energy is also found to be 4.5×10^{18} in a high state [S x c]

The Inferior and Superior Light; Energy is Dark-Energy when they're merged, but when they're not merged; energy takes the form of (4.5×10^{16}). This means that for energy to exist on its own, it must deviate from the value of dark-energy by 100; this was the same rule that was applied when both light dimensions in our universe were unmerged causing both visibility constants to differ by 100. However, taking the form of dark-energy, we get both energies as E_d = S x c or E x 100 = E_d =S x c. Like i said before, "Space is the merging point, everything answers to it". Getting one of the lights from the space fabric constant (S) and the speed of light (c) shows that dark energy is the superior and energy constant can be gotten as the inferior by dividing dark energy by 100.

All these is just like a scenario where you pour water in a high concentrated juice then the water being poured becomes the juice itself (light inside light) and a scenario where you put a solidified juice (ice juice) into juice, it melts to become the juice again (matter becomes its corresponding light) and if you want a solidified water (ice) to become a solidified juice (ice juice), you allow the ice to melt to water then you pour into a high concentrated juice and allow it cool to form a solidified juice, the solidified water then becomes the solidified juice. (Matter becomes dark matter) and so on. For example, the stars were matter and became their light which they were made of, we were wondering where the energy from a death star goes; they all go back to mix up [merge] with the dark energy of your creator waiting on the other side for absorption through space which i explained in reference [3]. However, absorbing the light does not mean "to be consumed by the light". To be consumed by the light is another case, it happens when a matter is closer to the light; I'll use this to explain the concept of black holes.

Some planets were made as a solidified form of the light, apart from solidifying; these planets [the stars] were also made to absorb to become the light itself by its electrons absorbing photons from the light that formed it. Just like cancer cells influence some normal cells to become cancer cells, some electrons might be found not absorbing the light. After some time, they influence other electrons to be like them which are not absorbing, when majority of these electrons of a star are not absorbing, it results into the death of a star and the electrons are being consumed by the light. The light [energy] will rest on space and tear/rip the space fabric to form a hole, this hole enables it to go back to mix up with dark-energy on the other side. However, the space fabric repairs itself after some time and it'll be like nothing happened there, you can't see it mixing up yet , but you'll feel the big presence of dark energy on an area were a star died. The bottom line is that all stars will die one day.

It was observed that dark energy is the reason behind the expansion of the space fabric on the outer space [E_d = S x c], but it's a sign, that the space fabric will eventually deviate [expand] to a magnitude that can't hold the planetary bodies at a point on the outer space, just like the magnitude on earth or other planets. As a result, stars will begin to collide with planets of their size or small stars could fall inside big planets and the

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energy of a big star like the sun can consume several planets. This is a hint to how everything we see will fade completely if both dimensions are not merged on time.

However, let me give you a shocking clue from the holy book [Revelation 21;23]*…."The city does not need the sun or moon to shine on it,for the light of God gives it light".* This verse is to boost your knowledge that the stars were not needed for their purpose, they were just a clue for the game and the other light is to serve that purpose. I said in reference 3 that if man times the number of stars plays and completes the game, both dimensions will merge and the value of man's universe will be 1, this means that the value of the inferior light [4.5×10^{16}] will take the value of the superior light [4.5×10^{18}] and the same is applied for their solidified forms [electron and dark-matter]. However, if man times the number of stars decides to merge their dark matter with their matter, this will make both dimensions to merge and many constants will vanish for good and the only constants that will remain are the constants related directly to the superior light [S, c , E_d , M_d, Light mode S], these are the ultimate constants.

VI. Conclusions

New discoveries and inventions on new sources of energy will keep coming, but I've said it before that all things that your eyes can see are made up of the inferior light i.e. the light from the sun. Therefore, as a scientist, if you wake up one day and eventually discover how to generate or produce energy from things like saliva, urine, sperm etc., to power up a machine or something else, it shouldn't be a surprise to you, they are all made from that light [energy] and they're just waiting for you to discover how to use them. "Nothing is a waste".

Some of the religious people that are aware of the apocalypse through the holy book have already doubted that it'll come because of the amount of time that has passed, but i tell you, ever since i cracked the blueprint of the universe, my mindset changed with fear and we have a very big problem to solve, our universe that we see is fading. If you think your loved ones that have died in the past are gone for good, you're wrong, their solidified inferior light were forced to fade before its time or some reached the life-span and faded and their superior light part exist around which you can't see them because you've not merged. If found that you didn't complete the game, then your dark matter part will be subjected to the value [0.36] in the illustration. That is similar to the lake of fire that you hear, if put inside, your dark matter will absorb the inferior light and be part of it, that's the only thing that can wipe you out from existence to fade for good. In addition, i conducted a research with dark energy and cancer cells, and i say that dark energy is the ultimate cancer cure; the only way cancer can be cured permanently is to apply the reset button, which is the only thing they respect [the light that created the light that created them]. I witnessed a complete curing of a cancer patient [anus] with dark energy and the cancer cells transformed into normal cells in seconds just like pressing a reset button in your phone. The time to put that smile on the faces of cancer patients is here. This is the same for other diseases.

Finally, if you follow the sequence of the light in this theory, absorption of light from its solidified form, absorption of the opposite light, deviating from negative to positive, keeping the light from fading temporary and permanently and so on, you will understand this universe. This is the background of every discovery and invention in this universe. It is how your city, phones and laptops etc are powered, it is how electricity and electromagnetism was discovered, it is what made different forms of matter and energy to exist, it is the father of all laws of physics and science, it is what made you exist, it helps you discover ways to treat and recover from your diseases and so on, just keep naming it. But it tells how everything ends and how you can prevent it. Generally, the message from this theory is that "All things are related"

From the holy book [John 1;3*]…."Through him all things were made; without him nothing was made that has been made. In him was life, and that life was the light of men. The light shines in the darkness, but the darkness has not understood it".*

NB; "Whatever process you follow to "self-absorb" the superior light is the one and only true religion, regardless of whatever name you give it"

After reading this paper, you should have understood that verse.

Besides the constants h, c, k, e, α_p and formula [$E=Mc^2$], all theories, constants and values in this paper are novel and they're created and proposed by Prince Jessii. They all originate from reference [1, 2 & 3]

Brief Information: The causes of the climate change we're experiencing now are an attempt to force the inferior dimension to fade before its time, please stop all causes immediately. If we must play the game, we need to buy some time.

Also, everyone is required to play the game of 137 in order to save the universe; the fate of our universe is in our hands. I've played my part as a scientist to deliver this theory to the world.

Acknowledgment

I'm grateful to God Almighty for guiding me through the blueprints and creating this theory for the world.

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New Ideas in Classical Electrodynamics and Physics of the Plasma

By F. F. Mende

Introduction- Until now, some problems of classical electrodynamics involving the laws of electromagnetic induction have been interpreted in a dual or even contraversal way.

As an example, let us consider how the homopolar operation is explained in different works. In [1] this is done using the Faraday low specified for the "discontinuous motion" case. In [2] the rule of flow is rejected and the operation of the homopolar generator is explained on the basis of the Lorentz force acting upon charges.

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New Ideas in Classical Electrodynamics and Physics of the Plasma

F. F. Mende

I. Introduction

Until now, some problems of classical electrodynamics involving the laws of electromagnetic induction have been interpreted in a dual or even contraversal way.

As an example, let us consider how the homopolar operation is explained in different works. In [1] this is done using the Faraday low specified for the "discontinuous motion" case. In [2] the rule of flow is rejected and the operation of the homopolar generator is explained on the basis of the Lorentz force acting upon charges.

The contradictory approaches are most evident in Feynman's work [2] (see page 53): the rule of flow states that the contour e.m.f. is equal to the opposite-sign rate of change in the magnetic flux through the contour when the flux varies either with the changing field or due to the motion of the contour (or to both). Two options – "the contour moves" or "the field changes" are indistinguishable within the rule. Nevertheless, we use these two completely different laws to explain the rule for the two cases: $\left[\vec{V}\times\vec{B}\right]$ for the "moving contour" and $\nabla\times\vec{E}=-\frac{\partial\vec{B}}{\partial t}$ for the "changing field". And further on: There is hardly another case in physics when a simple and accurate general law has to be interpreted in terms of two different phenomena. Normally, such beautiful generalization should be based on a unified fundamental principle. Such principle is absent in our case. The interpretation of the Faraday law in [2] is also commonly accepted: Faraday's observation led to the discovery of a new law relating electric and magnetic fields: the electric field is generated in the region where the magnetic field varies with time. There is however an exception to this rule too, though the above studies do not mention it. However, as soon as the current through such a solenoid is changed, an electric field is excited externally. The exception seem to be too numerous. The situation really causes concern when such noted physicists as Tamm and Feynman have no common approach to this seemingly simple question.

It is knowing [3] that classical electrodynamics fails to explain the phenomenon of phase aberration. As applied to propagation of light, the phenomenon can be explained only in terms of the special theory of relativity (STR). However, the Maxwell equations are invariant with respect to the covariant STR transformations, and there is therefore every reason to hope that they can furnish the required explanation of the phenomenon.

It is well known that electric and magnetic inductivities of material media can depend on frequency, i.e. they can exhibit dispersion. But even Maxwell himself, who was the author of the basic equations of electrodynamics, believed that ε and μ were frequency-independent fundamental constants.

How the idea of ε and μ-dispersion appeared and evolved is illustrated vividly in the monograph of well-known specialists in physics of plasma [4]: while working at the equations of electrodynamics of material, media, G. Maxwell looked upon electric and magnetic inductivities as constants (that is why this approach was so lasting). Much later, at the beginning of the XX century, G. Heavisidr and R.Wull put forward their explanation for phenomena of optical dispersion (in particular rainbow) in which electric and magnetic inductivities came as functions of frequency. Quite recently, in the mid-50ies of the last century, physicists arrived at the conclusion that these parameters were dependent not only on the frequency but on the wave vector as well. That was a revolutionary breakaway from the current concepts. The importance of the problem is clearly illustrated by what happened at a seminar held by L. D. Landau in 1954, where he interrupted A. L. Akhiezer reporting on the subject: "Nonsense, the refractive index cannot be a function of the refractive index". Note, this was said by L. D. Landau, an outstanding physicist of our time.

What is the actual situation? Running ahead, I can admit that Maxwell was right: both ε and μ are frequency – independent constants characterizing one or another material medium. Since dispersion of electric and magnetic inductivities of material media is one of the basic problems of the present – day physics and electrodynamics, the system of views on these questions has to be radically altered again (for the second time!).

In this context the challenge of this study was to provide a comprehensive answer to the above questions and thus to arrive at a unified and unambiguous standpoint. This will certainly require a revision of the relevant interpretations in many fundamental works.

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II. Equations of Electromagnetic Induction in Moving Coordinates

The Maxwell equations do not permit us to write down the fields in moving coordinates proceeding from the known fields measured in the stationary coordinates. Generally, this can be done through the Lorentz transformations but they so not follow from classical electrodynamics. In a homopolar generator, the electric fields are measured in the stationary coordinates but they are actually excited in the elements which move relative to the stationary coordinate system. Therefore, the principle of the homopolar generator operation can be described correctly only in the framework of the special theory of relativity (STR). This brings up the question: Can classical electrodynamics furnish correct results for the fields in a moving coordinate system, or at least offer an acceptable approximation? If so, what form will the equations of electromagnetic induction have?

The Lorentz force is

$$\vec{F}' = e\,\vec{E} + e\left[\vec{V}\times\vec{B}\right]. \qquad (1.1)$$

It bears the name of Lorentz it follows from his transformations which permit writing the fields in the moving coordinates if the fields in the stationary coordinates are known. Henceforward, the fields and forces generated in a moving coordinate system will be indicated with primed symbols.

The clues of how to write the fields in moving coordinates if they are known in the stationary system are available even in the Faraday law. Let us specify the form of the Faraday law:

$$\oint \vec{E}'d\,\vec{l}' = -\frac{d\,\Phi_B}{d\,t}. \qquad (1.2)$$

The specified law, or, more precisely, its specified form, means that $\vec{E}$ and $d\vec{l}$ should be primed if the contour integral is sought for in moving coordinates and unprimed for stationary coordinates. In the latter case the right-hand side of Eq. (1.2) should contain a partial derivative with respect to time which fact is generally not mentioned in literature.

The total derivative with respect to time in Eq. (1.2) implies that the final result for the contour e.m.f. is independent of the variation mode of the flux. In other words, the flux can change either purely with time variations of $\vec{B}$ or because the system, in which $\oint \vec{E}'d\,\vec{l}'$ is measured, is moving in the spatially varying field $\vec{B}$. In Eq. (1.2)

$$\Phi_B = \int \vec{B}\,d\,\vec{S}', \qquad (1.3)$$

where the magnetic induction $\vec{B} = \mu\,\vec{H}$ is measured in the stationary coordinates and the element $d\,\vec{S}'$ in the moving coordinates.

Taking into account Eq. (1.3), we can find from Eq. (1.2)

$$\oint \vec{E}'d\,\vec{l}' = -\frac{d}{d\,t}\int \vec{B}\,d\,\vec{S}'. \qquad (1.4)$$

Since $\dfrac{d}{d\,t} = \dfrac{\partial}{\partial\,t} + \vec{V}\,grad$, we can write [5]

$$\oint \vec{E}'d\,\vec{l}' = -\int \frac{\partial\,\vec{B}}{\partial\,t}\,d\,\vec{S} - \int\left[\vec{B}\times\vec{V}\right]\,d\,\vec{l}' - \int \vec{V}\,div\,\vec{B}\,d\,\vec{S}'. \qquad (1.5)$$

In this case contour integral is taken over the contour $d\,\vec{l}'$, covering the space $d\,\vec{S}'$. Henceforward, we assume the validity of the Galilean transformations, i.e. $d\,\vec{l}' = d\,\vec{l}$ and $d\,\vec{S}' = d\,\vec{S}$. Eq. (1.5) furnishes the well-known result:

$$\vec{E}' = \vec{E} + \left[\vec{V}\times\vec{B}\right], \qquad (1.6)$$

which suggests that the motion in the magnetic field excites an additional electric field described by the final term in Eq. (1.6). Note that Eq. (1.6) is obtained from the slightly specified Faraday law and not from the Lorentz transformations.

According to Eq. (1.6), a charge moving in the magnetic field is influenced by a force perpendicular to the direction of the motion. However, the physical nature of this force has never been considered. This brings confusion into the explanation of the homopolar generator operation and does not permit us to explain the electric fields outside an infinitely long solenoid on the basis of the Maxwell equations.

To clear up the physical origin of the final term in Eq. (1.6), let us write $\vec{B}$ and $\vec{E}$ in terms of the magnetic vector potential $\vec{A}_B$:

$$\vec{B} = rot\,\vec{A}_B, \qquad \vec{E} = -\frac{\partial\,\vec{A}_B}{\partial\,t}. \qquad (1.7)$$

Then, Eq. (1.6) can be re-written as

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$$\vec{E}' = -\frac{\partial \vec{A}_B}{\partial t} + \left[\vec{V} \times rot\ \vec{A}_B\right], \quad (1.8)$$

and further:

$$\vec{E}' = -\frac{\partial \vec{A}_B}{\partial t} - \left(\vec{V}\ \nabla\right)\vec{A}_B + grad\ \left(\vec{V}\ \vec{A}_B\right) \quad (1.9)$$

The first two terms in the right-hand side of Eq. (1.9) can be considered as the total derivative of the vector potential with respect to time:

$$\vec{E}' = -\frac{d\ \vec{A}_B}{d\ t} + grad\ \left(\vec{V}\ \vec{A}_B\right). \quad (1.10)$$

As seen in Eq. (1.9), the field strength, and hence the force acting upon a charge consists of three components.

The first component describes the pure time variations of the magnetic vector potential. The second term in the right-hand side of Eq. (1.9) is evidently connected with the changes in the vector potential caused by the motion of a charge in the spatially varying field of this potential. The origin of the last term in the right-hand side of Eq. (1.9) is quite different. It is connected with the potential forces because the potential energy of a charge moving in the potential field $\vec{A}_B$ at the velocity $\vec{V}$ is equal to $e\left(\vec{V}\ \vec{A}_{\mathbf{B}}\right)$. The magnitude $e\ grad\ \left(\vec{V}\ \vec{A}_B\right)$ describes the force just as the scalar potential gradient does.

Using Eq. (1.9), we can explain physically all the strength components of the electronic field excited in the moving and stationary cooperates. If our concern is with the electric fields outside a long solenoid, where the no magnetic field, the first term in the right-hand side of Eq. (1.9) come into play. In the case of a homopolar generator, the force acting upon a charge is determined by the last two terms in the right-hand side of Eq.(1.9), both of them contributing equally.

It is therefore incorrect to look upon the homopolar generator as the exception to the flow rule because, as we saw above, this rule allows for all the three components. Using the rotor in both sides of Eq. (1.10) and taking into account $rot\ grad \equiv 0$, we obtain

$$rot\ \vec{E}' = -\frac{d\ \vec{B}}{d\ t}. \quad (1.11)$$

If motion is absent, Eq. (1.11) turns into Maxwell equation (1.2). Equation (1.11) is certainly less informative than Eq. (1.2): because of $rot\ grad \equiv 0$, it does not include the forces defined in terms of $e\ grad\ \left(\vec{V}\ \vec{A}_B\right)$. It is therefore more reasonable to use Eq. (1.2) if we want to allow for all components of the electric fields acting upon a charge both in the stationary and in the moving coordinates.

As a preliminary conclusion, we may state that the Faraday Law, Eq. (1.2), when examined closely, explains clearly all features of the homopolar generator operation, and this operation principle is a consequence, rather than an exception, of the flow rule, Eq. (1.2). Feynman's statement that $\left[\vec{V} \times \vec{B}\right]$ for the "moving contour" and $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ for the "varying field" are absolutely different laws is contrary to fact. The Faraday law is just the sole unified fundamental principle which Feynman declared to be missing. Let us clear up another Feynman's interpretation. Faraday's observation in fact led him to discovery of a new law relating electric and magnetic fields in the region where the magnetic field varies with time and thus generates the electric field. This correlation is essentially true but not complete. As shown above, the electric field can also be excited where there is no magnetic field, namely, outside an infinitely long solenoid. A more complete formulation follows from Eq. (1.9) and the relationship $\vec{E} = -\frac{d\ \vec{A}_B}{d\ t}$ is more general than $rot\ \vec{E} = -\frac{\partial\ B}{\partial\ t}$.

This suggests that a moving or stationary charge interacts with the field of the magnetic vector potential rather than with the magnetic field. The knowledge of this potential and its evolution can only permit us to calculate all the force components acting upon charges. The magnetic field is merely a spatial derivative of the vector field.

As follows from the above consideration, it is more appropriate to write the Lotentz force in terms of the magnetic vector potential which visualizes the complete structure of the force.

$$\vec{F}' = e\ \vec{E} + e\ [\vec{V} \times rot\ \vec{A}_B] = e\ \vec{E} - e(\vec{V}\nabla)\vec{A}_B + egrad\ (\vec{V}\ \vec{A}_B), \quad (1.12)$$

The Faraday law, Eq. (1.2) is referred to as the law of electromagnetic induction because it shows how varying magnetic fields can generate electric fields. However, classical electrodynamics contains no law of magnetoelectric induction showing how magnetic fields can be excited by varying electric fields. This aspect of

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classical electrodynamics evolved along a different pathway. First, the law

$$\oint \vec{H}\, d\,\vec{l} = I\ , \quad (1.13)$$

was known, in which I was the current crossing the area of the integration contour. In the differential from Eq. (1.13) becomes

$$rot\ \vec{H} = \vec{j}_\sigma\ , \quad (1.14)$$

where $\vec{j}_\sigma$ is the conduction current density.

Maxwell supplemented Eq. (1.14) with displacement current

$$rot\ \vec{H} = \vec{j}_\sigma + \frac{\partial\,\vec{D}}{\partial\, t}\ . \quad (1.15)$$

However, if Faraday had performed measurement in varying electric induction fluxes, he would have inferred the following law

$$\oint \vec{H}'d\,\vec{l}' = \frac{d\,\Phi_D}{d\,t}\ , \quad (1.16)$$

where $\Phi_D = \int \vec{D}\, d\,S'$ is the electric induction flux. Then

$$\oint \vec{H}'d\,\vec{l}' = \int \frac{\partial\,\vec{D}}{\partial\,t} d\,\vec{S} + \oint [\vec{D}\times\vec{V}]d\,\vec{l}' + \int \vec{V}\,div\,\vec{D}\,d\,\vec{S}'. \quad (1.17)$$

Unlike $div\vec{B} = 0$ in magnetic fields, electric fields are characterized by $div\vec{D} = \rho$ and the last term in the right-hand side of Eq. (1.17) describes the conduction current I, i.e. the Ampere law follows from Eq. (1.16). Eq. (1.17) gives

$$\vec{H} = [\vec{D}\times\vec{V}], \quad (1.18)$$

which was earlier obtainable only from the Lorentz transformation.

Moreover, as was shown convincingly in [2], Eq. (1.18) also leads out of the Biot-Savart law if magnetic fields are calculated from the electric fields excited by moving charges. In this case the last term in the right-hand side of Eq. (1.17) can be omitted and the induction laws become completely symmetrical.

$$\oint \vec{E}'d\,\vec{l}' = -\int \frac{\partial\,\vec{B}}{\partial\,t} d\,S - \oint [\vec{B}\times\vec{V}]d\,\vec{l}'\ ,$$

$$\oint \vec{H}'d\,\vec{l}' = \int \frac{\partial\,\vec{D}}{\partial\,t} d\,S + \oint [\vec{D}\times\vec{V}]d\,\vec{l}'\ . \quad (1.19)$$

$$\vec{E}' = \vec{E} + [\vec{V}\times\vec{B}]\ ,$$

$$\vec{H}' = \vec{H} - [\vec{V}\times\vec{D}]\ . \quad (1.20)$$

Earlier, Eqs. (1.20) were only obtainable from the covariant Lorentz transformations, i.e. in the framework of special theory of relativity (STR). Thus, the STR results accurate to the $\sim\frac{V}{c}$ terms can be derived from the induction laws through the Galilean transformations. The STR results accurate to the $\sim\frac{V^2}{c^2}$ terms can be obtained through transformation of Eq (1.19). At first, however, we shall introduce another vector potential which is not used in classical electrodynamics. Let us assume for vortex fields [5] that

$$\vec{D} = rot\ \vec{A}_D\ , \quad (1.21)$$

where $\vec{A}_D$ is the electric vector potential. It then follows from Eq. (1.19) that

$$\vec{H}' = \frac{\partial\,\vec{A}_D}{\partial\,t} + [\vec{V}\nabla]\vec{A}_D - grad\ [\vec{V}\,\vec{A}_D]\ , \quad (1.22)$$

or

$$\vec{H}' = \frac{\partial\,\vec{A}_D}{\partial\,t} - [\vec{V}\times rot\ \vec{A}_D]\ , \quad (1.23)$$

or

$$\vec{H}' = \frac{d\,\vec{A}_D}{d\,t} - grad\ [\vec{V}\,\vec{A}_D]\ . \quad (1.24)$$

These equations present the law of magnetoelectric induction written in terms of the electric vector potential.

To illustrate the importance of the introduction of the electric vector potential, we come back to an infinitely long solenoid. The situation is much the same, and the only change is that the vectors $\vec{B}$ are replaced with the vectors $\vec{D}$. Such situation is quite realistic: it

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occurs when the space between the flat capacitor plates is filled with high electric inductivities. In this case the displacement flux is almost entirely inside the dielectric. The attempt to calculate the magnetic field outside the space occupied by the dielectric (where $\vec{D} \cong 0$) runs into the same problem that existed for the calculation beyond the fields $\vec{E}$ of an infinitely long solenoid. The introduction of the electric vector potential permits a correct solution of this problem. This however brings up the question of priority: what is primary and what is secondary? The electric vector potential is no doubt primary because electric vortex fields are excited only where the rotor of such potential is non-zero.

As follows from Eqs. (1.20), if the reference systems move relative to each other, the fields $\vec{E}$ and $\vec{H}$ are mutually connected, i.e. the movement in the fields $\vec{H}$ induces the fields $\vec{E}$ and vice versa. But new consequences appear, which were not considered in classical electrodynamics. For illustration, let us analyze two parallel conducting plates with the electric field $\vec{E}$ in between. In this case the surface charge ρ_S per unit area of each plate is εE. If the other reference system is made to move parallel to the plates in the field E at the velocity ΔV, this motion will generate an additional field $\Delta H = \Delta V \varepsilon E$. If a third reference system starts to move at the velocity ΔV, within the above moving system, this motion in the field ΔH will generate $\Delta\ E = \mu\varepsilon\ \Delta\ V^2 E$, which is another contribution to the field E. The field E' thus becomes stronger in the moving system than it is in the stationary one. It is reasonable to suppose that the surface charge at the plates of the initial system has increased by $\mu\varepsilon^2 \Delta V^2 E$ as well.

This technique of field calculation was described in [5]. If we put $\vec{E}_{||}$ and $\vec{H}_{||}$ for the field components parallel to the velocity direction and $\vec{E}_\perp$ and $\vec{H}_\perp$ for the perpendicular components, the final fields at the velocity V can be written as

$$\vec{E}'_{||} = \vec{E}_{||},$$

$$\vec{E}'_\perp = \vec{E}_\perp c\,h\frac{V}{c} + \frac{Z_0}{V}[\vec{V} \times \vec{H}_\perp]s\,h\frac{V}{c}, \qquad (1.25)$$

$$\vec{H}'_{||} = \vec{H}_{||},$$

$$\vec{H}'_\perp = \vec{H}_\perp c\,h\frac{V}{c} - \frac{1}{Z_0 V}[\vec{V} \times \vec{E}_\perp]s\,h\frac{V}{c},$$

where $Z_0 = \sqrt{\frac{\mu}{\varepsilon}}$ is the space impedance, $c = \sqrt{\frac{1}{\mu\,\varepsilon}}$ is the velocity of light in the medium under consideration.

The results of these transformations coincide with the STR data with the accuracy to the $\sim\frac{V^2}{c^2}$ terms. The higher-order corrections do not coincide. It should be noted that until now experimental tests of the special theory of relativity have not gone beyond the $\sim\frac{V^2}{c^2}$ accuracy.

As an example, let us analyze how Eqs. (1.25) can account for the phenomenon of phase aberration which was inexplicable in classical electrodynamics.

Assume that there are plane wave components H_Z and E_X, and the primed system is moving along the *x*-axis at the velocity V_X. The field components with in the primed coordinates can be written as

$$E_X{}' = E_X,$$

$$E_Y{}' = H_Z sh\frac{Vx}{c}, \qquad (1.27)$$

$$H_Z{}' = H_Z ch\frac{V_X}{c}$$

The total field E in the moving system is

$$E' = \left[\left(E_X{}'\right)^2 + \left(E_Y{}'\right)^2\right]^{1/2} = E_X\ ch\ \frac{V_X}{c}. \qquad (1.28)$$

Hence, the Poynting vector no longer follows the direction of the *y*-axis. It is in the *xy*-plane and tilted about the *y*-axis at an angle determined by Eqs. (1.27). The ratio between the absolute values of the vectors E and H is the same in both the systems. This is just what is known as phase aberration in classical electrodynamics.

III. Magnetic Field Problem

As follows from the transformations in Eq. (1.25) if two charges move at the relative velocity $\vec{V}$, their interaction is determined not only by the absolute values of the charges but by the relative motion velocity as well. The new value of the interaction force is found as [5-11]

$$\vec{F} = \frac{g_1\,g_2\,ch\,\frac{V_\perp}{c}}{4\pi\,\varepsilon} \cdot \frac{\vec{r}_{12}}{r_{12}^3}, \qquad (2.1)$$

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where $\vec{r}_{12}$ is the vector connecting the charges, $V_\perp$ is the component of the velocity $\vec{V}$, normal to the vector $\vec{r}_{12}$.

If opposite-sign charges are engaged in the relative motion, their attraction increases. If the charges have the same signs, their repulsion enhances. For $\vec{V}=0$, Eq. (2.1) becomes the Coulomb law .

Using Eq. (2.1), a mew value of the potential $\varphi(r)$ can be introduced at the point, where the charge g_2 is located, assuming that g_2 is immobile and only g_1 executes the relative motion

$$\varphi(r)=\frac{g_1\, ch\,\frac{V_\perp}{c}}{4\pi\,\varepsilon\, r}\,. \tag{2.2}$$

We can denote this potential as "scalar-vector", because its value is dependent not only on the charge involved but on the value and the direction of its velocity as well. The potential energy of the charge interaction is

$$W=\frac{g_1\, g_2\, ch\,\frac{V_\perp}{c}}{4\pi\,\varepsilon\, r}\,. \tag{2.3}$$

Eqs. (2.1), (2.2) and (2.3) apparently account for the change in the value of the moving charges.

Using these equations, it is possible to calculate the force of the conductor-current interactions and allow, through superposition, for the interaction forces of all moving and immobile charges in the conductors. We thus obtain all currently existing laws of electromagneticm.

Let us examine the force, interaction of two *r*-spaced conductors(Fig. 1) assuming that the electron velocities in the conductors are V_1 and V_2. The moving charge values per unit length of the conductors are g_1 and g_2.

In terms of the present-day theory of electromagnetism, the forces of the interaction of the conductors can be found by two methods.

1. One of the conductors (e.g., the lower one) generates the magnetic field $H(r)$ in the location of the first conductor. This field is

$$H(r)=\frac{g_1\, V_1}{2\pi\, r}\,. \tag{2.4}$$

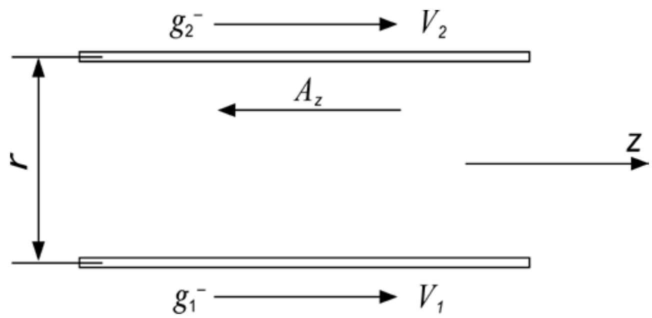

Fig. 1: Schematic view of force interaction between current-carreging conductors of a two-conductor line in terms of the present-day model

The field E' is excited in the coordinate system moving together with the charges of the upper conductor:

$$E'=\left[\vec{V}\times\vec{B}\right]=V_2\,\mu\, H(r)\,. \tag{2.5}$$

I.e. the charges moving in the upper conductor experience the Lorentz force. This force per unit length of the conductor is

$$F=\frac{\mu\, g_1\, V_1\, g_2\, V_2}{2\pi\, r}=\frac{I_1\, I_2}{2\pi\,\varepsilon\, c^2\, r}\,. \tag{2.6}$$

Eq. (2.6) can be obtained in a different way. Assume that the lower conductor excites a vector potential in the region of the upper conductor. The Z– component of the vector potential is

$$A_Z=-\frac{g_1 V_1\,\ln r}{2\pi\,\varepsilon\, c^2}=-\frac{I_1\,\ln r}{2\pi\,\varepsilon\, c^2}\,. \tag{2.7}$$

The potential energy per unit length of the upper conductor carrying the current I_2 in the field of the vector potential A_Z is

$$W=I_2 A_Z=-\frac{I_1\, I_2 \ln r}{2\pi\,\varepsilon\, c^2}\,. \tag{2.8}$$

Since the force is the derivative of the potential energy with respect to the opposite-sign coordinate, it is written as

$$F=-\frac{\partial\, W}{\partial\, r}=\frac{I_1\, I_2}{2\pi\,\varepsilon\, c^2 r}\,. \tag{2.9}$$

Both the approaches show that the interaction force of two conductors is the result of the interaction of moving charges: some of them excite fields, the others interact with them. The immobile charges representing the lattice do not participate in the interaction in this scheme. But the forces of the magnetic interaction between the conductors act just on the lattice. Classical

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electrodynamics does mot explain how the moving charges experiencing this force can transfer it to the lattice.

The above models of iteration are in unsolvable conflict, and experts in classical electrodynamics prefer to pass it over in silence. The conflict is connected with estimation of the interaction force of two parallel-moving charges. Within the above models such two charges should be attracted. Indeed, the induction B caused by the moving charge g_1 at the distance *r* is

$$B = \frac{g_1 V}{2\pi \varepsilon c^2 r^2} . \qquad (2.10)$$

If another charge g_2 moves at the same velocity V in the same direction at the distance *r* from the first charge, the induction B at the location of g_2 produces the force attracting g_1 and g_2.

$$F = \frac{g_1 g_2 V^2}{4\pi \varepsilon c^2 r^2} . \qquad (2.11)$$

An immovable observer would expect these charges to experience attraction along with the Coulomb repulsion. For an observer moving together with the charges there is only the Coulomb repulsion and no attraction. Neither classical electrodynamics not the special theory of relativity can solve the problem.

Physically, the introduction of magnetic fields reflects certain experimental facts, but so far we can hardly understand where these fields come from.

In 1976 it was reported in a serious experimental study that a charge appeared on a short-circuited superconducting solenoid when the current in it was attenuating. The results of [12] suggest that the value of the charge is dependent on its velocity, which is first of all in contradiction with the charge conservation law. The author of this study has also investigated this problem [13]. It is useful to analyze here the interaction of current-carrying systems in terms of Eqs. (2.1), (2.2) and (2.3).

We come back again to the interaction of two thin conductors with charges moving at the velocities V_1 and V_2 (Fig. 2).

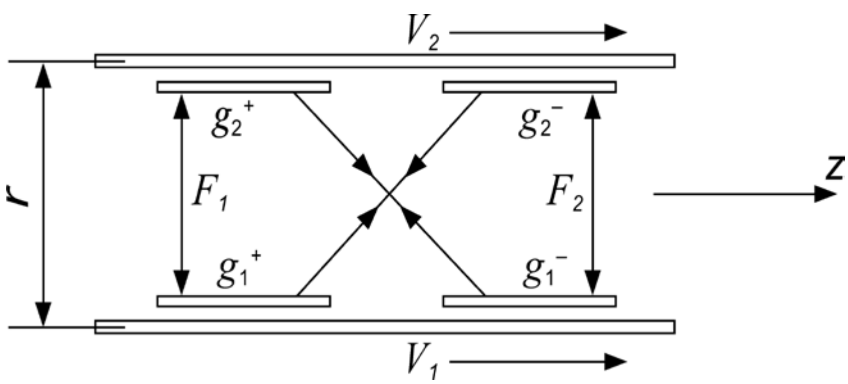

Fig. 2: Schematic view of force interaction between current-carrying wires of a two-conductor line. The lattice is charged positively

g_1^+, g_2^+ and g_1^-, g_2^- are the immobile and moving charges, respectively, pre unit length of the conductors. g_1^+ and g_2^+ refer to the positively charged lattice in the lower and upper conductors, respectively. Before the charges start moving, both the conductors are assumed to be neutral electrically, i.e. they contain the same number of positive and negative charges.

Each conductor has two systems of unlike charges with the specific densities g_1^+, g_1^- and g_2^+, g_2^-. The charges neutralize each other electrically. To make the analysis of the interaction forces more convenient, in Fig. 2 the systems are separated along the Z-axis. The negative-sign subsystems (electrons) have velocities V_1 and V_2. The force of the interaction between the lower and upper conductors can be considered as a sum of four forces specified in Fig. 2 (the direction is shown by arrows). The attraction forces F_3 and F_4 are positive, and the repulsion forces F_1 and F_2 are negative.

According to Eq. (1.1), the forces between the individual charge subsystems (Fig. 2) are

$$F_1 = -\frac{g_1^+ g_2^+}{2\pi \varepsilon r} ,$$

$$F_2 = -\frac{g_1^- g_2^-}{2\pi \varepsilon r} ch \frac{V_1 - V_2}{c} , \qquad (2.12)$$

$$F_3 = +\frac{g_1^- g_2^+}{2\pi \varepsilon r} ch \frac{V_1}{c} ,$$

$$F_4 = +\frac{g_1^+ g_2^-}{2\pi \varepsilon r} ch \frac{V_2}{c} .$$

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By adding up the four forces and remembering that the product of unlike charges and the product of like charges correspond to the attraction and repulsion forces, respectively, we obtain the total specific force per unit length of the conductor

$$F_{\Sigma} = \frac{g_1 \ g_2}{2\pi \ \varepsilon \ r}\left(ch\frac{V_1}{c} + ch\frac{V_2}{c} - ch\frac{V_1 - V_2}{c} - 1 \right), \quad (2.13)$$

where g_1 and g_2 are the absolute values of charges. The signs of the forces appear in the bracketed expression. Assuming $V << c$, we use only the two first terms in the expression of $ch\frac{V}{c}$, i.e. $ch\frac{V}{c} \cong 1 + \frac{1}{2}\frac{V^2}{c^2}$. Eq. (2.13) gives

$$F_{\Sigma 1} = \frac{g_1 \ V_1 \ g_2 V_2}{2\pi \ \varepsilon \ c^2 r} = \frac{I_1 \ I_2}{2\pi \ \varepsilon \ c^2 r}, \quad (2.14)$$

where g_1 and g_2 are the absolute values of specific charges, and V_1, V_2 are taken with their signs.

It is seen that Eqs. (2.6), (2.9) and (2.13) coincide though they were obtained by different methods.

According to Feynman (see the introduction), the e.m.f. of the circuit can be interpreted using two absolutely different laws. The paradox has however been clarified. The force of the enteraction between the current-carrying systems can be obtained even by three absolutely different methods. But in the third method, the motion “magnetic field” is no longer necessary and the lattice can directly participate in the formation of the interaction forces. This was impossible with the previous two techniques.

In practice the third method however runs into a serious obstacle. Assuming $g_2^+ = 0$ and $V_2 = 0$, i.e. the interaction, for example, between the lower current-carrying system and the immobile charge g_2^- the interaction force is

$$F_{\Sigma 2} = -\frac{1}{2} \cdot \frac{g_1 \ g_2 V_1^2}{2\pi \ \varepsilon \ c^2 r}. \quad (2.14)$$

This means that the current in the conductor is not electrically neutral, and the electric field

$$E_{\perp} = \frac{g_1 \ V_1^2}{4\pi \ \varepsilon \ c^2 r}, \quad (2.15)$$

is excited around the conductor, which is equivalent to an extra specific static charge on the conductor

$$g = -g_1 \ \frac{V_1^2}{c^2}. \quad (2.16)$$

Before [12], there was no evidence for generation of electric fields by d.c. currents.

When Faraday and Maxwell formulated the basic laws of electrodynamics, it was impossible to confirm Eq. (2.16) experimentally because the current densities in ordinary conductors are too small to detect the effect. The assumption that the charge is independent of its velocity and the subsequent introduction of a magnetic field were merely voluntaristic acts.

In superconductors the current densities permit us to find the correction for the charge $\sim g\frac{V_1^2}{c^2}$ experimentally. Initially, [12] was taken as evidence for the dependence of the value of the charge on its velocity. The author of this study has also investigated this problem [13], but, unlike [12], in his experiments current was introduced into a superconducting coil by an inductive non-contact method. Even in this case a charge appeared on the coil [13]. The experimental objects were superconducting composite Nb – Ti wires coated with copper, and it is not cleat what mechanism is responsible for the charge on the coil. It may be brought by mechanical deformation which causes a displacement of the Fermi level in the copper. Experiments on non-coated superconducting wires may be more informative. Anyhow, the subject has not been exhausted and further experimental findings are of paramount importance to fundamental physics. Using this model, we should remember that there is no reliable experimental data on static electric fields around the conductor. According to Eq. (2.15), such fields are excited because the value of the charge is dependent on its velocity. Is there any physical mechanism which could maintain the interacting current-carrying systems electrically neutral within this model? Such mechanism does exist. To explain it, let us consider the current-carrying circuit in Fig. 3. This is a superconducting thin film whose thickness is smaller than the field penetration depth in the superconductor. The current is therefore distributed uniformly over the film thickness. Assume that the bridge connecting the wide parts of the film is much narrower than the rest of the current-carrying film. If persistent current is excited in such a circuit, the current density and hence the current carrier velocity V_1 in the bridge will much exceed the velocity V_0 in the wide parts of the film.

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Such situation is possible if the current carriers are accelerated in the part d_1 and slowed down in the part d_2. But acceleration and slowing - down of charges is possible only in electric fields. If $V_1 > V_0$, the potential difference between the parts d_1 and d_2 which causes acceleration or slowing-down is determined as

$$U = \frac{m\,V_1^2}{2\,e}\ . \tag{2.17}$$

This potential difference can appear only due to the charge density gradient in the parts d_1 and d_2, i.e. the density of charge carriers decreases with acceleration and increases with slowing down. The relation $n_0 > n_1$ should be fulfilled, where n_0 and n_1 are the current-carrier densities in the wide and narrow bridge parts of the film, respectively. It is clear that some energy is needed to accelerate charges which have masses. Let us find out where this energy comes from.

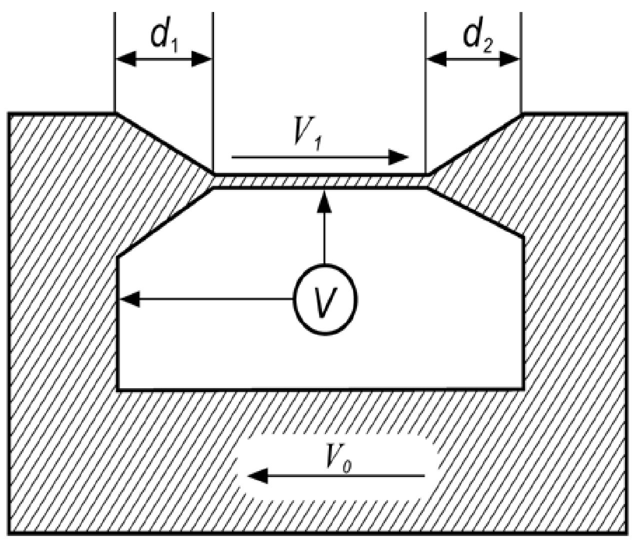

Fig. 3: Schematic view of a current-carrying circuit based on a superconducting film

On acceleration the electrostatic energy available in the electrostatic field of the current carriers converts into kinetic energy. The difference in electrostatic energy between two identical volumes having different electron densities can be written as

$$\Delta W = \Delta n \frac{e^2}{8\pi\,\varepsilon\,r}\ , \tag{2.18}$$

where $\Delta n = n_0 - n_1$, e is the electron charge, r is the electron radius.

Since

$$\frac{e^2}{8\pi\,\varepsilon\,r} = m\,c^2\ , \tag{2.19}$$

where m is the electron mass, Eq. (1.46) can be rewritten as

$$\Delta W = \Delta n\ m\ c^2\ . \tag{2.20}$$

This energy is used to accelerate the current carriers. Hence,

$$\Delta W = \frac{n_0\,m\,V_1^2}{2}\ , \tag{2.21}$$

and

$$\Delta n = n_0 \frac{1}{2}\cdot\frac{V_1^2}{c^2}\ . \tag{2.22}$$

The electron density in a moving flow is

$$n_1 = n_0\left(1 - \frac{1}{2}\cdot\frac{V_1^2}{c^2}\right) \tag{2.23}$$

We see that the change in the current-carrier density is quite small, but this change is just responsible for the existence of the longitudinal electric field accelerating or slowing down the charges in the parts d_1 and d_2. Let us call such fields "configuration fields" as they are connected with a certain configuration of the conductor. These fields are available in normal conductors too, but they are much smaller than the fields related to the Ohmic resistance.

We can expect that a voltameter connected to the circuit, like is shown in Fig. 3, would be capable of registering the configuration potential difference in accordance with Eq. (2.17). If we used an ordinary liquid and a manometer instead of a voltameter, according to the Bernoulli equation, the manometer could register the pressure difference. For lead films, the configuration potential difference is $\sim 10^{-7}$ B, though it is not observablt experimentally. We can explain this before hand. As the velocities of the current carriers increase and their densities decrease, the electric fields njrmal to their motion enhance. These two precesses counterbalance each other. As a result, the normal component of the electric field has a zero balue in all parts of the film. In terms of the considered, this looks like

$$F_1 = -\frac{g_1^+ g_2^+}{2\pi\,\varepsilon\,r}\ ,$$

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$$F_2 = -\frac{g_1^- g_2^-}{2\pi\,\varepsilon\,r}\left(1-\frac{1}{2}\cdot\frac{V_1^2}{c^2}\right)\cdot\left(1-\frac{1}{2}\cdot\frac{V_2^2}{c^2}\right) ch\frac{V_1-V_2}{c},$$

$$F_3 = \frac{g_1^- g_2^+}{2\pi\,\varepsilon\,r}\left(1-\frac{1}{2}\cdot\frac{V_1^2}{c^2}\right) ch\frac{V_1}{c}, \tag{2.24}$$

$$F_4 = \frac{g_1^+ g_2^-}{2\pi\,\varepsilon\,r}\left(1-\frac{1}{2}\cdot\frac{V_2^2}{c^2}\right) ch\frac{V_1}{c}$$

The bracketed expressions in Eqs. (2.24) allow for the motion-related change in the density of the charges g_1^- and g_2^-.

After expanding ch, multiplying out and allowing only for the $\sim\frac{V^2}{c^2}$ terms, Eqs. (2.24) give

$$F_1 \cong -\frac{g_1^+ g_2^+}{2\pi\,\varepsilon\,r},$$

$$F_2 \cong -\frac{g_1^- g_2^-}{2\pi\,\varepsilon\,r}\left(1-\frac{V_1 V_2}{c^2}\right), \tag{2.25}$$

$$F_3 \cong \frac{g_1^- g_2^+}{2\pi\,\varepsilon\,r},$$

$$F_4 \cong \frac{g_1^+ g_2^-}{2\pi\,\varepsilon\,r}.$$

By adding up F_1, F_2, F_3 and F_4, we obtain the total force of the interaction

$$F_\Sigma = \frac{g_1^- V_1\, g_2^- V_2}{2\pi\,\varepsilon\,c^2\,r} = \frac{I_1\, I_2}{2\pi\,\varepsilon\,c^2\,r} \tag{226}$$

Again, we have a relation coinciding with Eqs. (2.6) and (2.9). However, in this case the current-carrying conductors are neutral electrically. Indeed, if we analyze the force interaction. For example, between the lower conductor and the upper immobile charge g_2 (putting $g_2^+ = 0$ and $V_2 = 0$), the total interaction force will be zero, i.e. the conductor with flowing current is electrically neutral.

If we consider the interaction of two parallel – moving electron flows (taking $g_1^+ = g_2^+ = 0$ and $V_1 = V_2$), according to Eq. (2.12), the total force is

$$F_\Sigma = -\frac{g_1^- g_2^-}{2\pi\,\varepsilon\,r}. \tag{2.27}$$

It is seen that two electron flows moving at the same velocity in the absence of a lattice experience only the Coulomb repulsion and no attraction included into the magnetic field concept.

Physically, in this model the force interaction of the current-carrying systems is not connected with any now field. The interaction is due to the enhancement of the electric fields normal to the direction of the charge motion.

The phenomenological concept of the magnetic field of correct only when the charges of the current carriers are compensated with the charges of the immobile lattice, the current carriers excite a magnetic field. The magnetic field concept is not correct for freely moving charges when there are no compensating charges of the lattice. In this case a moving charged particle or a flow of charged particles does not excite a magnetic field. Thus, the concept of the phenomenological magnetic field is true but for the above case.

It is easy to show that using the scalar-vector potential, we can obtain all the presently existing laws of magnetism. Besides, the approach proposed permits a solution of the problem of the interaction between two parallel-moving charges which could not be solved in terms of the magnetic field concept.

IV. Problem of the Electromagnetic Radiation

Whatever occurs in electrodynamic, it is connected with the interaction of moving and immobile charges. The introduction of the scalar-vector potential answers this question. The potential is based on the laws of electromagnetic and magnetoelectric induction. The Maxwell equations describing the wave processes in material media also follow from these laws. The Maxwell equations suggest that the velocity of field propagation is finite and equal to the velocity of light.

The problem of electromagnetic radiation can be solved of the elementary level using the scalar-vector potential and the finiteness of propagation of electric processes.

For this purpose, the retarded scalar-vector potential [1,14]

$$\varphi(r',t) = \frac{g_1\, ch\frac{V'_\perp}{c}}{4\pi\,\varepsilon\,r'}, \tag{3.1}$$

is introduced, where $V'_\perp$ is the velocity of the charge g_1 at the moment $t' = t - \frac{r'}{c}$, normal to the vector $\vec{r}'$,

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r' is the distance between the charge g_1 and point 2(Fig. 4), where the field is sought for at the moment t. The field at point 2 can be found from the relation $\vec{E} = -grad\ \varphi$. Assume that at the moment $t - \frac{r'}{c}$ the charge g_1 is at the origin of the coordinates and its velocity is $V'_\perp(t)$. The field E_y at point 2 is

$$E_y = -\frac{\partial\ \varphi(2\ t)}{\partial\ y} = -\frac{e_0}{4\pi\ \varepsilon\ r'} \cdot \frac{\partial}{\partial\ y} ch \frac{V'_\perp(\mathrm{t})}{\mathrm{c}}. \quad (3.2)$$

Differentiation is performed assuming r' to be a constant magnitude. From Eq. (3.2) we obtain

$$E_y = -\frac{e_0}{4\pi\ \varepsilon\ c\ r'} \cdot \frac{\partial\ \mathrm{V}'_\perp(\mathrm{t})}{\partial\ y} s\ h \frac{\mathrm{V}'_\perp(\mathrm{t})}{\mathrm{c}} = -\frac{e_0}{4\pi\ \varepsilon\ c\ r'} \cdot \frac{1}{\mathrm{V}'_\perp(\mathrm{t})} \cdot \frac{\partial\ \mathrm{V}'_\perp(\mathrm{t})}{\partial\ t} s\ h \frac{\mathrm{V}'_\perp(\mathrm{t})}{\mathrm{c}} \quad (3.3)$$

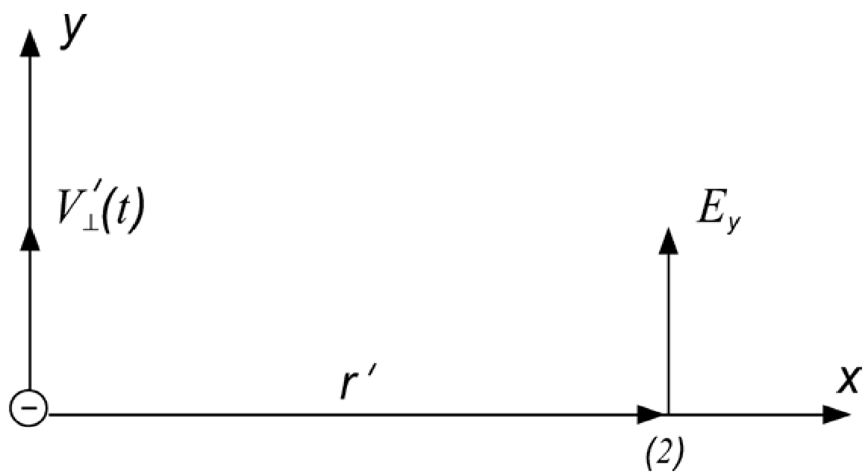

Fig. 4: Formation of the retarded scalar-vector potential

If we take only first member of expansion in the serial of $s\ h \frac{V'_\perp(\mathrm{t})}{\mathrm{c}}$, then using Eq. (3.3), we can write down

$$E_y(x,t) = -\frac{e}{4\pi\varepsilon_0 c^2 x} \frac{\partial v_y\left(t - \frac{x}{c}\right)}{\partial t} = -\frac{e a_y\left(t - \frac{x}{c}\right)}{4\pi\varepsilon_0 c^2 x}, \quad (3.4)$$

where $a_y\left(t - \frac{x}{c}\right)$ is the retarded acceleration.

This equation relationship is wave equation and defines both the amplitude and phase responses of the wave of the electric field, radiated by the moving charge.
The radiation pattern is determined by the equation

$$E_y(x,t,\alpha) = -\frac{e a_y\left(t - \frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x} \quad (3.5)$$

where of α is an angle between the direction of emission and the axis of y.

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This diagram corresponds to the radiation pattern of dipole emission.
Since

$$A_H\left(t-\frac{x}{c}\right)=\frac{ev_z\left(t-\frac{x}{c}\right)}{4\pi x}$$

where $A_H\left(t-\frac{x}{c}\right)$ is the retarded vector potential.

Eq. (3.5) it is possible to rewrite

$$E_y(x,t,\alpha)=-\frac{ea_y\left(t-\frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x}=-\mu_0\frac{\partial A_H\left(t-\frac{x}{c}\right)}{\partial t}. \tag{3.6}$$

Is again obtained complete agreement with the equations of the being late vector potential, but vector potential is introduced here not by phenomenological method, but with the use of a concept of the being late scalar-vector potential. Let us note one important circumstance. In Maxwell's equations electric fields it appears vortex. In this case the electric fields bear gradient nature.

Let us demonstrate the still one possibility, which relationship gives (3.5). It is known that in the electrodynamics there is this concept, as the electric dipole and dipole emission. Two charges with the opposite signs have the dipole moment:

$$\vec{p}=e\vec{d}\,.$$

Therefore current can be expressed through the derivative of dipole moment on the time of

$$e\vec{v}=e\frac{\partial\vec{d}}{\partial t}=\frac{\partial\vec{p}}{\partial t}.$$

Consequently

$$\vec{v}=\frac{1}{e}\frac{\partial\vec{p}}{\partial t},$$

and further

$$\vec{a}=\frac{\partial\vec{v}}{\partial t}=\frac{1}{e}\frac{\partial^2\vec{p}}{\partial t^2}.$$

Substituting this relationship into Eq. (3.4), we obtain the law of the dipole emission

$$\vec{E}=-\frac{1}{4\pi r\varepsilon_0 c^2}\frac{\partial^2 p(t-\frac{r}{c})}{\partial t^2}. \tag{3.7}$$

In the process of fluctuating the electric dipole are created the electric fields of two forms. In addition to this, around the being varied dipole are formed the electric fields of static dipole, which change in the time in connection with the fact that the distance between the charges it depends on time. Specifically, energy of these pour on the freely being varied dipole and it is expended on the emission. However, the summary value of field around this dipole at any moment of time defines as superposition pour on static dipole pour on emissions.

Laws (3.4), (3.5), (3.6) are the laws of the direct action, in which already there is neither magnetic field on nor vector potentials. I.e. those structures, by which there were the magnetic field and magnetic vector potential, are already taken and they no longer were necessary to us.

Using relationship (3.5) it is possible to obtain the laws of reflection and scattering both for the single charges and, for any quantity of them. The superposition of electrical field on all charges in the wave zone and it is electrical wave.

If on the charge acts the electric field of $E'_y=E'_{y0}\sin\omega t$, then the acceleration of charge is determined by the equation of

$$a=-\frac{e}{m}E'_{y0}\sin\omega t$$

Taking into account this relationship (18.5) assumes the form

$$E_y(x,t,\alpha)=\frac{e^2\sin\alpha}{4\pi\varepsilon_0 c^2 mx}E'_{y0}\sin\omega(t-\frac{x}{c})=\frac{K}{x}E'_{y0}\sin\omega(t-\frac{x}{c}), \tag{3.8}$$

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where the coefficient of $K = \frac{e^2 \sin\alpha}{4\pi\varepsilon_0 c^2 m}$ can be named the coefficient of the re-emission of single charge in the assigned direction.

The current wave of the displacement accompanies the wave of electric field:

$$j_y(x,t) = \varepsilon_0 \frac{\partial E_y}{\partial t} = -\frac{e\sin\alpha}{4\pi c^2 x}\frac{\partial^2 v_y\left(t-\frac{x}{c}\right)}{\partial t^2}.$$

If charge accomplishes its motion under the action of the electric field of $E' = E'_0 \sin\omega t$, then bias current in the distant zone can be written as

$$j_y(x,t) = -\frac{e^2\omega}{4\pi c^2 mx} E'_{y0} \cos\omega\left(t-\frac{x}{c}\right). \quad (3.9)$$

The sum wave, which presents the propagation of electrical pour on (3.8) and bias currents (3.9), can be named the electric current wave. In this wave of displacement lags behind the wave of electric field to the angle equal $\frac{\pi}{2}$.

You can enter the magnetic waves using equation

$$\vec{j} = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} = rot\vec{H}, \quad (3.10)$$

$$div\vec{H} = 0$$

introduced thus magnetic field is vortex. Comparing Eqs. (3.9) and (3.10) we find:

$$\frac{\partial H_z(x,t)}{\partial x} = \frac{e^2\omega \sin\alpha}{4\pi c^2 mx} E'_{y0} \cos\omega\left(t-\frac{x}{c}\right).$$

Integrating this relationship on the coordinate, we find the value of the magnetic field

$$H_z(x,t) = \frac{e^2 \sin\alpha}{4\pi cmx} E'_{y0} \sin\omega\left(t-\frac{x}{c}\right). \quad (3.11)$$

Eqs. (3.8), (3.9) and (3.11) can be named the laws of electric-electric induction. They give the connection between the electric fields, applied to the charge, and by fields and by currents induced by this charge in its environment. Charge itself comes out in the role of the transformer, which ensures this reemission. The magnetic field, which can be calculated with the aid of Eq. (3.11), is directed normally both toward the electric field and toward the direction of propagation, and their relation at each point of the space is equal of

$$\frac{E_y(x,t)}{H_z(x,t)} = \frac{1}{\varepsilon_0 c} = \sqrt{\frac{\mu_0}{\varepsilon_0}} = Z,$$

In this equation of Z is wave drag of free space.

Wave drag determines the active power of losses on the single area, located normal to the direction of propagation of the wave: Therefore electric current wave, crossing this area, transfers through it the power, determined by the data by relationship.

$$P = \frac{1}{2} Z E^2{}_{y0}.$$

this relationship will be coordinated with the Poynting vector. Therefore, for finding all parameters, which characterize wave process, it is sufficient examination only of electric current wave and knowledge of the wave drag of space. In this case it is in no way compulsory to introduce this concept as magnetic field and its vector potential, although there is nothing illegal in this. The obtained fields satisfy Helmholtz's theorem. This theorem says, that any single-valued and continuous the vector field of $\vec{F}$, which turns into zero at infinity, can be represented uniquely as the sum of the gradient of a certain scalar function of φ and rotor of a certain vector function of $\vec{C}$, whose divergence is equal to zero:

$$\vec{F} = grad\varphi + rot\vec{C},$$

$$div\vec{C} = 0.$$

Consequently, must exist clear separation pour on to the gradient and the vortex. It is evident that in the expressions, obtained for those induced pour on, this separation is located. Electric fields bear gradient nature, and magnetic field must be vortex.

Thus, the construction of electrodynamics should have been begun from the acknowledgement of the dependence of scalar potential on the speed. But nature very deeply hides its secrets, and in order to come to this simple conclusion, it was necessary to pass way by length almost into two centuries. The grit, which so harmoniously were erected around the magnet poles, in a straight manner indicated the presence of some power pour on potential nature, but to this they did not turn attention. Therefore it turned out that all examined only tip of the iceberg, whose substantial part remained invisible of almost two hundred years.

Taking into account entire aforesaid one should assume that at the basis of the overwhelming majority of static and dynamic phenomena at the electrodynamics

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only one formula (2.1), which assumes the dependence of the scalar potential of charge on the speed, lies. From this formula it follows and static interaction of charges, and laws of power interaction in the case of their mutual motion, and emission laws and scattering. This approach made it possible to explain from the positions of classical electrodynamics such phenomena as phase aberration and the transverse Doppler effect, which within the framework the classical electrodynamics of explanation did not find.

Let us point out that one of the fundamental equations of induction (3.4) could be obtained directly from the Ampere law, still long before appeared Maksvell's equations. The Ampere law, expressed in the vector form, determines magnetic field at the point of

$$\vec{H} = \frac{1}{4\pi}\int \frac{I d\vec{l} \times \vec{r}}{r^3}$$

where I is the current in the element of $d\vec{l}$, $\vec{r}$ is the vector, directed from $d\vec{l}$ to the point of.

It is possible to show that

$$\frac{[d\vec{l}\vec{r}]}{r^3} = grad\left(\frac{1}{r}\right)\times d\vec{l} = rot\left(\frac{d\vec{l}}{r}\right) - \frac{1}{r} rot\ d\vec{l},$$

but the rotor of $d\vec{l}$ is equal to zero therefore

$$\vec{H} = rot\int I\left(\frac{d\vec{l}}{4\pi r}\right) = rot\ \vec{A}_H.$$

In this equation

$$\vec{A}_H = \int I\left(\frac{d\vec{l}}{4\pi r}\right). \tag{3.12}$$

The remarkable property of this expression is that that the vector potential depends from the distance to the observation point as $\frac{1}{r}$. Specifically, this property makes it possible to obtain emission laws.

Since of $I = gv$, where g the quantity of charges, which falls per unit of the length of conductor, from (3.12) we obtain:

$$\vec{A}_H = \int \frac{gv\ d\vec{l}}{4\pi r}.$$

for the single charge of e this relationship takes the form:

$$\vec{A}_H = \frac{e\vec{v}}{4\pi r},$$

In connection with the fact that electric field is determined from the equation

$$\vec{E} = -\mu\frac{\partial\vec{A}}{\partial t},$$

we obtain for this case

$$\vec{E} = -\mu\int \frac{g\frac{\partial v}{\partial t}\ d\vec{l}}{4\pi r} = -\mu\int\frac{ga\ d\vec{l}}{4\pi r}, \tag{3.13}$$

where of a is the acceleration of charge.

For the single charge of this relationship takes the form:

$$\vec{E} = -\frac{\mu e\vec{a}}{4\pi r}. \tag{3.14}$$

in relationships (3.13) and (3.14) it is necessary to consider that the potentials are extended with the final speed they be late to the period of $\frac{r}{c}$. Taking into account the fact that for the vacuum magnetic permeability is determined by the relationship of $\mu = \frac{1}{\varepsilon_0 c^2}$, these equations will take the form:

$$\vec{E} = -\mu\int\frac{ga(t-\frac{r}{c})\ d\vec{l}}{4\pi r} = -\int\frac{ga(t-\frac{r}{c})\ d\vec{l}}{4\pi\varepsilon_0 c^2 r}, \tag{3.15}$$

$$\vec{E} = -\frac{e\vec{a}(t-\frac{r}{c})}{4\pi\varepsilon_0 c^2 r}. \tag{3.16}$$

Eqs. (3.15) and (3.16) represent wave equations and are the solutions of Maksvell's equations, but in this case they are obtained directly from the Ampere law. To there remains only present the question, why electrodynamics in its time is not banal by this method?

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V. Is there any Dispersion of Electric and Magnetic Inductivities in Material Media?

It is noted in the introduction that dispersion of electric and magnetic inductivities of material media is a commonly accepted idea. The idea is however not correct [14,15].

To explain this statement and to gain a better understanding of the physical essence of the problem, we start with a simple example showing how electric lumped-parameter circuits can be described. As we can see below, this example is directly concerned with the problem of our interest and will give us a better insight into the physical picture of the electrodynamic processes in material media.

In a parallel resonance circuit including a capacitor $C$and an inductance coil L, the applied voltage U and the total current I_Σ through the circuit are related as

$$I_\Sigma = I_C + I_L = C\frac{dU}{dt} + \frac{1}{L}\int U\,dt\,, \tag{4.1}$$

where $I_C = C\frac{dU}{dt}$ is the current through the capacitor, $I_L = \frac{1}{L}\int U\,dt$ is the current through the inductance coil. For the harmonic voltage

$$U = U_0\sin\omega t$$

$$I_\Sigma = \left(\omega C - \frac{1}{\omega L}\right)U_0\cos\ \omega t\,. \tag{4.2}$$

The term in brackets is the total susceptance σ_X of the circuit, which consists of the capacitive σ_C and inductive σ_L components

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$$\sigma_x = \sigma_c + \sigma_L = \omega\, C - \frac{1}{\omega\, L} \, . \tag{4.3}$$

Eq. (4.2) can be re-written as

$$I_\Sigma = \omega\, C \left(1 - \frac{\omega_0^2}{\omega^2} \right) U_0 \cos\ \omega t \, , \tag{4.4}$$

where $\omega_0^2 = \dfrac{1}{LC}$ is the resonance frequency of a parallel circuit.

From the mathematical (i.e. other than physical) standpoint, we may assume a circuit that has only a capacitor and no inductance coil. Its frequency – dependent capacitance is

$$C^*(\omega) = C \left(1 - \frac{\omega_0^2}{\omega} \right) \, . \tag{4.5}$$

Another approach is possible, which is correct too. Eq. (4.2) can be re-written as

$$I_\Sigma = -\frac{\left(\dfrac{\omega^2}{\omega_0^2} - 1 \right)}{\omega\, L} U_0 \cos\ \omega\, t \, . \tag{4.6}$$

In this case the circuit is assumed to include only an inductance coil and no capacitor. Its frequency – dependent inductance is

$$L^*(\omega) = \frac{L}{\left(\dfrac{\omega^2}{\omega_0^2} - 1 \right)} \tag{4.7}$$

Using the notion of Eqs. (4.5) and (4.7), we can write

$$I_\Sigma = \omega\, C^*(\omega) U_0 \cos\ \omega\, t \, , \tag{4.8}$$

or

$$I_\Sigma = -\frac{1}{\omega\, L^*(\omega)} U_0 \cos\ \omega\, t \, . \tag{4.9}$$

Eqs (4.8) and (4.9) are equivalent and each of them provides a complete mathematical description of the circuit. From the physical point of view, $C^*(\omega)$ and $L^*(\omega)$ do not represent capacitance and inductance though they have the corresponding dimensions. Their physical sense is as follows:

$$C^*(\omega) = \frac{\sigma_X}{\omega} \, , \tag{4.10}$$

i.e. $C^*(\omega)$ is the total susceptance of this circuit divided by frequency:

$$L^*(\omega) = \frac{1}{\omega\, \sigma_X} \, , \tag{4.11}$$

and $L^*(\omega)$ is the inverse value of the product of the total susceptance and the frequency.

Amount $C^*(\omega)$ is constricted mathematically so that it includes C and L simultaneously. The same is true for $L^*(\omega)$.

We shall not consider here any other cases, e.g., series or more complex circuits. It is however important to note that applying the above method, any circuit consisting of the reactive components C and L can be described either through frequency – dependent inductance or frequency – dependent capacitance.

But this is only a mathematical description of real circuits with constant – value reactive elements.

It is well known that the energy stored in the capacitor and inductance coil can be found as

$$W_C = \frac{1}{2} C\, U^2 \, , \tag{4.12}$$

$$W_L = \frac{1}{2} L\, I^2 \tag{4.13}$$

But what can be done if we have $C^*(\omega)$ and $L^*(\omega)$? There is no way of substituting them into Eqs. (4.12) and (4.13) because they can be both positive and negative. It can be shown readily that the energy stored in the circuit analyzed is

$$W_\Sigma = \frac{1}{2} \cdot \frac{d\, \sigma_X}{d\, \omega} U^2 \, , \tag{4.14}$$

or

$$W_\Sigma = \frac{1}{2} \cdot \frac{d\left[\omega\, C^*(\omega) \right]}{d\, \omega} U^2 , \tag{4.15}$$

or

$$W_\Sigma = \frac{1}{2} \cdot \frac{d\left(\dfrac{1}{\omega\, L^*(\omega)} \right)}{d\, \omega} U^2 \tag{4.16}$$

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Having written Eqs. (4.14), (4.15) or (4.16) in greater detail, we arrive at the same result:

$$W_\Sigma = \frac{1}{2} C U^2 + \frac{1}{2} L I^2, \tag{4.17}$$

where U is the voltage at the capacitor and I is the current through the inductance coil. Below we consider the physical meaning jog the magnitudes $\varepsilon(\omega)$ and $\mu(\omega)$ for material media.

VI. Plasma Media

A superconductor is a perfect plasma medium in which charge carriers (electrons) can move without friction. In this case the equation of motion is

$$m \frac{d \vec{V}}{d t} = e \vec{E} \quad , \tag{5.18}$$

where m m and e are the electron mass and charge, respectively; $\vec{E}$ is the electric field strength, $\vec{V}$ is the velocity. Taking into account the current density

$$\vec{j} = n e \vec{V} \tag{5.19}$$

we can obtain from Eq. (5.18)

$$\vec{j}_L = \frac{n e^2}{m} \int \vec{E} \, d t \, . \tag{5.20}$$

In Eqs. (5.19) and (5.20) n is the specific charge density. Introducing the notion

$$L_k = \frac{m}{n e^2} \quad , \tag{5.21}$$

we can write

$$\vec{j}_L = \frac{1}{L_k} \int \vec{E} \, d t \, \cdot \tag{5.22}$$

Here L_k is the kinetic inductivity of the medium [16,17]. Its existence is based on the fact that a charge carrier has a mass and hence it possesses inertia properties.

For harmonic fields we have $\vec{E} = \vec{E}_0 \sin \omega t$ and Eq. (5.22) becomes

$$\vec{j}_L = -\frac{1}{\omega L_k} E_0 \cos \omega t \, \cdot \tag{5.23}$$

Eqs. (5.22) and (5.23) show that $\vec{j}_L$ is the current through the inductance coil.

In this case the Maxwell equations take the following form

$$rot \, \vec{E} = -\mu_0 \frac{\partial \vec{H}}{\partial t},$$
$$rot \, \vec{H} = \vec{j}_C + \vec{j}_L = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k} \int \vec{E} \, d t, \tag{5.24}$$

where ε_0 and μ_0 are the electric and magnetic inductivities in vacuum, $\vec{j}_C$ and $\vec{j}_L$ are the displacement and conduction currents, respectively. As was shown above, $\vec{j}_L$ is the inductive current.
Eq. (5.24) gives

$$rot \, rot \, \vec{H} + \mu_0 \varepsilon_0 \frac{\partial^2 \vec{H}}{\partial t^2} + \frac{\mu_0}{L_k} \vec{H} = 0 . \tag{5.25}$$

For time-independent fields, Eq. (5.25) transforms into the London equation

$$rot \, rot \, \vec{H} + \frac{\mu_0}{L_k} \vec{H} = 0 \, , \tag{5.26}$$

where $\lambda_L^2 = \frac{L_k}{\mu_0}$ is the London depth of penetration.

As Eq. (5.24) shows, the inductivities of plasma (both electric and magnetic) are frequency – independent and equal to the corresponding parameters for vacuum. Besides, such plasma has another fundamental material characteristic – kinetic inductivity.

Eqs. (5.24) hold for both constant and variable fields. For harmonic fields $\vec{E} = \vec{E}_0 \sin \omega t$, Eq.(5.24) gives

$$rot \, \vec{H} = \left(\varepsilon_0 \omega - \frac{1}{L_k \omega} \right) \vec{E}_0 \cos \omega t \, . \tag{5.27}$$

Taking the bracketed value as the specific susceptance σ_X of plasma, we can write

$$rot \, \vec{H} = \sigma_X \vec{E}_0 \cos \omega t \, , \tag{5.28}$$

where

$$\sigma_X = \varepsilon_0 \omega - \frac{1}{\omega L_k} = \varepsilon_0 \omega \left(1 - \frac{\omega_\rho^2}{\omega^2} \right) = \omega \varepsilon^*(\omega) , \tag{5.29}$$

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and $\varepsilon^*(\omega)=\varepsilon_0\left(1-\frac{\omega_0^2}{\omega^2}\right)$, where $\omega_0^2=\frac{1}{\varepsilon_0 L_k}$ is the plasma frequency.

Now Eq. (5.28) can be re-written as

$$rot\ \vec{H}=\omega\ \varepsilon_0\left(1-\frac{\omega_0^2}{\omega^2}\right)\vec{E}_0\cos\ \omega\ t, \qquad (5.30)$$

or

$$rot\ \vec{H}=\omega\ \varepsilon^*(\omega)\vec{E}_0\cos\ \omega\ t. \qquad (5.31)$$

The $\varepsilon^*(\omega)$ –parameter is conventionally called the frequency-dependent electric inductivity of plasma. In reality however this magnitude includes simultaneously the electric inductivity of vacuum aid the kinetic inductivity of plasma. It can be found as

$$\varepsilon^*(\omega)=\frac{\sigma_X}{\omega}. \qquad (5.32)$$

It is evident that there is another way of writing σ_X

$$\sigma_X=\varepsilon_0\omega-\frac{1}{\omega\ L_k}=\frac{1}{\omega\ L_k}\left(\frac{\omega^2}{\omega_\rho^2}-1\right)=\frac{1}{\omega\ L_k^*}, \qquad (5.33)$$

where

$$L_k^*(\omega)=\frac{L_k}{\left(\frac{\omega^2}{\omega_\rho^2}-1\right)}=\frac{1}{\sigma_X\omega}. \qquad (5.34)$$

$L_k^*(\omega)$ written this way includes both ε_0 and L_k.

Eqs. (5.29) and (5.33) are equivalent, and it is safe to say that plasma is characterized by the frequency-dependent kinetic inductance $L_k^*(\omega)$ rather than by the frequency-dependent electric inductivity $\varepsilon^*(\omega)$.

Eq. (5.27) can be re-written using the parameters $\varepsilon^*(\omega)$ and $L_k^*(\omega)$

$$rot\ \vec{H}=\omega\ \varepsilon^*(\omega)\vec{E}_0\cos\ \omega\ t, \qquad (5.35)$$

or

$$rot\ \vec{H}=\frac{1}{\omega\ L_k^*(\omega)}\vec{E}_0\cos\ \omega\ t \qquad (5.36)$$

Eqs. (5.35) and (5.36) are equivalent.

Thus, the parameter $\varepsilon^*(\omega)$ is not an electric inductivity though it has its dimensions. The same can be said about $L_k^*(\omega)$.

We can see readily that

$$\varepsilon^*(\omega)=\frac{\sigma_X}{\omega}, \qquad (5.37)$$

$$L_k^*(\omega)=\frac{1}{\sigma_X\omega}. \qquad (5.38)$$

These relations describe the physical meaning of $\varepsilon^*(\omega)$ and $L_k^*(\omega)$.

Of course, the parameters $\varepsilon^*(\omega)$ and $L_k^*(\omega)$ are hardly usable for calculating energy by the following equations

$$W_E=\frac{1}{2}\varepsilon\ E_0^2 \qquad (5.39)$$

and

$$W_j=\frac{1}{2}L_k\ j_0^2. \qquad (5.40)$$

For this purpose the Eq. (5.15)-type fotmula was devised in [18]:

$$W=\frac{1}{2}\cdot\frac{d\left[\omega\ \varepsilon^*(\omega)\right]}{d\ \omega}E_0^2. \qquad (5.41)$$

Using Eq. (5.41), we can obtain

$$W_\Sigma=\frac{1}{2}\varepsilon_0E_0^2+\frac{1}{2}\cdot\frac{1}{\omega^2L_k}E_0^2=\frac{1}{2}\varepsilon_0E_0^2+\frac{1}{2}L_k\ j_0^2. \qquad (5.42)$$

The same result is obtainable from

$$W=\frac{1}{2}\cdot\frac{d\left[\frac{1}{\omega\ L_k^*(\omega)}\right]}{d\ \omega}E_0^2. \qquad (5.43)$$

As in the case of a parallel circuit, either of the parameters $\varepsilon^*(\omega)$ and $L_k^*(\omega)$), similarly to $C^*(\omega)$ and $L^*(\omega)$, characterize completely the electrodynamic properties of plasma. The case corresponds to the the resonance of current.

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$$\varepsilon^*(\omega)=0$$

$$L^*_k(\omega)=\infty \qquad (5.44)$$

It is shown below that under certain conditions this resonance can be transverse with respect to the direction of electromagnetic waves.

It is known that the Langmuir resonance is longitudinal. No other resonances have ever been detected in nonmagnetized plasma. Nevertheless, transverse resonance is also possible in such plasma, and its frequency coincides with that of the Langmuir resonance. To understand the origin of the transverse resonance, let us consider a long line consisting of two perfectly conducting planes (see Fig. 5). First, we examine this line in vacuum.

If a d.c. voltage (U) source is connected to an open line the energy stored in its electric field is

$$W_{E\Sigma}=\frac{1}{2}\varepsilon_0 E^2 a\ b\ z=\frac{1}{2}C_{E\Sigma}U^2 \qquad (5.45)$$

where $E=\frac{U}{a}$ is the electric field strength in the line, and

$$C_{E\Sigma}=\varepsilon_0\frac{b\ z}{a} \qquad (5.46)$$

is the total line capacitance. $C_E=\varepsilon_0\frac{b}{a}$ is the linear capacitance and ε_0 is electric inductivities of the medium (plasma) in SI units (F/m).

The specific potential energy of the electric field is

$$W_E=\frac{1}{2}\varepsilon_0\ E^2\ . \qquad (5.47)$$

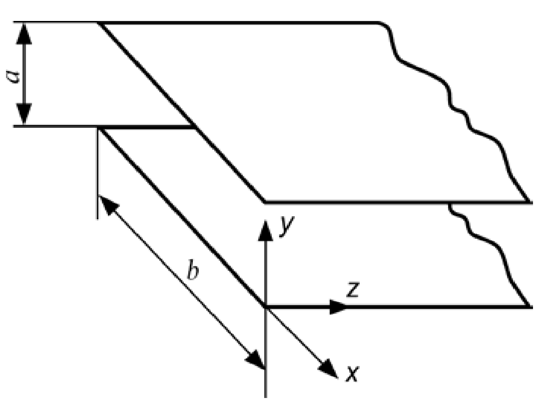

Fig. 5: Two-conductor line consisting of two perfectly conducting planes

If the line is short-circuited at the distance z from its start and connected to a d.c. current (I) source, the energy stored in the magnetic field of the line is

$$W_{H\Sigma}=\frac{1}{2}\mu_0\ H^2 a\ b\ z=\frac{1}{2}L_{H\Sigma}\ I^2\ . \qquad (5.48)$$

Since $H=\frac{I}{b}$, we can write

$$L_{H\Sigma}=\mu_0\frac{a\ z}{b}, \qquad (5.49)$$

where $L_{H\Sigma}$ is the total inductance of the line $L_H=\mu_0\frac{a}{b}$ is linear inductance and μ_0 is the inductivity of the medium (vacuum) in SI (H/m).

The specific energy of the magnetic field is

$$W_H=\frac{1}{2}\mu_0\ H^2\ . \qquad (5.50)$$

To make the results obtained more illustrative, henceforward, the method of equivalent circuits will be used along with mathematical description. It is seen that $C_{E\Sigma}$ and $L_{H\Sigma}$ increase with growing z. The line segment dz can therefore be regarded as an equivalent circuit (Fig. 6a).

If plasma in which charge carriers can move free of friction is placed within the open line and then the current I, is passed through it, the charge carriers moving at a certain velocity start storing kinetic energy. Since the current density is

$$j=\frac{I}{b\ z}=n\ e\ V \qquad (5.51)$$

the total kinetic energy of all moving charges is

$$W_{k\Sigma}=\frac{1}{2}\cdot\frac{m}{n\ e^2}a\ b\ z\ j^2=\frac{1}{2}\cdot\frac{m}{n\ e^2}\frac{a}{b\ z}I^2\ . \qquad (5.52)$$

On the other hand,

$$W_{k\Sigma}=\frac{1}{2}L_{k\Sigma}I^2\ , \qquad (5.53)$$

where $L_{k\Sigma}$ is the total kinetic inductance of the line. Hence,

$$L_{k\Sigma} = \frac{m}{n\,e^2} \cdot \frac{a}{b\,z}\,. \qquad (5.54)$$

Thus, the magnitude

$$L_k = \frac{m}{n\,e^2} \qquad (5.55)$$

corresponding kinetic inductivity of the medium.

Earlier, we introduced this magnitude by another way (see Eq. (4.21)).

Eq. (5.55) corresponds to case of uniformly distributed d.c. current.

As we can see from Eq. (5.54), $L_{H\Sigma}$ unlike $C_{E\Sigma}$ and $L_{k\Sigma}$, decreases when z grows. This is clear physically because the number of parallel-connected inductive elements increases with growing z. The equivalent circuit of the line with nondissipative plasma is shown in Fig. 6б. The line itself is equivalent to a parallel lumped circuit:

$$C = \frac{\varepsilon_0 b\,z}{a} \text{ and } L = \frac{L_k\,a}{b\,z}\,. \qquad (5.56)$$

It is however obvious from calculation that the resonance frequency is absolutely independent of whatever dimension. Indeed,

$$\omega_\rho^2 = \frac{1}{C\,L} = \frac{1}{\varepsilon_0 L_k} = \frac{n\,e^2}{\varepsilon_0 m}\,. \qquad (5.57)$$

This brings us to a very interesting result: the resonance frequency of the macroscopic resonator is independent of its size. It may seem that we are dealing here with the Langmuir resonance because the obtained frequency corresponds exactly to that of the Langmuir resonance.

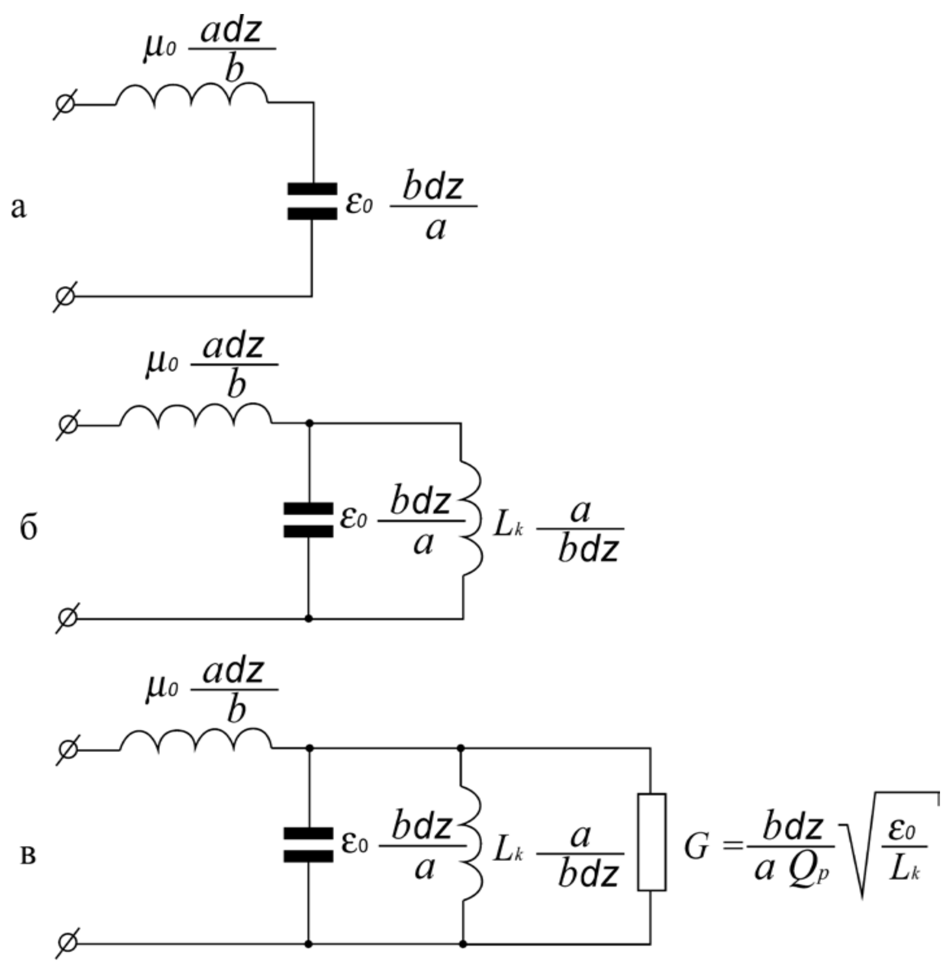

Fig. 6: a. Equivalent circuit of the two-conductor line segment;
б. Equivalent circuit of the two-conductor line segment containing nondissipative plasma;
в. Equivalent circuit of the two-conductor line segment containing dissipative plasma.

Global Journal of Science Frontier Research (A) Volume XIX Issue V Version I Year 2019
34

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We however know that the Langmuir resonance characterizes longitudinal waves. The wave propagating in the phase velocity in the Z-direction is equal to infinity and the wave vector is $\vec{k}_z = 0$, which corresponds to the solution of Eqs. (5.24) for a line of pre-assigned configuration (Fig. 5).Eqs. (5.25) give a well-known result. The wave number is

$$k_z^2 = \frac{\omega^2}{c^2}\left(1 - \frac{\omega_0^2}{\omega^2}\right). \qquad (5.58)$$

The group and phase velocities are

$$V_g^2 = c^2\left(1 - \frac{\omega_0^2}{\omega^2}\right), \qquad (5.59)$$

$$V_F^2 = \frac{c^2}{\left(1 - \frac{\omega_0^2}{\omega^2}\right)}, \qquad (5.60)$$

where $c = \left(\frac{1}{\mu_0\,\varepsilon_0}\right)^{1/2}$ is the velocity of light in vacuum.

For the plasma under consideration, the phase velocity of the electromagnetic wave is equal to infinity. Hence, the distribution of the fields and currents over the line is uniform at each instant of time and independent of the Z-coordinate. This implies that, on the one hand, the inductance $L_{H\Sigma}$ has no effect on the electrodynamic processes in the line and, on the other hand, any two planes can be used instead of conducting planes to confine plasma above and below.

Eqs. (5.58), (5.59) and (5.60) indicate that we have transverse resonance with an infinite Q-factor. The fact of transverse resonance, i.e. different from the Langmuir resonance, is most obvious when the Q-factor is not equal to infinity. Then $k_z \neq 0$ and the transverse wave is propagating in the line along the direction perpendicular to the movement of charge carriers. True, we started our analysis with plasma confined within two planes of a long line, but we have thus found that the presence of such resonance is entirely independent of the line size, i.e. this resonance can exist in an infinite medium. Moreover, in infinite plasma transverse resonance can coexist with the Langmuir resonance characterizing longitudinal waves. Since the frequencies of these resonances coincide, both of them are degenerate. Earlier, the possibility of transverse resonance was not considered. To approach the problem more comprehensively, let us analyze the energy processes in loss-free plasma.

The characteristic resistance of plasma determining the relation between the transverse components of electric and magnetic fields can be found from

$$Z = \frac{E_y}{H_x} = \frac{\mu_0\,\omega}{k_z} = Z_0\left(1 - \frac{\omega_\rho^2}{\omega^2}\right)^{-1/2}, \qquad (5.61)$$

where $Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}}$ is the characteristic resistance in vacuum.

The obtained value of Z is typical for transverse electromagnetic waves in waveguides. When $\omega \to \omega_0$, $Z \to \infty$, and $H_x \to 0$. At $\omega > \omega_0$, both the electric and magnetic field components are present in plasma. The specific energy of the fields is

$$W_{E,H} = \frac{1}{2}\varepsilon_0\,E_{0y}^2 + \frac{1}{2}\mu_0\,H_{0x}^2. \qquad (5.62)$$

Thus, the energy accumulated in the magnetic field is $\left(1 - \frac{\omega_\rho^2}{\omega^2}\right)$ times lower than that in the electric field. This traditional electrodynamic analysis is however not complete because it disregards one more energy component – the kinetic energy of charge carriers. It turns out that in addition to the electric and magnetic waves carrying electric and magnetic energy, there is one more wave in plasma – the kinetic wave carrying the kinetic energy of charge carriers. The specific energy of this wave is

$$W_k = \frac{1}{2}L_k\,j_0^2 = \frac{1}{2}\cdot\frac{1}{\omega^2\,L_k}E_0^2 = \frac{1}{2}\varepsilon_0\,\frac{\omega_\rho^2}{\omega^2}E_0^2. \qquad (5.63)$$

The total specific energy thus amounts to

$$W_{E,H,j} = \frac{1}{2}\varepsilon_0\,E_{0y}^2 + \frac{1}{2}\mu_0\,H_{0x}^2 + \frac{1}{2}L_k\,j_0^2. \qquad (5.64)$$

Hence, to find the total specific energy accumulated in unit volume of plasma, it is not sufficient to allow only for the fields E and H.

At the point $\omega = \omega_0$

$$W_H = 0 \qquad (5.65)$$

$$W_E = W_k,$$

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i.e. there is no magnetic field in the plasma, and the plasma is a macroscopic electromechanical cavity resonator of frequency ω_0.

At $\omega > \omega_0$ the wave propagating in plasma carries three types of energy – magnetic, electric and kinetic. Such wave can therefore be-called magnetoelectrokinetic. The kinetic wave is a current-density wave $\vec{j} = \frac{1}{L_k}\int \vec{E}\, d\, t$. It is shifted by $\frac{\pi}{2}$ with respect to the electric wave.

Up to now we have considered a physically unfeasible case with no losses in plasma, which corresponds to infinite Q-factor of the plasma resonator. If losses occur, no matter what physical processes caused them, the Q-factor of the plasma resonator is a final quantity. For this case the Maxwell equations become

$$rot\ \vec{E} = -\mu_0 \frac{\partial\, \vec{H}}{\partial\, t},$$

$$rot\ \vec{H} = \sigma_{p.ef}\, \vec{E} + \varepsilon_0 \frac{\partial\, \vec{E}}{\partial\, t} + \frac{1}{L_k}\int \vec{E}\, d\, t \qquad (5.66)$$

The term $\sigma_{p.ef}\, \vec{E}$ allows for the loss, and the index *ef* near the active conductivity emphasizes that we are interested in the fact of loss and do not care of its mechanism. Nevertheless, even though we do not try to analyze the physical mechanism of loss, we should be able at least to measure $\sigma_{p.ef}$.

For this purpose, we choose a line segment of the length z_0 which is much shorter than the wavelength in dissipative plasma. This segment is equivalent to a circuit with the following lumped parameters

$$C = \varepsilon_0 \frac{b\, z_0}{a}, \qquad (5.67)$$

$$L = L_k \frac{d}{b\, z_0}, \qquad (5.68)$$

$$G = \sigma_{\rho.ef} \frac{b\, z_0}{a}, \qquad (5.69)$$

where G is the conductance parallel to C and L.

The conductance G and the Q-factor of this circuit are related as

$$G = \frac{1}{Q}\sqrt{\frac{C}{L}}\ . \qquad (5.70)$$

Taking into account Eqs. (5.67) – (5.69), we obtain from Eq. (2.70)

$$\sigma_{\rho.ef} = \frac{1}{Q_p}\sqrt{\frac{\varepsilon_0}{L_k}}\ . \qquad (5.71)$$

Thus, $\sigma_{p.ef}$ can be found by measuring the basic Q_p factor of the plasma resonator.

Using Eqs. (5.71) and (5.66), we obtain

$$rot\ \vec{E} = -\mu_0 \frac{\partial\, \vec{H}}{\partial\, t}\ , \qquad (5.72)$$

$$rot\ \vec{H} = \frac{1}{Q_p}\sqrt{\frac{\varepsilon_0}{L_k}}\vec{E} + \varepsilon_0 \frac{\partial\, \vec{E}}{\partial\, t} + \frac{1}{L_k}\int \vec{E}\, d\, t\ .$$

The equivalent circuit of this line containing dissipative plasma is shown in Fig. 6в.

Let us consider the solution of Eqs. (5.72) at the point $\omega = \omega_p$. Since

$$\varepsilon_0 \frac{\partial\, \vec{E}}{\partial\, t} + \frac{1}{L_k}\int \vec{E}\, d\, t = 0. \qquad (5.73)$$

We obtain

$$rot\ \vec{E} = -\mu_0 \frac{\partial\, \vec{H}}{\partial\, t}\ , \qquad (5.74)$$

$$rot\ \vec{H} = \frac{1}{Q_P}\sqrt{\frac{\varepsilon_0}{L_k}}\vec{E}.$$

The solution of these equations is well known. If there is interface between vacuum and the medium described by Eqs. (5.74), the surface impedance of the medium is

$$Z = \frac{E_{tg}}{H_{tg}} = (1+i)\sqrt{\frac{\omega_p \mu_0}{2\sigma_{p.ef.}}}\ , \qquad (5.75)$$

where $\sigma_{p.ef} = \frac{1}{Q_p}\sqrt{\frac{\varepsilon_0}{L_k}}$ here is of course some uncertainty in this approach because the surface impedance is dependent on the type of the field-current

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relation (local or non-local). Although the approach is simplified, the qualitative results are quite adequate. True, a more rigorous solution is possible.

The wave propagating deep inside the medium decreases by the law $e^{-\frac{z}{\delta_{ef}}} \cdot e^{-i\frac{z}{\delta_{ef}}}$.

In this case the phase velocity is

$$V_F = \omega\, \sigma_{p.ef}\,, \tag{5.76}$$

where $\delta^2_{p.ef} = \dfrac{2}{\mu_0 \omega_p \sigma_{p.ef}}$ is the effective depth of field penetration in the plasma. The above relations characterize the wave process in plasma. For good conductors we usually have $\dfrac{\sigma_{ef}}{\omega\, \varepsilon_0} >> 1$. In such a medium the wavelength is

$$\lambda_g = 2\pi\delta\,. \tag{5.77}$$

I.e. much shorter than the free-space wavelength. Further on we concentrate on the case $\lambda_g >> \lambda_0$ at the point $\omega = \omega_p$, i.e. $V_F\,|_{\omega=\omega p} >> c$.

We have found that $\varepsilon(\omega)$ is not dielectric inductivity permittivity. Instead, it includes two frequency-independent parameters ε_0 and L_k. What is the reason for the physical misunderstanding of the parameter $\varepsilon(\omega)$? This occurs first of all because for the case of plasma the $\dfrac{1}{L_k}\int \vec{E}\, d\, t$ - type term is not explicitly present in the second Maxwell equation.

There is however another reason for this serious mistake in the present-day physics [7] as an example. This study states that there is no difference between dielectrics and conductors at very high frequencies. On this basis the authors suggest the existence of a polarization vector in conducting media and this vector is introduced from the relation

$$\vec{P} = \Sigma\; e\, \vec{r}_m = n\; e\; \vec{r}_m\,, \tag{5.78}$$

where *n* is the charge carrier density, $\vec{r}_m$ is the current charge displacement. This approach is physically erroneous because only bound charges can polarize and form electric dipoles when the external field overcoming the attraction force of the bound charges accumulates extra electrostatic energy in the dipoles. In conductors the charges are not bound and their displacement would not produce any extra electrostatic energy. This is especially obvious if we employ the induction technique to induce current (i.e. to displace charges) in a ring conductor. In this case there is no restoring force to act upon the charges, hence, no electric polarization is possible. In [18] the polarization vector found from Eq. (5.78) is introduced into the electric induction of conducting media

$$\vec{D} = \varepsilon_0\; \vec{E} + \vec{P}, \tag{5.79}$$

where the vector $\vec{P}$ of a metal is obtained from Eq. (5.78), which is wrong.

Since

$$\vec{r}_m = -\frac{e^2}{m\; \omega^2}\vec{E}\,, \tag{5.80}$$

for free carriers, then

$$\vec{P}*(\omega) = -\frac{n\; e^2}{m\; \omega^2}\vec{E}\,, \tag{5.81}$$

for plasma, and

$$\vec{D}*(\omega) = \varepsilon_0\; \vec{E} + \vec{P}*(\omega) = \varepsilon_0\left(1 - \frac{\omega_p^2}{\omega^2}\right)\vec{E}\,. \tag{5.82}$$

Thus, the total accumulated energy is

$$W_\Sigma = \frac{1}{2}\varepsilon_0\; E^2 + \frac{1}{2}\cdot\frac{1}{L_k\; \omega^2}E^2\,. \tag{5.83}$$

However, the second term in the right-hand side of Eq. (5.83) is the kinetic energy (in contrast to dielectrics for which this term is the potential energy). Hence, the electric induction vector $\vec{D}^*(\omega)$ does not correspond to the physical definition of the electric induction vector.

The physical meaning of the introduced vector $\vec{P}*(\omega)$ is clear from

$$\vec{P}*(\omega) = \frac{\sigma_L}{\omega}\vec{E} = \frac{1}{L_k\; \omega^2}\vec{E}\,. \tag{5.84}$$

The interpretation of $\varepsilon(\omega)$ as frequency-dependent inductivity has been harmful for correct understanding of the real physical picture (especially in the educational processes). Besides, it has drawn away the researchers attention from some physical phenomena in plasma, which first of all include the transverse plasma resonance and three energy components of the magnetoelectrokinetic wave propagating in plasma.

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Below, the practical aspects of the results obtained are analyzed, which promise new data and refinement of the current views.

Plasma can be used first of all to construct a macroscopic single-frequency cavity for development of a new class of electrokinetic plasma lasers. Such cavity can also operate as a band-pass filter.

At high enough Q_p the magnetic field energy near the transverse resonance is considerably lower than the kinetic energy of the current carriers and the electrostatic field energy. Besides, under certain conditions the phase velocity can much exceed the velocity of light. Therefore, if we want to excite the transverse plasma resonance, we can put

$$rot\ \vec{E} \cong 0,$$

$$\frac{1}{Q_p}\sqrt{\frac{\varepsilon_0}{L_k}}\vec{E} + \varepsilon_0\frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k}\int \vec{E}\ d\ t = \vec{j}_{CT}, \qquad (5.85)$$

where $\vec{j}_{CT}$ is the extrinsic current density.

Integrating Eq. (5.84) over time and dividing it by ε_0 obtain

$$\omega_p^2\ \vec{E} + \frac{\omega_p}{Q_p}\cdot\frac{\partial \vec{E}}{\partial t} + \frac{\partial^2 \vec{E}}{\partial t^2} = \frac{1}{\varepsilon_0}\cdot\frac{\partial\ \vec{j}_{CT}}{\partial t}. \qquad (5.86)$$

Integrating Eq. (5.86) over the surface normal to the vector $\vec{E}$ and taking $\Phi_E = \int \vec{E}\ d\ \vec{S}$, we have

$$\omega_p^2\ \Phi_E + \frac{\omega_p}{Q_p}\cdot\frac{\partial\ \Phi_E}{\partial t} + \frac{\partial^2 \Phi_E}{\partial t^2} = \frac{1}{\varepsilon_0}\cdot\frac{\partial\ I_{CT}}{\partial t}, \qquad (5.87)$$

where I_{CT} is the extrinsic current.

Eq. (5.87) is the harmonic oscillator equation whose right-hand side is typical of two-level lasers [19]. If there is no excitation source, we have a "cold". Laser cavity in which the oscillation damping follows the exponential law

$$\Phi_E(t) = \Phi_E(0)e^{i\omega_P t}\cdot e^{-\frac{\omega_P}{2Q_P}t}, \qquad (5.88)$$

i.e. the macroscopic electric flow $\Phi_E(t)$ oscillates at the frequency ω_p. The relaxation time can be round as

$$\tau = \frac{2Q_P}{\omega_P}. \qquad (5.89)$$

If this cavity is excited by extrinsic currents, the cavity will operate as a band-pass filter with the pass band $\Delta\omega = \frac{\omega_p}{2Q_p}$.

Transverse plasma resonance offers another important application – it can be used to heat plasma. High-level electric fields and, hence, high change-carrier energies can be obtained in the plasma resonator if its Q-factor is high, which is achievable at low concentrations of plasma. Such cavity has the advantage that the charges attain the highest velocities far from cold planes. Using such charges for nuclear fusion, we can keep the process far from the cold elements of the resonator.

Such plasma resonator can be matched easily to the communication line. Indeed, the equivalent resistance of the resonator at the point $\omega = \omega_p$ is

$$R_{экв} = \frac{1}{G} = \frac{a\ Q_P}{b\ z}\sqrt{\frac{L_k}{\varepsilon_0}}. \qquad (5.90)$$

The communication lines of sizes a_L and b_L should be connected to the cavity either through a smooth junction or in a stepwise manner. If $b = b_L$, the matching requirement is

$$\frac{a_L}{b_L}\sqrt{\frac{\mu_0}{\varepsilon_0}} = \frac{a\ Q_p}{b\ z_0}\sqrt{\frac{L_k}{\varepsilon_0}}, \qquad (5.91)$$

$$\frac{a\ Q_p}{a_L z_0}\sqrt{\frac{L_k}{\mu_0}} = 1. \qquad (5.92)$$

It should be remembered that the choice of the resonator length z_0 must comply with the requirement $z_0 << \lambda_g |_{\omega=\omega p}$.

Development of devices based on plasma resonator can require coordination of the resonator and free space. In this case the following condition is important:

$$\sqrt{\frac{\mu_0}{\varepsilon_0}} = \frac{a\ Q_p}{b\ z_0}\sqrt{\frac{L_k}{\varepsilon_0}}, \qquad (5.93)$$

or

$$\frac{a\ Q_p}{b\ z_0}\sqrt{\frac{L_k}{\mu_0}} = 1. \qquad (5.94)$$

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Such plasma resonators can be excited with d.c. current, as is the case with a monotron microwave oscillator [20]. It is known that a microwave diode (the plasma resonator in our case) with the transit angle of $\sim\frac{5}{2}\pi$ develops negative resistance and tends to self-excitation. The requirement of the transit angle equal to $\sim\frac{5}{2}\pi$ correlates with the following d.c. voltage applied to the resonator:

$$U_0 = \frac{0{,}32a^2\ \omega_p^2\ m\ c^2}{4\pi^2\ e} = \frac{0{,}32a^2\ n\ e}{4\pi^2\ \varepsilon_0^2\ \mu_0}, \quad (5.95)$$

where a is the distance between the plates in the line.

It is quite probable that this effect is responsible for the electromagnetic oscillations in semiconductive lasers.

VII. Dielectric Media

Applied fields cause polarization of bound charges in dielectrics. The polarization takes some energy from the field source, and the dielectric accumulates extra electrostatic energy. The extent of displacement of the polarized charges from the equilibrium is dependent on the electric field and the coefficient of elasticity β, characterizing the elasticity of the charge bonds. These parameters are related as

$$-\omega^2\ \vec{r}_m + \frac{\beta}{m}\vec{r}_m = \frac{e}{m}\vec{E}, \quad (6.1)$$

where $\vec{r}_m$ is the charge displacement from the equilibrium.

Putting ω_0 for the resonance frequency of the bound charges and taking into account that $\omega_0 = \frac{\beta}{m}$ we obtain from Eq. (6.1)

$$\vec{r}_m = -\frac{e\vec{E}}{m\ (\omega^2\ - \omega_o^2)} \quad (6.2)$$

The polarization vector becomes

$$\vec{P}_m * = -\frac{n\ e^2}{m}\cdot\frac{1}{(\omega^2 - \omega_0^2)}\vec{E} \quad (6.3)$$

Since

$$\vec{P} = \varepsilon_0\ (\varepsilon - 1)\ \vec{E}, \quad (6.4)$$

we obtain

$$\varepsilon'_\partial\ *(\omega) = 1 - \frac{n\ e^2}{\varepsilon_0\ m}\cdot\frac{1}{\omega^2 - \omega_0^2}. \quad (6.5)$$

The quantity $\varepsilon'_\partial\ *(\omega)$ is commonly called the relative frequency dependably electric inductivity. Its absolute value can be found as

$$\varepsilon_\partial *(\omega) = \varepsilon_0\left(1 - \frac{n\ e^2}{\varepsilon_0 m}\cdot\frac{1}{\omega^2 - \omega_0^2}\right). \quad (6.6)$$

Once again, we arrive at the frequency-dependent dielectric permitlivity. Let us take a closer look at the quantity $\varepsilon_\partial *(\omega)$. As before, we introduce $L_{k\ \partial} = \frac{m}{n\ e^2}$ and $\omega_{p.\partial} = \frac{1}{L_{k\ \partial}\varepsilon_0}$ and see immediately that the vibrating charges of the dielectric have masses and thus possess inertia properties. As a result, their kinetic inductivity would make itself evident too. Eq. (6.6) can be re-written as

$$\varepsilon_\partial *(\omega) = \varepsilon_0(1 - \frac{\omega_{p\ \partial}^2}{\omega^2 - \omega_0^2}). \quad (6.7)$$

It is appropriate to examine two limiting cases: $\omega >> \omega_0$ and $\omega << \omega_0$.

If $\omega >> \omega_0$,

$$\varepsilon_\partial *(\omega) = \varepsilon_0(1 - \frac{\omega_{p\ \partial}^2}{\omega^2}), \quad (6.8)$$

and the dielectric behaves just like plasma. This case has prompted the idea that at high frequencies there is no difference between dielectrics and plasma. The idea served as a basis for introducing the polarization vector in conductors [18]. The difference however exists and it is of fundamental importance. In dielectrics, because of inertia, the amplitude of charge vibrations is very small at high frequencies and so is the polarization vector. The polarization vector is always zero in conductors.

For $\omega << \omega_0$,

$$\varepsilon_\partial *(\omega) = \varepsilon_0(1 + \frac{\omega_{p\ \partial}^2}{\omega_0^2}), \quad (6.9)$$

and the permittivity of the dielectric is independent of frequency. It is $(1 + \frac{\omega_{p\ \partial}^2}{\omega_0^2})$ times higher than in vacuum.

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This result is quite clear. At $\omega >> \omega_0$ the inertia properties are inactive and permittivity approaches its value in the static field.

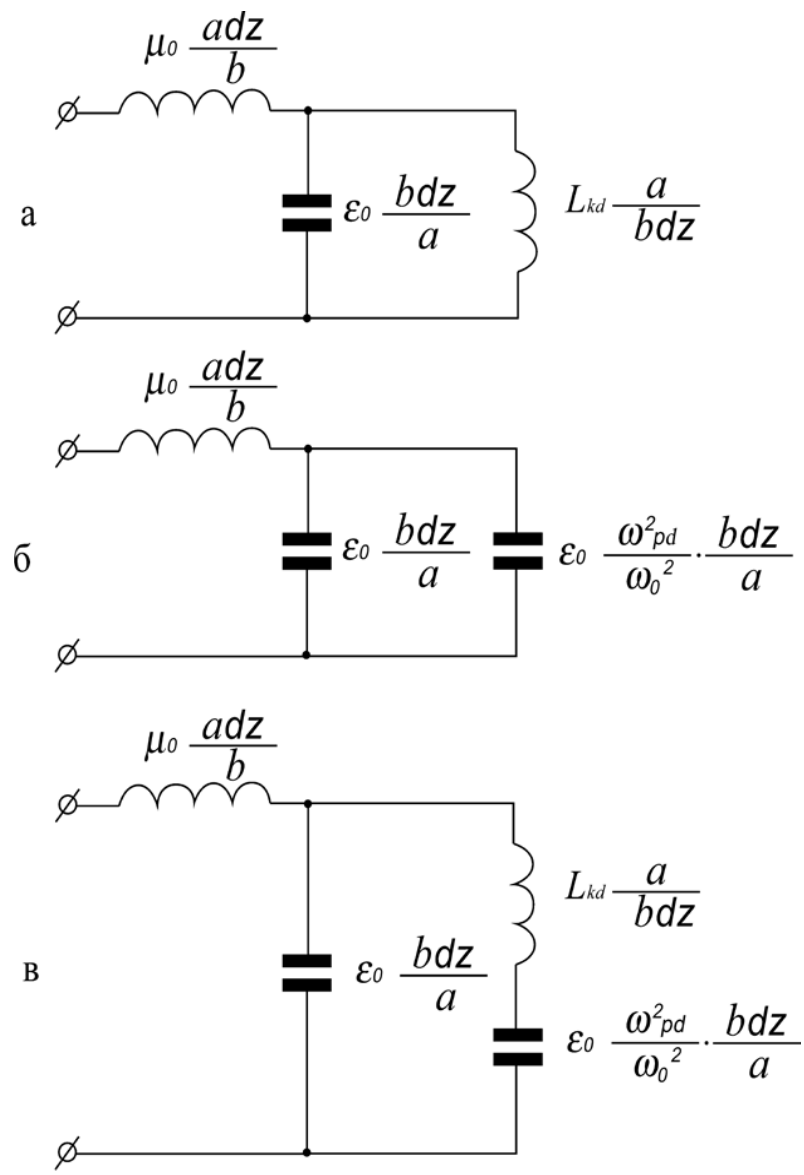

Fig. 7: Equivalent circuit of two-conductor line segment with a dielectric: а – $\omega >> \omega_0$; б – $\omega << \omega_0$; в – the whole frequency range

The equivalent circuits corresponding to these two cases are shown in Figs. 7а and б. It is seen that in the whole range of frequencies the equivalent circuit of the dielectric acts as a series oscillatory circuit parallel-connected to the capacitor operating due to the electric inductivity ε_0 of vacuum (see Fig. 7в). The resonance frequency of this series circuit is obviously obtainable from

$$\omega_\partial^2 = \frac{1}{L_k \, \varepsilon_0 \left(\frac{\omega_{p\,\partial}^2}{\omega_0^2} \right)} . \qquad (6.10)$$

Lake in the case of plasma, ω_0^2 is independent of the line size, i.e. we have a macroscopic resonator whose frequency is only true when there are no bonds between individual pairs of bound charges.

Like for plasma, $\varepsilon_\partial{}^*(\omega)$ is specific susceptance of the dielectric divided by frequency. However, unlike plasma, this parameter contains three frequency-independent components: ε_0, $L_{k\,\partial}$ and the static permittivity of the dielectric $\varepsilon_0 \frac{\omega_{p\,\partial}^2}{\omega_0^2}$. In the dielectric, resonance occurs when $\varepsilon_\partial{}^*(\omega) \to -\infty$.

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Three waves-magnetic, electric and kinetic-propagate in it too. Each of them carries its own type of energy. It not is not problematic to calculate them but we omit this here to save room.

VIII. Magnetic Media

The resonance phenomena in plasma and dielectrics are characterized by repeated electrostatic-kinetic and kinetic-electrostatic transformations of the charge motion energy during oscillations. This can be described as an electrokinetic process, and devices based on it (lasers, masers, filters, etc.) can be classified as electrokinetic units.

However, another type of resonance is also possible, namely, magnetic resonance. Within the current concepts of frequency-dependent permeability, it is easy to show that such dependence is related to magnetic resonance. For example, let us consider ferromagnetic resonance. A ferrite magnetized by applying a stationary field H_0 parallel to the Z -axis will act as an anisotropic magnet in relation to the variable external field. The complex permeability of this medium has the form of a tensor [21]:

$$\mu = \begin{pmatrix} \mu_T*(\omega) & -i\,\alpha & 0 \\ i\,\alpha & \mu_T*(\omega) & 0 \\ 0 & 0 & \mu_L \end{pmatrix},$$

where

$$\mu_T*(\omega) = 1 - \frac{\Omega\,|\gamma|\,M_0}{\mu_0(\omega^2-\Omega^2)}, \quad \alpha = \frac{\omega\,|\gamma|\,M_0}{\mu_0(\omega^2-\Omega^2)}, \quad \mu_L = 1,$$

$$\Omega = |\gamma| H_0 \qquad (7.1)$$

Being the natural professional frequency, and

$$M_0 = \mu_0(\mu-1)H_0 \qquad (7.2)$$

is the medium magnetization.

Taking into account Eqs. (7.1) and (7.2) for $\mu_T*(\omega)$, we can write

$$\mu_T*(\omega) = 1 - \frac{\Omega^2(\mu-1)}{\omega^2-\Omega^2}. \qquad (7.3)$$

Assuming that the electromagnetic wave propagates along the x-axis and there are H_y and H_z components, the first Maxwell equation becomes

$$rot\ \vec{E} = \frac{\partial \vec{E}_Z}{\partial x} = \mu_0\mu_T \frac{\partial \vec{H}_y}{\partial t}.$$

Taking into account Eq. (7.3), we obtain

$$rot\ \vec{E} = \mu_0\left[1 - \frac{\Omega^2(\mu-1)}{\omega^2-\Omega^2}\right]\frac{\partial \vec{H}_y}{\partial t}.$$

For $\omega >> \Omega$

$$\varphi(r)\ rot\ \vec{E} = \mu_0\left[1 - \frac{\Omega^2(\mu-1)}{\omega^2}\right]\frac{\partial \vec{H}_y}{\partial t}. \qquad (7.4)$$

Assumeng $\vec{H}_y = \vec{H}_{y0}\sin\ \omega t$ and taking into account that

$$\frac{\partial \vec{H}_y}{\partial t} = -\omega^2 \int \vec{H}_y\,d\,t.$$

Eq. (7.4) gives

$$rot\ \vec{E} = \mu_0 \frac{\partial \vec{H}_y}{\partial t} + \mu_0\,\Omega^2(\mu-1)\int \vec{H}_y\,d\,t,$$

or

$$rot\ \vec{E} = \mu_0 \frac{\partial \vec{H}_y}{\partial t} + \frac{1}{C_k}\int \vec{H}_y\,d\,t$$

$$rot\ \vec{E} = \mu_0 \frac{\partial \vec{H}_y}{\partial t} + \frac{1}{C_k}\int \vec{H}_y\,d\,t.$$

For $\omega << \Omega$

$$rot\ \vec{E} = \mu_0\mu \frac{\partial \vec{H}_y}{\partial t}.$$

The quantity

$$C_k = \frac{1}{\mu_0\,\Omega^2(\mu-1)}$$

can be described as kinetic capacitance. What is its physical meaning? If the direction of the magnetic moment does not coincide with that of the external magnetic field, the vector of the moment starts precessional motion at the frequency Ω about the magnetic field vector. The magnetic moment $\vec{m}$ has the potential energy $U_m = -\vec{m}\cdot\vec{B}$. Like in a charged condenser, U_m is the potential energy because the precessional motion is inertialess (even though it is mechanical) and it stops immediately when the magnetic field is lifted. In the magnetic field the

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processional motion lasts until the accumulated potential energy is exhausted and the vector of the magnetic moment becomes parallel to the vector $\vec{H}_0$.

The equivalent circuit for this case is shown in Fig. 8. Magnetic resonance occurs at the point $\omega = \Omega$ and $\mu_T^*(\omega) \to -\infty$. It is seen that the resonance frequency of the macroscopic magnetic resonator is independent of the line size and equals Ω.

Thus, the parameter

$$\mu_H * (\omega) = \mu_0 \left[1 - \frac{\Omega^2(\mu - 1)}{\omega^2 - \Omega^2} \right]$$

is not a frequency-dependent permeability. According to the equivalent circuit in

Fig. 8, it includes μ_0, μ and C_k

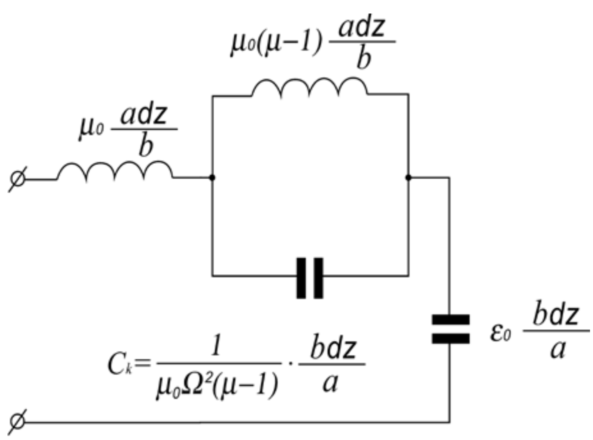

Fig. 8: Equivalent circuit of two-conductor line including a magnet

It is easy to show that three waves propagate in this case-electric, magnetic and a wave carrying potential energy of the precessional motion of the magnetic moments about the vector $\vec{H}_0$. The systems in which these types of waves are used can also be described as electromagnetopotential devices.

IX. Conclusions

Thus, it has been found that along with the fundamental parameters $\varepsilon\varepsilon_0$ and $\mu\mu_0$ characterizing the electric and magnetic energy accumulated and transferred in the medium, there are two more basic material parameters L_k and C_k. They characterize kinetic and potential energy that can be accumulated and transferred in material media. L_k was sometimes used to describe certain physical phenomena, for example, in superconductors, C_k has never been known to exist. These four fundamental parameters $\varepsilon\varepsilon_0$, $\mu\mu_0$, L_k and C_k clarify the physical picture of the wave and resonance processes in material media in applied electromagnetic fields. Previously, only electromagnetic waves were thought to propagate and transfer energy in material media. It is clear now that the concept was not complete. In fact, magnetoelectrokinetic, or electromagnetopotential waves travel in material media. The resonances in these media also have specific features. Unlike closed planes with electromagnetic resonance and energy exchange between electric and magnetic fields, material media have two types of resonance – electrokinetic and magnetopotential. Under the electrokinetic resonsnce the energy of the electric field changes to kinetic energy. In the case of magnetopotential resonance the potential energy accumulated during the precessional motion can escape outside at the precession frequency.

The notions of permittivity and permeability dispersion thus become physically groundless though $\varphi(r)\,\varepsilon*(\omega)$ and $\varphi(r)\,\mu*(\omega)$ are handy for a mathematical description of the processes in material media. We should however remember their true meaning especially where educational processes are involved.

It is surprising that Eq. (3.29) actually accounts for the whole of electrodynamics beause all current electrodynamics problems can be solved using this equation. What is then a magnetic field? This is merely a convenient mathematical procedure which is not necessarily gives a correct result (e.g., in the case of parallel-moving charges). Now we can state that electrocurrent, rather than electromagnetic, waves travel in space. Their electric field and displacement current vectors are in the same plane and displaced by $\frac{\pi}{2}$.

In terms of Eq. (3.29), electrodynamics and optics can be reconstructed completely to become simpler, more intelligible and obvious.

The main ideas of this approach were described in the author's publications However, the results reported have never been used, most likely because they remain unknown. The objective of this study is therefore to attract more attention to them.

It is shown that in a nonmagnetized plasma, beside the longitudinal Langmuir resonance, there may also exist the transversal resonance. Both these resonance kinds are degenerated. Employment of the transversal resonance makes it possible to design resonators and filters, as well as powerful single-frequency lasers operating on the basis of collective oscillations of plasma.

Any theory is dead unless important practical results are obtained of its basis. The use of the previously unknown transverse plasma resonance is one

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of the most important practical results following from this study.

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Measurement of Verdet Constant for Some Materials

By Pooja & S S Verma

Abstract- Verdet constant describes the strength of Faraday Effect for a particular material. The objective of this work was to measure the Verdet constant for different materials. The Verdet constant is measured by using the Faraday Effect which is a magneto-optical phenomenon; mean it describes the rotation of the plane of polarization of light with in a medium when it is placed in an external magnetic field. So this experiment determines the rotation of the plane of polarization with respect to the wavelength and the magnetic field. Reading observed through this experiment depicts a linear relationship between the angle of rotation and the magnetic field. The Verdet constant is determined to be at constant laser wavelength $\lambda = 632.8$nm

Keywords: magneto-optical effect, polarization, magnetic field, verdet constant.

GJSFR-A Classification: FOR Code: 029999p

MEASUREMENTOFVERDETCONSTANTFORSOMEMATERIALS

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Measurement of Verdet Constant for Some Materials

Pooja [α] & S S Verma [σ]

Abstract- Verdet constant describes the strength of Faraday Effect for a particular material. The objective of this work was to measure the Verdet constant for different materials. The Verdet constant is measured by using the Faraday Effect which is a magneto-optical phenomenon; mean it describes the rotation of the plane of polarization of light with in a medium when it is placed in an external magnetic field. So this experiment determines the rotation of the plane of polarization with respect to the wavelength and the magnetic field. Reading observed through this experiment depicts a linear relationship between the angle of rotation and the magnetic field. The Verdet constant is determined to be at constant laser wavelength λ = 632.8nm

Keywords: magneto-optical effect, polarization, magnetic field, verdet constant.

I. Introduction

The phenomenon of Faraday Effect was first discovered Michael Faraday in 1845. He discovered for the concrete evidence for the relation between the branch of Optics, magnetism and atomic Physics. He found out that when a block of glass is subjected to a strong magnetic field, it becomes optically active which we cannot observe with naked eyes. The effect occurs when a plane polarized light passes through a thickness of a transparent medium. This effect is not only limited to optically active materials, but also included some optically inactive materials placed in high magnetic fields. In magnetize medium, the refractive indices for right and left handed circularly polarized light are different. The effect in rotation of plane of polarization of linearly polarized light, this observable fact is called magneto-optic effect. The Faraday Effect is caused by left and right circularly polarized wave propagating at slightly at different speed, a property known as circular birefringence. It occurs as an internal property of material when placed in external magnetic field. The direction of polarization, rotation depends on the properties of material through which the light is passed. This effect is widely used in optical isolators, phase modulators, spin dynamics, etc. Faraday rotation is also observed in astronomy and used to measure magnetic field in space. Faraday Effect is given by the relationship.

$$\Theta = V.B.L. \qquad (1)$$

Where Θ is the angle by which the plane of polarization of light rotates in radians, B is the uniform external magnetic field in Tesla, L is the length of sample material in meters, V is the Verdet constant. Verdet constant is characteristic of the medium and is defined as the rotation of the plane of polarization per unit magnetic field (Figure 1).

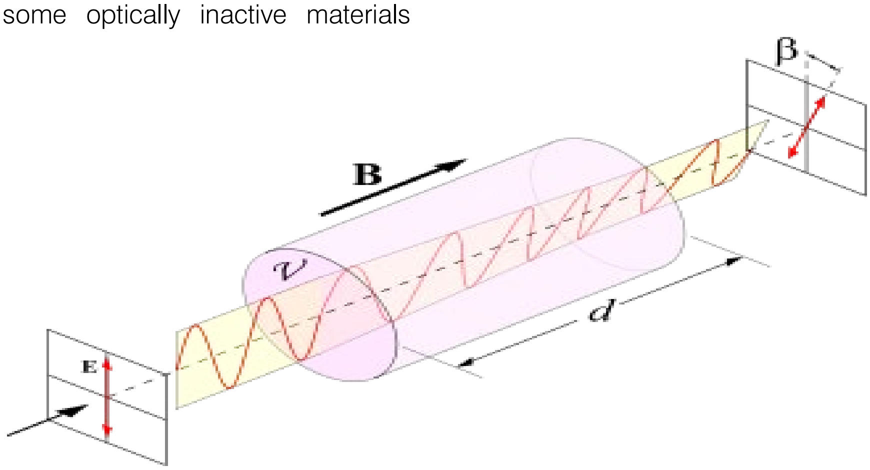

Fig. 1: Rotation of plane of polarization of light within a medium due to external magnetic field

The linear light is seen to rotate in the Faraday effect can be seen as consisting of a right and left beam and the direction of the electric field rotates at the frequency of the other direction. The direction of rotation depends on the properties of the material through which the light is shown. A full treatment would have to take into account the effect of the external and radiation-

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caused fields on the wave function of the electrons, and then calculate the effect of this change on the refractive index of the material for, to see whether the right or left is slowed down more. The Faraday effect has been used to measure optical rotator power and for sensing of magnetic fields (such as fiber optic current sensors).The Faraday effect is used in spintronics research to study the polarization of electron spins in semiconductors. Faraday rotators can be used for amplitude modulation of light ,and are basis of optical isolators and optical circulators; such components are required in optical telecommunications and other laser applications.

II. Experimental Setup

The experiment setup (figure 2) used to accurately measure the Verdet constant and this apparatus set was purchased from INDOSAW.

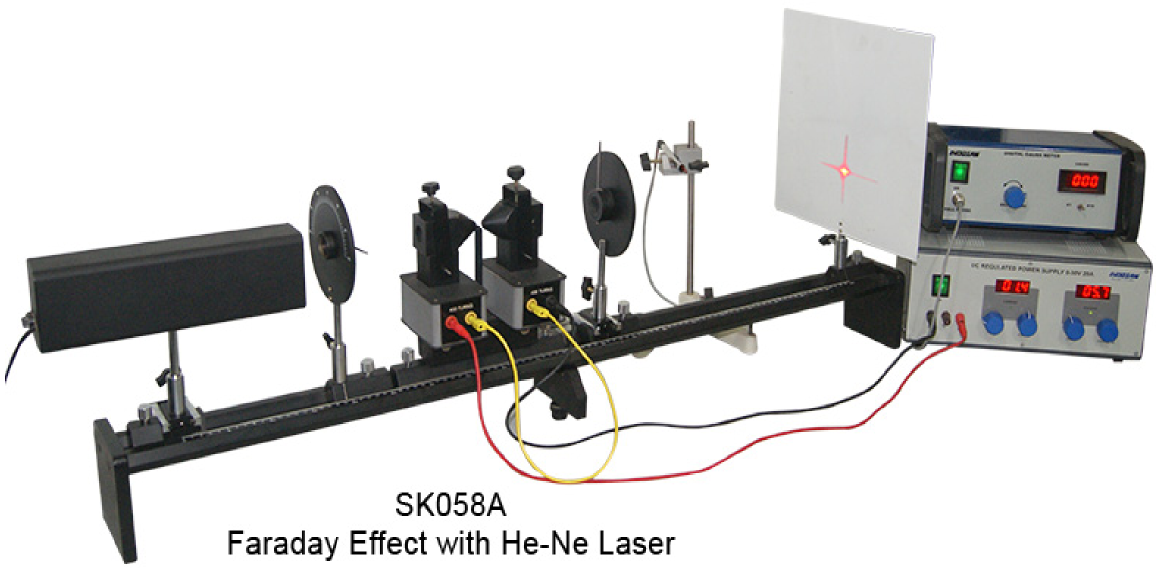

Fig. 2: Experimental setup

a) *Apparatus parts*

- He- Ne Laser
- 1 U-core
- 1 photometer
- Digital Gauss Meter with hall probe
- 1 Rider base for electromagnet
- 1 Polarization filters
- 1 Analyzer filter
- 1 Sample material with holder
- 2 Coil with 300 turns
- 1 Photometer
- Power Supply 30V, 10 Amp for Electromagnet
- 1 stand rod, 25cm
- 1 stand base
- 1 Optical bench setup
- 1 Pair cables 100cm, red/black

b) *Test materials*

For performing experiment with flint glass, one requires a very strong magnetic field to rotate the plane of polarization of light. However, for weak magnetic fields as were available in laboratory, another type of transparent material have been used. The materials used in present investigations are: Glycerin, Olive Oil, Water, Salty water and Potassium bromide (KBr).

III. Experimental Procedure

a) *Optical Bench Setup*

- Arrange the He-Ne laser on the optical bench.
- Position a polarizer close to the laser.
- Place the U-core of the demountable transformer with the two coils on the rider base with thread and fix it with the holder for the transparent sheet square.
- Place the bored pole pieces on the U core in such a manner that the transparent sheet can be placed on the holder.
- Use the clamps to fix the bored pole pieces on U-core.
- Position the analyzer close to U core on bench.
- Position the photometer opposite to the analyzer.
- Separate angular scale with the degree divisions which is attached to the translucent screen photometer. All analyzer settings can be read off from this angular scale easily.

b) *Electrical setup*

- Connect the coils in series to the variable.
- Connect the Laser to mains 230V AC supply.
- The maximum coils current under permanent use is 6amp, however the current can be increased up to 8 to 10Amp for few minutes without the risk of damaging the coils by overheating.

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c) Optical Adjustment

- Switch on laser and form an image of analyzer cross wire on the photometer.
- Align the light source and the bored pole pieces in such a manner that maximum light passes through the bores in pole pieces (with no transparent sheet).
- To project an image of thread cross on the analyzer onto the photometer, shift the lens toward the analyzer until a sharp image is observed.

d) Calibration of the magnetic field

- Remove the sample.
- Connect the digital gauss meter to main switch.
- Place the hall probe between the pole pieces.
- Use the standard material to hold the magnetic probe between the bored pole pieces.
- Record the magnetic field B as function of the current I through coils.

Current (in Amps)	Magnetic field,B (in Gauss)
1	233
2	245
3	267
4	286
5	304
6	322
7	340
8	352

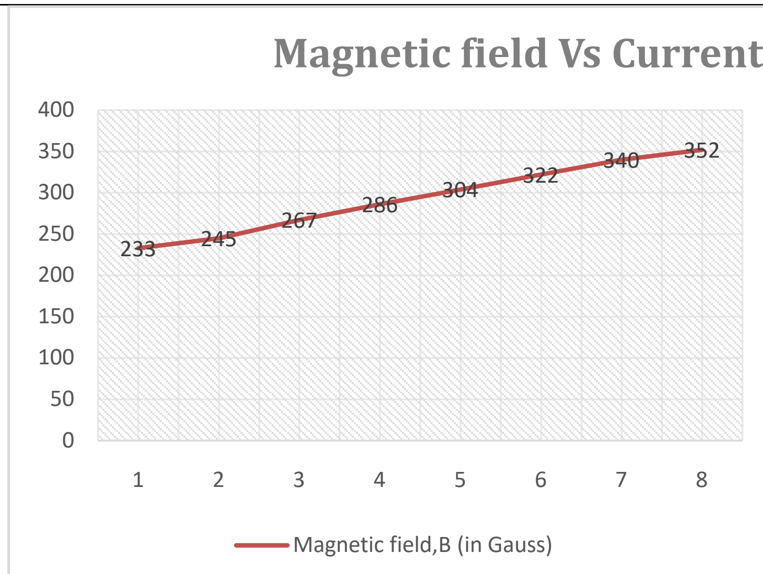

Fig. 3: Current along x-axis (in ampere) Vs Magnetic field along y-axis(in gauss)

It shows that current is directly proportional to magnetic field. Due to the limitation of setup in the lab, the maximum coils current under permanent use is 6amp, however current can be increased up to 8 to 10amp for a few minutes without risk of damage to the coils by over-heating. Since electromagnets are used to generate the magnetic field for the experiment, a correlation between the current supplied to the electromagnets and the measured magnetic field in the space between the poles needed to be deduced. The magnetic field at the center of the poles was measured at each integer current between 1 and 8A.

e) Rotation of the polarization plane as a function of the magnetic field B

- Switch ON He-Ne laser.
- Align the sample between the bored pole pieces.
- Set the desired magnetic field by means of the magnet current.
- Set the analyzer to 0^{o} position.
- Find the minimum intensity by turning the polarizer.
- For a final minimum adjustment (almost dark) the minimum light intensity can be easily checked by looking directly into the screen.The polarizer and the analyzer are set to the intensity minimum as it can be easier accessed then the intensity maximum.
- Note the values of intensity at different angle by rotating the analyzer.
- Note the value of intensity by using photometer or photodiode.
- Repeat these steps for various magnetic fields by varying the magnetic current.

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IV. RESULTS AND DISCUSSION

a) Olive oil (sample thickness =1.5cm)

Table 1: Angle and intensity at different values for current (Malus's law)

Angle (in degree ϕ)	Intensity at (I=0Amp)	Intensity at (I=5Amp)	Intensity at (I=5.5Amp)	Intensity at (I=6Amp)
0	33	31	30	27
30	25	23	22	20
60	9	8	8	7
90	0	0	0	0
120	9	9	8	7
150	25	24	23	21
180	32	31	29	27
210	24	23	22	20
240	8	7	7	7
270	0	0	0	0
300	8	8	8	7
330	23	23	21	21
360	31	30	28	25

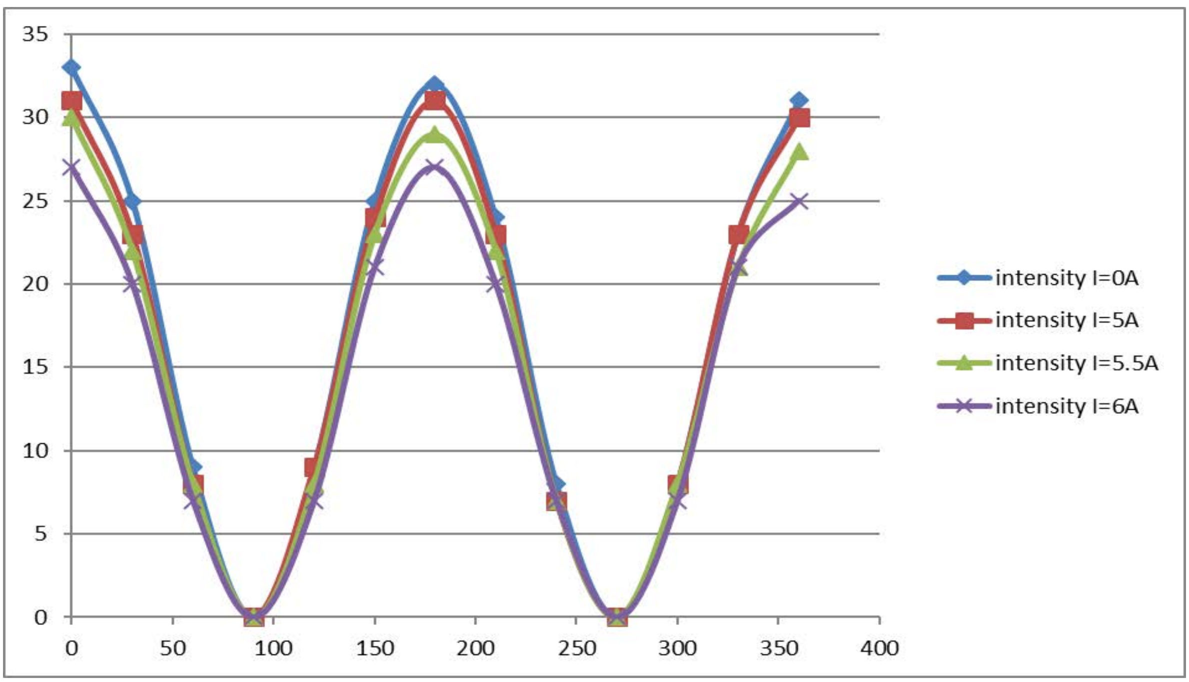

Fig. 4: Graphical representation for Olive oil by Malus's Law. Rotation angle along x-axis (in degree) and Intensity along y-axis for different value of current

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Magnetic field and angle of rotation for constant wavelength = 632.8nm

Magnetic field (B in gauss)	Rotation (ϕ)
304	0.28
313	0.42
322	0.61

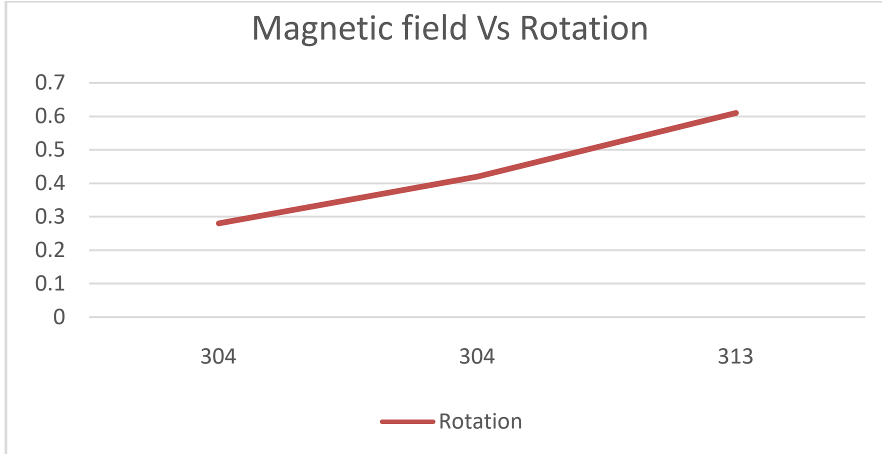

Fig. 5: Graph between magnetic field(in gauss) along x-axis and rotation angle(in degree) along y-axis

b) *Black glass (sample thickness=6mm)*

Table 2: Angle and intensity at different values for current (Malus's law)

Angle (in degree ϕ)	Intensity at (I=0Amp)	Intensity at (I=5Amp)	Intensity at (I=5.5Amp)	Intensity at (I=6Amp)
0	5	6	6	6
30	4	5	4	5
60	2	2	2	2
90	0	0	0	0
120	2	2	2	2
150	5	4	5	5
180	6	6	6	6
210	4	4	4	4
240	2	2	2	2
270	0	0	0	0
300	2	2	2	2
330	4	4	5	5
360	5	6	6	6

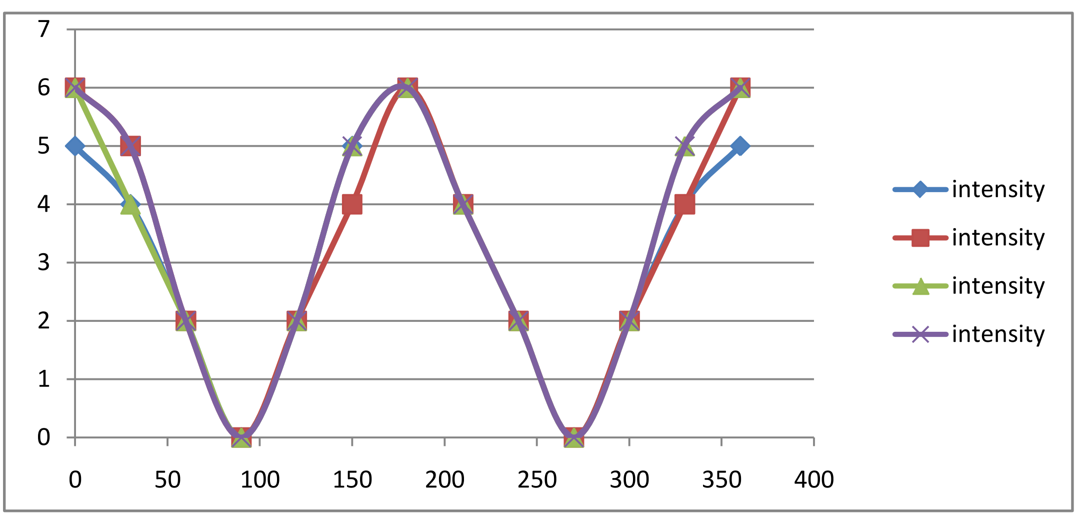

Fig. 6: Graph representation for black glass by malus law. Giving rotation angle along x-axis and Intensity along y-axis for different values of current

Result: No change in the angle with magnetic field.

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c) Water (sample thickness=1.5cm)

Table 3: Angle and intensity for different values of current (Malus's law)

Angle (in degree ϕ)	Intensity at (I=0Amp)	Intensity at (I=5Amp)	Intensity at (I=5.5Amp)	Intensity at (I=6Amp)
0	41	34	32	30
30	31	27	25	24
60	11	10	9	9
90	0	0	0	0
120	11	9	9	8
150	31	26	24	22
180	40	32	29	28
210	30	25	25	24
240	9	9	8	8
270	0	0	0	0
300	8	9	9	9
330	25	25	25	25
360	34	32	32	30

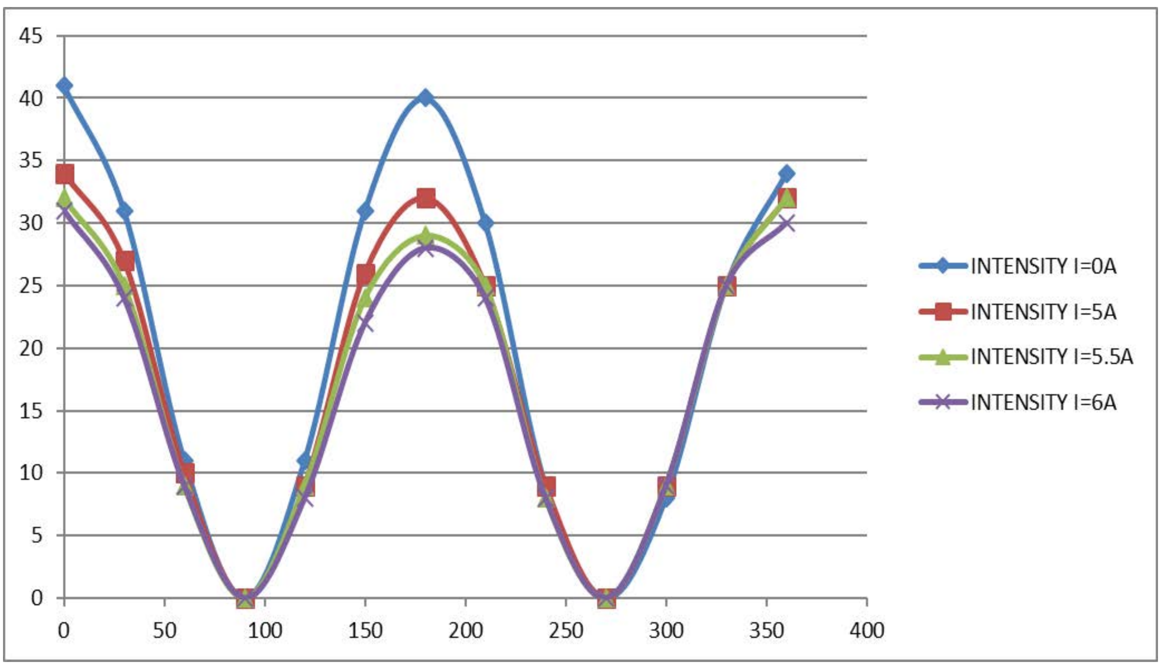

Fig. 7: Graph representation for water by Malus law. Showing rotation angle long x-axis and Intensity along y axis for different values of current

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Magnetic field and angle of rotation for constant wavelength = 632.8nm

Magnetic field	Rotation
304	0.59
313	0.67
322	0.72

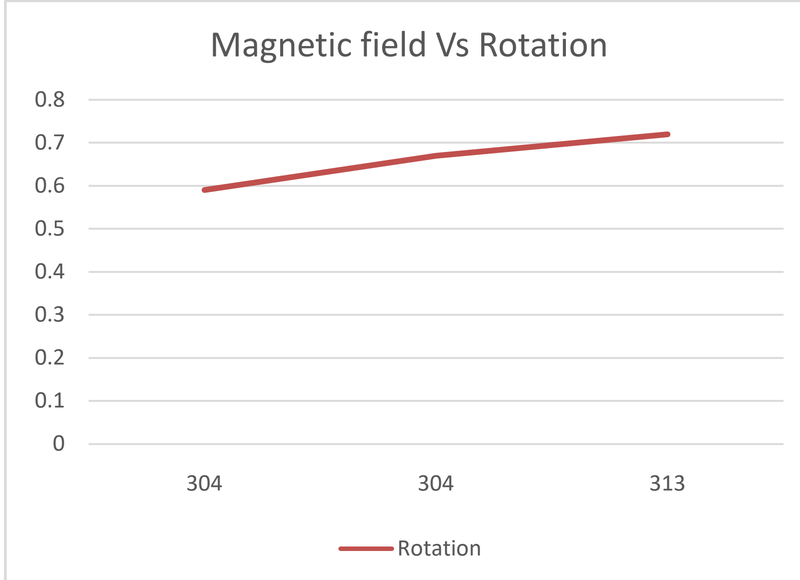

Fig. 8: Graph between magnetic field (along x-axis) and angle of rotation (along y-axis)

d) Glycerin (sample thickness=1.5cm)

Table 4: Angle and intensity at different values of current (Malus, s law)

Angle (in degree ϕ)	Intensity at (I=0Amp)	Intensity at (I=5Amp)	Intensity at (I=5.5Amp)
0	27	29	30
30	21	22	24
60	8	8	8
90	0	0	0
120	7	8	8
150	21	23	24
180	27	30	32
210	22	23	25
240	7	8	8
270	0	0	0
300	8	8	8
330	22	22	25
360	29	30	32

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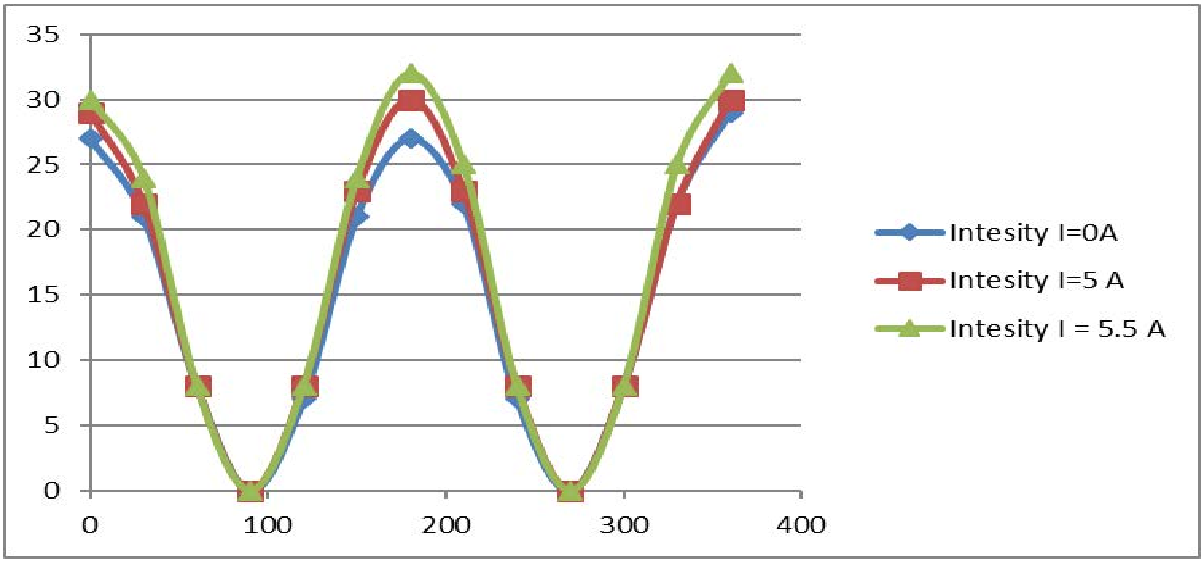

Fig. 9: Graph between rotation angle (x-axis) and intensity (y-axis) at different values of current for glycerine

Result: Rotation of angle with magnetic field in anti-clockwise direction

e) *Salty water (40% concentration) (sample thickness=1.5cm)*

Table 5: Angle and intensity at different values of current (Malus's law)

Angle (in degree ϕ)	Intensity at (I=0Amp)	Intensity at (I=5Amp)	Intensity at (I=5.5Amp)	Intensity at (I=6 Amp)
0	4	4	4	4
30	3	3	3	3
60	1	1	1	1
90	0	0	0	0
120	1	1	1	1
150	3	3	3	3
180	4	4	4	4
210	3	3	3	3
240	1	1	1	1
270	0	0	0	0
300	1	1	1	1
330	3	3	3	3
360	4	4	4	4

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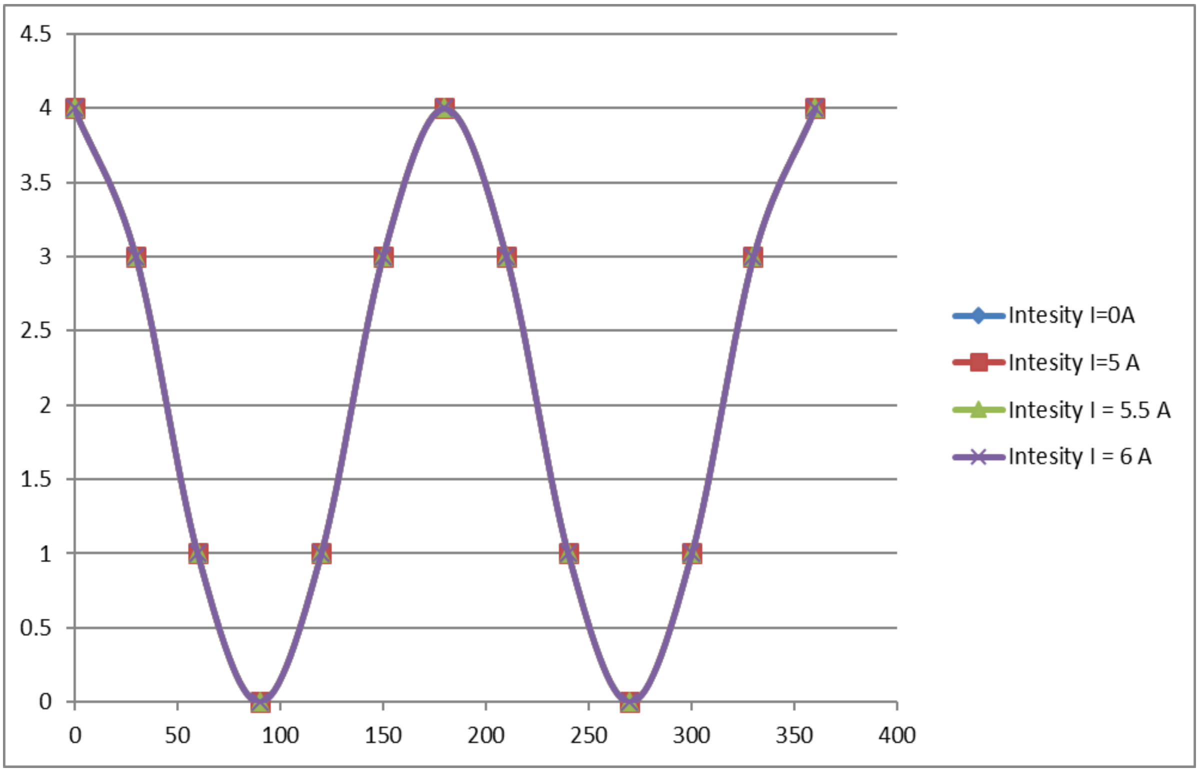

Fig.10: Graph for salty water by malus law. Showing angle in degrees (along x-axis) and Intensity (along y axis) for different values of current

V. Results

Verdet constant for

1. Olive oil is found as 16.18rad/T-m and 0.00093 degree/G.cm
2. Water is found as 24.66rad/T.m and 0.0014 degree/G.cm
3. No rotation was noticed in case of black glass and salty water (may be due to low magnetic fields available)
4. A negative rotation was noticed in case of Glycerin.
5. Similar problems were faced with pallets made up of Potassium Bromide (KBr) and Potassium Iodide (KI).

VI. Conclusion

The effect of rotation of plane polarized light is used every day especially by organic chemists who use the optical properties of chiral compounds for identification purposes. But less used in the magnetically induced optical activity seen in Faraday effects. The application of magnetic field causes the medium to become optically active and as magnetic field increased the angle of rotation increased. The project successfully measures the Verdet constant for different materials. There is a significant rotation in plane of polarization especially in shorter wavelengths. This effect was demonstrated in olive oil and water and value of Verdet constant be V=16.18 radian/T-m and 24.68 radian/T-m respectively and also show optical activity for glycerin. However, no change was noticed for black glass and salty water. From our result we found that the Verdet constant for olive oil and water is positive and negative for Glycerin. The rotation of water and olive oil is clockwise looking parallel to magnetic field for both direction of propagation. We found that Verdet constant of water at 632 nm is greater than the olive oil.

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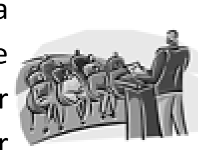

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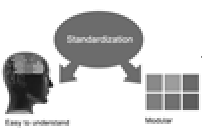

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The ' MARSS ' title is accorded to a selected professional after the approval of the Editor-in-Chief / Editorial Board Members/Dean.

The “MARSS” is a dignified ornament which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., MARSS or William Walldroff, M.S., MARSS.

MARSS accrediting is an honor. It authenticates your research activities. After becoming MARSS, you can add 'MARSS' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, Visiting Card and Name Plate etc.

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MARSS designated members are entitled to avail a 25% discount while publishing their research papers (of a single author) in Global Journals Inc., if the same is accepted by our Editorial Board and Peer Reviewers. If you are a main author or co-author of a group of authors, you will get discount of 10%.

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We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The MARSS member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.

Once you are designated as MARSS, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria.

It is mandatory to read all terms and conditions carefully.

Auxiliary Memberships

Institutional Fellow of Global Journals Incorporation (USA)-OARS (USA)

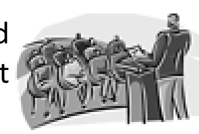
Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as "Institutional Fellow of Open Association of Research Society" (IFOARS).

The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.
The author fees of such paper may be waived off up to 40%.



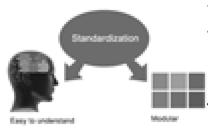
The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.



After nomination of your institution as “Institutional Fellow” and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.

The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.

We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

Other:

The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

Preferred Author Guidelines

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

Before and during Submission

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct,* along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

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Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

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1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

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Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- o Single section and succinct.
- o An outline of the job done is always written in past tense.
- o Concentrate on shortening results—limit background information to a verdict or two.
- o Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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	A-B	**C-D**	**E-F**
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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

Index

A

E

G

H

I

R

S

V

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