Special Relativity for high school children, new approach.

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stanislav@spassky.net

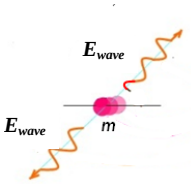
Good day. Let me introduce myself – Spassky Stanislav Vsevolodovich, author of the so-called "two-level approach" in high school. Its essence is that teaching at school should be performed at two levels **simultaneously**. Today's standard is as clothing of the same size: "for everybody and for nobody".

...On TV I regularly hear as a "code" that in 1905 great Einstein created the great Special Theory of Relativity **inapprehensible within the framework of common sense**, and **on its basis** he discovered the **Formula of The Century: $E=mc^2$.** I think that Einstein – the man of humor – would have set this "coding" in a quotable aphorism!

Now I'd like to show you that Special Theory of Relativity – it is very simple, for the high schoolchildren, too. I offer its wave interpretation including "within the framework of common sense". There are few computations, those that are, are at the high school level. Read part 1 which presents very simple derivation of $E=mc^2$ formula and you will see it yourself.

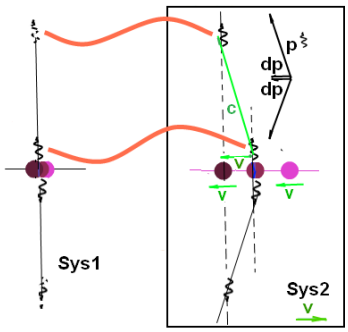
Part 1. Let's start with simple derivation of $E=mc^2$.

It was the **classical physics** that divided objects into 2 types: **with mass and without mass**. The objects **with mass** are specified as $E_{kin}=m{\cdot}v^2/2$ and $p=m{\cdot}v$ ($E_{kin}/p=v/2$ ratio). The objects (and microobjects) **without mass** always move at the velocity of light **c**, the relation between their energy and momentum is $E= p{\cdot}c$ ($E/p=c$). Such **microobjects** are also specified by the combination of properties of **wave and particle**. E.g. the **light particles (photons)** exhibit all properties of a **traveling electromagnetic wave**. For the traveling electromagnetic waves and their fragments $E= p{\cdot}c$ relation was found as long ago as by Maxwell and experimentally proved by Lebedev in 1899.



In 1905 Einstein proposed a scheme of an **imaginary experiment** to derive his $E=mc^2$ formula. A particle with mass **m** emits 2 identical electromagnetic waves (without mass) each having certain energy (say E_{wave}) in opposite directions.

It is customary and erroneous (**even now**) to assume that the essence of deriving this formula is **compulsory** use of the Special Theory. Indeed, Einstein derived this formula **not transparently**, using the Special Theory. Most likely, he wanted to demonstrate its significance. But the formula is derived quite easily, even within the framework of classical physics, because to have the rest energy of a particle E_0 the question is about low velocities **v** (this is the velocity of the system observing the phenomenon).



Now a couple of words how all this takes place.

In the figure the mentioned phenomenon is shown in 2 systems. System 1 is associated with the particle (left), in this system the particle is at rest emitting 2 **opposite** waves-particles (**having no mass**). System 2 moves relative to the particle at velocity **v rightwards** – perpendicular to the axis of movement of emitted waves-particles. In this system the particle with mass moves **leftwards** at velocity **v**. (Fig. shows 3 successive time moments of this phenomenon.)

It is obvious, that in System 1 after emission the particle with mass stays **in the same place** because the vectoral sum of opposite momenta of emitted waves-particles is **zero**. This means that in System 2 **after emission** a particle has to move left at the **original** velocity **v**.

But it is obvious that in System 2 because of its **movement rightwards** the

directions of movement of the said waves-particles are not opposite, they have component of velocity **left** by **v** and **c** ratio. The momenta of waves-particles are **always** directed in the direction of their travel. In System 2 the **total momentum** of both waves-particles as the **vectoral sum** is **2dp**. This means that emitting, they take a part from momentum of the particles, which in the classical physics is $p_{mass}=m \cdot v$. But particle velocity **v** (as noted above) does not change. So, in emission the mass of particle is to decrease by a certain value **Δm**.

Let's write down in System 2 the law of conservation of momentum, write it down in modules, i.e. without extra "minuses" in expressions. It must be kept in mind, that **v<<c**. Both waves-particles take momentum **2dp** leftwards. **dp** can be easily expressed from the proportion by triangles: **dp/p=v/c**, i.e. **dp=p·v/c**. Momentum **p** of each wave-particle is expressed through its energy **p=E/c**. We have **dm·v=2·dp=2(E/c)(v/c)** . **v** is dropped from the expression because it is present in both parts. We have, that **dm** (the so called **mass defect**) is expressed through the total energy of waves-particles lost in emission $dm=(2E)/c^2$. **The properties and value of dm cannot depend on the direction of movement of System 2 relative to the direction of waves-particles.**

So, it was quite easy to derive the famous formula. The rest is not more complicated.

Part 2. We cannot do without brief history.

1) **Relativity Principle.** Formulated as long ago as by Galileo. The principle means that all **inertial systems** are indistinguishable in the terms of the laws of physics. ("In a closed railway car it is impossible to determine whether it is standing or moving steadily ").

2) **Invariant of Light Velocity**. At their time physicists understood that the light is of wave nature (electromagnetic waves). From Maxwell equations **identical in all inertial systems Paradox** came to light – same wave velocity of light **in each inertial system**.

3) **Paradox emerged.** On the one hand the **Invariant of light velocity** "seems" to "fit well" into the **Law of Relativity**. On the other hand, this contradicts our common sense: the velocity of waves is to depend on our movement relative to the assumed wave medium – **aether**. That's how **the Problem of relativity** emerged, which the physics started to investigate in depth since 1881. The best known scientists Lorentz and Poincare made a great contribution in this field.

4) **The Invariant of Light Velocity** was proved in Michelson experiments in 1881 r. In **Michelson interferometer** a beam of light was split into two along orthogonal paths. Then the beams were again put together to create an interference pattern. The slightest "divergence" of beams due to the difference in wave velocity was, at this, to be visible in the pattern. The "divergence" effect did not manifest in any position of the device – this proved the paradoxical phenomenon of the Invariant of Light Velocity.

5) In 1905 young **Einstein** proposed a **strictly formal approach** later called **Special Theory of Relativity**. Based on two postulates – **the Principle of Relativity** and **the Invariant of Light Velocity** – his method made possible to find **strictly formally** how different physical concepts should transform in transition from one inertial system into an other. (Transformations of spatial coordinates and time had been found earlier by Lorentz and are known as **"Lorentz transformations"**).

6) At that time the Einstein's formal approach was attracting by novelty (**by its formalism**) and relative simplicity. But it was not accepted by everybody. Further on for different reasons this approach became the leading one. And for more than a **century** it is still leading, even though inapprehensible (within the framework of common sense"). Einstein himself denied the argument of "**common sense" in physics** and the notion of **aether** without which he could do.

7) **You, probably, heard** that Lorentz and Poincare - masters of the Problem of Relativity – being kind to young Einstein, did not accept his denial of aether. In the history

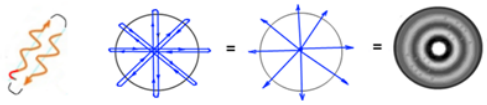
of physics this was passed off as the aged Lorentz and Poincare just **"failed to come up to"** the **real** understanding of the Problem of Relativity.

8) Opponents of Einstein's Theory of Relativity are quite a few. There are enough grounds, including denial of aether and "common sense". The critics of the theory generally aim their efforts at Michelson's experiments, i.e. the **phenomenon of Invariant of Light Velocity**. They think that to prove existence of **real** wave medium (aether) is to disprove the Special Theory. We'll see, that everything is just vice versa. That the Paradox of Invariant of Light Velocity is **apparent**. It is the "**wave approach**" on **aether** that brings us to simple explanation of the Special Theory of Relativity "within the framework of common sense". And not of the Special Theory of Relativity only.

Let's summarize. The **Paradox of Invariant of Light Velocity** originated in physics historically. Instead of explaining it, a certain set of **formal** actions was proposed which was called Special Theory of Relativity; the **explanation** of the paradox was recognized to be **impossible and not needed**. And this has been going on for more than 100 years already.

Part 3. So, the proposed model – interpretation.

1) Let's return to the mental experiment proposed by Einstein – emission by a particle with mass of two identical, but opposite electromagnetic waves-particles – "traveling" waves having no mass, but decreasing the mass of the particle. Just think. I.e. the element of the particle's mass being lost **has** to be **equivalent** to the pair of opposite waves both in terms of **energy** and **momentum**, in all observation systems, at that. I.e. **it is** the properties of the pair of opposite waves in the Special Theory that extend **over all** properties on the element of mass, and consequently, on the whole particle with mass.



2) Let's ask a question: before the emission what **represented** this lost mass to be equivalent in all respects to the pair of waves **before the emission**. Inside the particle this pair can be the **pair of opposite** waves-**harmonics** cycled on each other. I.e., be an element of the "standing wave". And the entire mass should be a set of similar pairs. Maybe of different frequency, most probably, of the frequency obtained by de Broglie (see below). Probably, of different directions, because the properties of mass cannot depend on direction of emission. Thus, we have an **important argument** for the fact, that the particle with mass should be a wave object of **"standing wave"** type. **At least**, it is in this way that the mass has to **manifest itself outwards** in compliance with Einstein's mental experiment: by a **set of pairs** of waves.

3) Our approach (interpretation) assumes **existence** of real wave medium – **aether**. And our material world is represented by wave objects of **two types**. Namely: particles **without mass** are represented by wave objects of "traveling wave" type, and the particles **with mass** are represented by wave objects of "standing wave" type, which can **move**. As you remember, the "standing wave" is oscillations in one place. The "standing wave" is represented by adding the totality of opposite "traveling waves". Remember vibrations on a string with fixed ends or "dancing" waves in a tea glass.

4) This approach assumes these two types of wave objects: "traveling wave" and "standing wave " **to be possible** in steady and localized forms. Note, that the localized traveling wave does not cause aversion by our common sense, even though, from the viewpoint of physics, there are questions. This property of localization is, most probably, associated with the fact, that our "**aether**" (as the wave medium) somewhat differs from the **classical** wave medium. We shall purposely skip the reflected wave mechanism in the "**standing wave**". But if we need "at least some" idea, then, the spherical zones of strong oscillations ("antinodes") can be assumed to form inhomogeneity zones on the wave medium as it is. They are located through every **half-wave** from the center. And these

are the best positions to form the reflected waves, because in this case all reflected waves are in phase.

5) What are the additional arguments for interpreting the particle with mass as a wave object of "standing wave" type?

2-nd argument: generality of nature of both types of particles.

3-rd argument: coincidence of the number of **particle types** ("without rest mass" and "with rest mass") and the **number of** wave form **types** ("traveling wave" and "standing wave").

4-th argument: In 1923 de Broglie suggested to use the Planck's law for photons **E= ν·h** and **for the particles with mass**, expressing their energy through mass (**E= m·c²**). He obtained some frequency **ν= E/h**. This frequency was really observed in particles in experiments. Presence of this frequency suggests that the massive particle is essentially the same photon, a kind of its modification, which because of high energy concentration "closed" the only direction of propagation which the particles without mass have. **We only specify the Einstein's idea that microobjects of our world are the energy: the wave energy.**

Part 4.Let's consider changes in mechanics in the Special Theory.

1) It is surprising how inapprehensible the categories of **energy and momentum** are updated in the Special Theory. What do we have in the **classical physics**? For the objects **with mass** the momentum is **p=m·v**, and kinetic energy is **E_{kin}=m·v²/2**. And for the objects **without mass** waves-particles of "traveling wave" type there is rigid relation between the momentum and the energy through multiplier **c**: **E=c·p**.

$$E=\frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}},\quad p=\frac{mv}{\sqrt{1-\frac{v^2}{c^2}}}$$

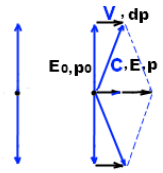
$$E=\frac{E_0}{\sqrt{1-\frac{v^2}{c^2}}},\quad p=\frac{E_0/c^2\cdot v}{\sqrt{1-\frac{v^2}{c^2}}}\quad\left(\text{or}\quad p=\frac{E\cdot v}{c^2}\right)$$

2) In the **Special Theory** appears **Lotentz factor** $\frac{1}{\sqrt{1-v^2/c^2}}$ usually denoted by "**β**". There appear the **energy of rest E_0** and its **increase with movement** (because of Lorentz factor). At low velocities **addition** to E_0 in movement coincides with familiar for us category of **kinetic energy: E_{kin} = m·c²/√(1- v²/c²) - m·c² ≈ m·v²/2**.

The bottom line of the table presents the same expressions for **E** and **p** without the use of the notion of "mass" **m**.

Now, how do we get it.

3) **Important notice.** Because of the **rigid relation** of **E** and **p** in harmonics (**E=c·p**) it is convenient to represent the harmonics by **vectors**. (**"Harmonics" are "traveling waves" that make up the object.**) Then, the **momentum for several harmonics is the vectoral sum** of these vectors, and the **energy is the sum of lengths** (modules) of these vectors. And we keep in mind coefficient "**c**" binding the energy and the momentum.



4) Let's consider such "object" (pair): take among the entire set of pairs one pair and consider it both **in rest** and **in movement** at velocity **v**, **transversely** to the harmonics. In the moving "object", because of its movement rightwards at velocity **v** , the harmonics should turn right with ratio of velocities **v** and **c** to compliance the shift of "object", so that in the **system connected with the object** these harmonics (as the "movement of energy", or movement of "energy fragments") would be perceived strictly transversal.

(**2-nd version**: version "in motion" can be considered as movement of "observer" left relative to the "object" in rest.)

5) **In rest** the momentum of the pair as vectoral sum is 0, and the energy is the sum of lengths of two vectors. When the "object" moves the momentum of harmoic **p** is directed in direction of movement of harmonic, inclined, in this case. The vector additions in momenta **dp** should be parallel to the movement. This is especially evident in the **version of observer's movement left**. By the ratio of sides in the triangle it is apparent that both the energy and the momentum of **each harmonic** increase by Lorentz factor: $\frac{c}{\sqrt{c^2-v^2}}=\frac{1}{\sqrt{1-v^2/c^2}}$. This is true for the **energy of the pair,** which is mentioned in the table.

The **momentum of the pair** (vectoral sum) is **2·dp**. By the ratio of sides in the triangle it is apparent, that **$2 \cdot dp = 2 \cdot (E/c) \cdot (v/c)$** or **$p_{object} = E_{object} \cdot v/c^2$**. This also agrees with the table.

6) The obtained ratios should also hold for the pair with other directions. Like for the object on the whole. To show this for other directions of harmonics is a little more difficult, account should be made of **Lorentz** distortions which we'll discuss later. Then we'll also discuss the version of the pair longitudinal to the movement.

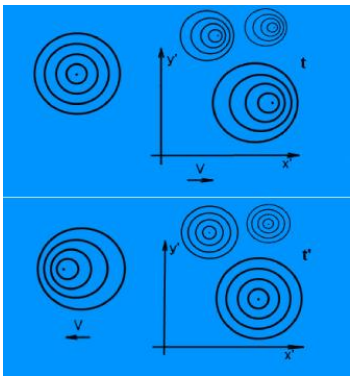
7) That's all about mechanics of the Special Theory. Look again at expressions for the energy and momentum in the table. What is inapprehensible and complicated? There is a set of harmonics with total **E** and **p**, and with movement of the object **E** and **p** of this set vary quite apprehensibly.

Part 5. Consider the main contradiction of the Special Theory.

1) Let's reason from the beginning. There is a set of inertial systems. It turns out that the Invariant of Light Velocity holds in them, and transitions from one system into an other **should** be accompanied by distortion of the coordinates and time ("Lorentz transformations" **for this Invariant to hold**. Why? What is the essence?

Let's call a **set** of these **inertial systems** "Lorentz systems". Classical physics used apprehensible for us Galileo transformations. This is because we unconsciously consider the bodies which surround us "solid", retaining all their sizes in motion. But if we understand that the particles of our world are of wave nature, the Lorentz systems turn out to the best that can be conceived for the world of such particles.

2) Let's try to understand the meaning of Lorentz transformation by way of a simplified example.



That's how look the waves diverging (top part of the figure) from a point source (left) in rest relative to the wave medium and from three sources (right), moving at equal velocity **v** right. Here the moving sources are attended with connected with them **ordinary system of coordinates** (other than Lorentz system).

It is apparent that the waves from the moving sources both for the external observer, and within their system are rarefied in the back and densified in the front because of the movement of the sources right relative to the medium. I.e. in such a system the **wave velocity depends on direction** (distance of the wave from the source in different directions).

3) Can the samples **in the moving system** be made to look without asymmetry? Yes, they can. E.g. for this the **time category** in the moving system should **be rearranged** (**t** to **t '**). We should present it so, that the external observer in rest at **every moment of his time t** sees at the same time different moments of this time **t'** depending on the value of **x** coordinate. (In Lorentz transforms you can see it in the numerator **$t' = (t - (v/c^2)x)/\ldots$**). At smaller **x** (left) the external observer sees **"as if"** later phase of **t'**. And "**as if**" because of this the wave had time to get away father from the **point** source. And if we consider the entire pattern of these three sources **within the moving system at any particular moment t'**, all three samples shall be symmetrical (shown in bottom half).

4) But. **Then,** in System 2 **at time t'** because of its property to densify the wave pattern on the left and rarefy on the right the pattern of the object **"really" at rest** on the left at this time **t',** in addition to understandable movement left shall look distorted, densified on the left and rarified on the right. I.e. "**as**" for the object moving left **relative to the medium**. So, both systems become **equivalent in the sense that in each of them the waves propagate "as" in the system connected with the medium, i.e. irrespective of the direction**.

5) So, this is more simply the essence of Lorentz systems with their transforms. All Lorentz systems are mutually symmetrical for the waves, and there are no **selected** ones.

Remember Einstein **denying aether** on the only grounds that a part of systems **really** connected with the hypothetical aether would stand out because of this only, and would break the required formal complete mutual symmetry of all systems.

With respect to considered introduction to time transformation the dependence on the longitudinal coordinate "ordinary people" are told that in the Theory of Relativity time transforms into space and vice versa. Can you imagine what happens at this moment with their brains?

6) An object of "standing wave" type **put in motion** should **distort**. However, it is clear, that in all **Lorentz systems** these objects in rest can both look similarly and manifest themselves similarly. Why? Because the objects of "standing wave" type are decomposed into harmonics and a set of harmonics of an object at rest can be simply copied and relocated into an other moving Lorentz system. We get the same object there. And the fact, that the light velocity in this system is equal (invariant) means that **in time** both the harmonics and the whole obtained object shall behave as the original one. **But in the time of the new system already**. The Lorentz systems are as if they were purposely invented for the world of wave objects, to replace the former Galileo systems of the classical physics.

7) As we ourselves are complexes of wave objects, for us the Lorentz systems are indistinguishable and we are unable to select from them systems really connected with the medium (maybe for a while, only). **And we ourselves select from all possible versions of inertial systems the Lorentz systems**, unconsciously, as the simplest. Because they are direction-symmetrical. Beginning to move the wave objects are distorted, the composition of their harmonic changes. But in all **key points** of the object at rest and moving object the **amplitude-phase** relations between respective harmonics hold. In all systems. This means that their interaction **localy** at every point of the object is identical in all systems. Therefore, the **physics** in Lorentz systems for the wave objects is the same and does not depend on directions. And has the simplest form.

8) One more effect of the wave nature of the particles of our world. Experience shows that value "**c**" can vary over the space. (This is indicated by bending of photon trajectories by the space masses.) But being a wave object we are unable to understand that velocity "**c**" can in a way differ in different areas. Because our metrics of space and time ("ruler" and "clock") is determined by the size and oscillation frequency of the objects we consist of. The size, frequency and local "c" are rigidly connected.

Let's summarize. So, we explained the phenomenon of **invariant of light velocity**. Logics only, no computations. Out of all possible versions of inertial systems we (people, scientists) **automatically** choose the version of **Lorentz systems** as the most convenient. It is because our world consists of **wave objects**.

Part 6. "Space-Time Distortions" in movement of objects.

By virtue of their wave nature objects are distorted in movement. It is these distortions that are compensated by Lorentz transformations so that in the systems connected with the object this object in rest would look undistorted.

Consider "standing wave" object in rest and in motion. What are the changes to take place?

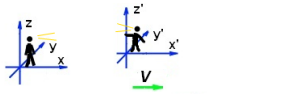
First, the oscillations in the moving object shall slow down.

Second. While in the object **at rest** all oscillations take place **simultaneously** over the entire volume, in the moving object the oscillations closer to the front start lag in phase. Therefore, some wave, the wave of establishing time t' phase is as if running forward over the object in the direction of travel of the object. I.e. we have the distortion of synchrony of events for the external observer (dependence of time t' on x). We discussed it early.

And in the third place: The object's longitudinal dimension shall diminish to some extent in course of its move.

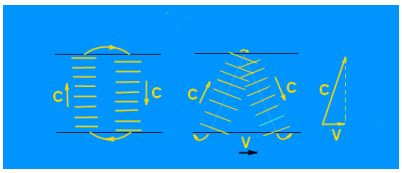
Lorentz transformation

$$x' = \frac{x - vt}{\sqrt{1 - v^2/c^2}}, \qquad x = \frac{x' + vt'}{\sqrt{1 - v^2/c^2}},$$
$$y' = y, \qquad y = y',$$
$$z' = z, \qquad z = z',$$
$$t' = \frac{t - (v/c^2)x}{\sqrt{1 - v^2/c^2}} \qquad t = \frac{t' + (v/c^2)x'}{\sqrt{1 - v^2/c^2}}$$



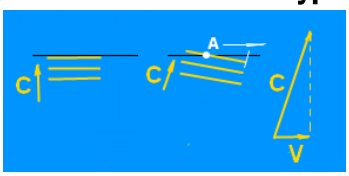
Lorentz's transformations are shown here, direct and inverse transformation. We will point out how distortions found by us are reflected therein.

Distortions of Type 1. Time dilation. If we examine the mentioned transverse pair at rest and in motion, we will see that due to the slope of harmonics in motion and at the transverse dimension maintained of the object, the trajectory length will increase **β**-fold. As all harmonics in the moving object are connected, then all vibrations in each point should be retarded, i.e. time in the moving object gets retarded. In the whole of the system connected with the object, time will be retarded for an external observer.



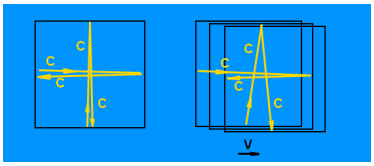
It can be seen **in the inverse transformation** within Lorentz transformations, in the last expression **t=..**, as **x'** should remain. We come to **Δt = Δt'·** $\frac{1}{\sqrt{1 - v^2/c^2}}$.

Distortions of Type 2. Violation of synchronicity. Let's examine the same pair of harmonics. Being at **rest,** the harmonic crosses a certain longitudinal (in relation to further motion of the object) border on the whole of the front **simultaneously**; while in a **moving particle** it will cross the latter **in a sloping pattern**. In order this front be perceived as horizontal in the moving system at one moment of "its" time **t'**, it is necessary that, for an external observer, the moment of time **t'** in observer's system would occur earlier in a more backward point of the object. Setting of each moment of time of the 2nd system **t'** is progressing forward. In the drawing we can see by **the interrelation of sides of the triangle** that the process of setting of "the time phase" **t'** runs forward with the speed V_{ph}, which is more than "**c**" in **c/v** times (V_{ph}=**c·c/v**); that is, it considerably exceeds the light speed **c**. And the wavelength **Λ** along **x** axis will increase in **c/v** times (**Λ= λ·c/v**), as compared to the **wavelength λ** of the harmonic. Vibrations which are synchronous in a resting particle will look non-synchronous in a moving particle. We get some kind of a **wave running forward along the object** with the derived speed V_{ph} and the derived wavelength **Λ**.



In reality, what is running along the object is the so-called "de Broglie wave"; this wave is not real but is produced by two opposite longitudinal waves with a slightly different "wavelength". A points run forward where their maximums meet each other and get added.

In **Lorentz's direct transformation,** this speed is reflected in a numerator for **t'=(t-(v/c²)x)/....** If, say, we make the numerator equal to 0 and consider **x/t**, we will obtain **V=c·(c/v)**.



Distortions of Type 3. Longitudinal reduction. To examine longitudinal reduction of the object in motion, we need to examine in the object at rest and in motion pairs which are transverse and longitudinal to the motion. If we take that **at rest** cycles of the transverse and longitudinal pairs are equal, say **2·L/c**, then **in a moving object** this relation should be disturbed. The longitudinal waves have **different speeds in relation to** the object, to any of its points: **(c-v)** in forward direction and **(c+v)** in back direction. Here are expressions for the both cycles **in the moving object**, transverse: **L· β /c + L· β/c**, and longitudinal: **(L/(c-v)+ L/(c+v))**. You can ascertain that the second expression is larger in **β** times. And as all harmonics in each point of the object are connected, then cycles shall remain the same in motion too. To fulfill it, it is needed that longitudinal dimensions of the object get reduction in **β** times, by Lorentz's factor.

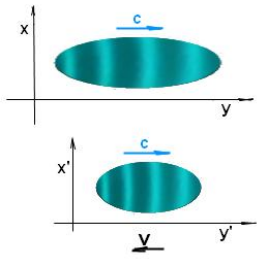
In Lorentz's direct transformation this reduction is reflected in **x=...** and is assured

by Lorentz's factor **β**. We can see that $\Delta x = \Delta x' \cdot \frac{1}{\sqrt{1 - v^2/c^2}}$

A small yet important note: In case of a moving system, we have time dilation (i.e. expansion of **t'** in relation to **t**) and compression along **x** axis; i.e. the volume element in 4D space (**x, y, z, t**) will be preserved in motion. So, at the formal approach to Special Theory, a "turn" in 4D space is used.

Part 7. Two small addenda to Social Theory topic.

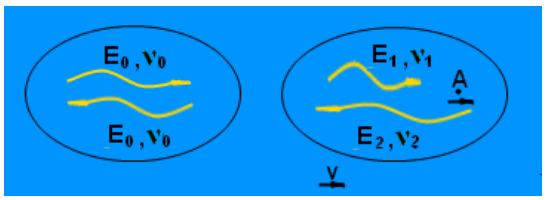
The meaning of Planck's formula. Let me remind you about Planck's law for a photon ("traveling wave" object) **E= ν·h**. Direct dependence of energy on frequency is not easily understood by everybody. In various systems, frequency ν of one and the same photon (as well as energy) will be "perceived" in a different way. We will show it using a simplified variant when the 2nd system moves along **x** axis, as the photon does. In the base of our analysis we will lay the object's frequency ν in each system. The both "pictures of the wave" (i.e. a number of wave segments, maximums) are identical in the both systems. Speed of waves is equal too: **c**. Thus, the length of the object in each system can be related to frequency of the wave object; this length is **inversely proportional to** ν. The width of the wave object in the both systems is identical. It means that the volume of the object is proportional to 1/ν, while **wave energy density** in physics is always proportional to **ν²**. So, we have that the energy of the "traveling wave" object is describes as **E~ ν**.



The promised demonstration of changes of mechanics in the longitudinal pair

(**This item may be skipped over, as it is not principal although not difficult in general**).

We promised you to show performance of kinematical interrelations $E_{motion}=E_{rest}/\sqrt{1 - v^2/c^2}$, $p_{motion}=(E_{rest}/c^2)\cdot v/\sqrt{1 - v^2/c^2}$ for a longitudinal pair of harmonics too. (Previously we demonstrated it for a transverse pair).



1) We take that at rest the each longitudinal harmonic energy of pair possesses energy **E₀** and frequency **ν₀**. In a moving system, the energy of harmonics changes in accordance with **E~ ν**, i.e. proportionally to changes of their frequencies. Their **total energy** as a sum of modules will be equal to $E_0\cdot(\nu_1/\nu_0)+E_0\cdot(\nu_2/\nu_0)$, while **impulse p** as a vector value – to $(E_0\cdot(\nu_1/\nu_0) - E_0\cdot(\nu_2/\nu_0))/c$, where ν_1 and ν_2 are changed frequencies of harmonics, **towards motion** of the object, and **against motion**. We have just to find the changes of harmonics frequencies.

2) Due to time dilation in a moving object, frequency in each point thereof will be equal to $\nu_0\cdot\sqrt{1 - v^2/c^2}$. A wave with frequency ν_1, as it overtakes each point of the object (e.g., point A), manifests the frequency $\nu_1\cdot(c-v)/c = \nu_1\cdot(1-v/c)$ in this point. We have obtained one and the same frequency in the point in two different ways, so we have $\nu_0\cdot\sqrt{1 - v^2/c^2} = \nu_1\cdot(1-v/c)$. The obtained result (ν_1/ν_0) will be put down in 3 forms. We will need only the 3rd form, while the 2nd form can be frequently seen in Special Theory in frequency transformation.

$$\nu_1/\nu_0 = \sqrt{1 - v^2/c^2}/(1-v/c) = \sqrt{(1+v/c)/(1-v/c)} = (1+v/c)/\sqrt{1 - v^2/c^2}$$

3) Now we will perform the same for the wave which is opposite to the motion of the object. Due to motion of the point of the object we have: $\nu_2\cdot(c+v)/c = \nu_2\cdot(1+v/c)$. In a similar way, we will come to:

$$\nu_2/\nu_0 = \sqrt{1 - v^2/c^2}/(1+v/c) = \sqrt{(1-v/c)/(1+v/c)} = (1-v/c)/\sqrt{1 - v^2/c^2}$$

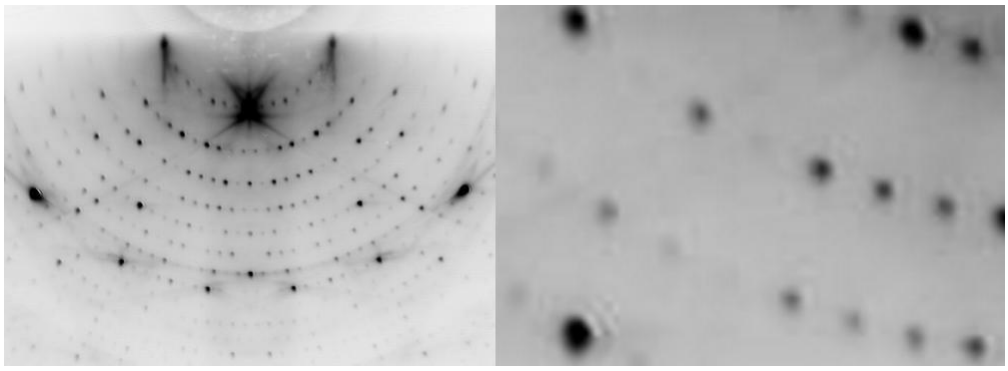
Using the 3rd expressions, we will see that $E_{motion}=E_0\cdot(\nu_1/\nu_0)+E_0\cdot(\nu_2/\nu_0) = E_{rest}/\sqrt{1-v^2/c^2}$, and $p_{motion}=((E_0\cdot(\nu_1/\nu_0)-E_0\cdot(\nu_2/\nu_0))/c = (E_{rest}/c^2)\cdot v/\sqrt{1-v^2/c^2}$, i.e. we will obtain the very thing we wanted.

Part 8. The topic is almost exhausted. Conclusions about possible expansion of the topic.

The purpose of this article is to familiarize schoolchildren with a simple ("wave") interpretation of Special Theory, so we have to restrict ourselves in presentation thereof. The interpretation shows that our whole world is just a picture made of "wave pictures" on a certain wave medium. Yet I would like to mention some points of potential expansion of this approach onto other problems, Quantum Mechanics and Gravitation.

I'd like to note that beginning from a certain time theoretical physics settled down to a course of purely formal schemes and, saying it honestly, it resembles more and more a type of a mixture of mathematics, "chemistry" and "circus show".

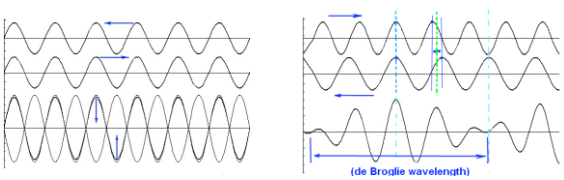
To confirm this "wave interpretation", I would like to show one example of interference of electrons found in Internet. I can't say it for sure, but it seems to me that apparent samples of a "standing wave" can be seen in the magnified fragments. Apart from the main maximum, additional concentric wave zones can be seen in the "highlighted points". It is possible that the cross section of the wave structure of electrons (which is characterized by the "standing wave" type) has been manifested itself in such a way.



Picking up way to Quantum Mechanics

1) There is a so-called "wave function" in Quantum Mechanics whose history is like that. In 1923 de Broglie suggested that the electron, similarly to the photon, possesses a certain frequency in accordance with Planck's law $\nu = E/h$: $\nu = mc^2/h$. Having nothing else, de Broglie "assumed" that there is some harmonic process progressing **synchronically** within the whole volume of the particle. (In general, there are no such processes in physics. For instance, vibrations of a "standing wave" are synchronous but are in anti-phase in adjacent zones). Then, de Broglie used Special Theory. Its violation of a " simultaneity" in moving object converted synchronous vibrations into a wave running forward with the speed which exceeded c: $V=c\cdot(c/v)$. There are no such waves on wave media. It was decided to treat this wave as **"probabilistic"**.

In our model, Special Theory as such arises from analysis of moving wave structures. It is the opposite. And we shall not gamble on such concepts as phase and group wave speed, as it is done when interpreting Special Theory in the standard way.



2) Let's examine the pair longitudinal to the direction of motion. **At rest,** "wavelengths" in pair are equal; maximums (as well as minimums) of the both waves meet all **at the same time** and **in the same**

places. It is a "standing wave". When the "object" moves, "wavelengths" will be already **different**. When these waves are added to each other, the maximums meet along the motion axis **not simultaneously**. Meeting places of maximums are running forward as "a certain wave". It is, as you can understand, "setting of time phase" in a moving object which we have examined. And, the speed of this time phase setting runs forward with the speed of **V=c·(c/v).** This wave is “a sort of” unreal, but in phenomenon of interference it will have to manifest itself as a de Broglie wave, as we will see later. We have already obtained its "wavelength" (**Λ= λ·c/v**). In this interval the wave which is running forward holds exactly by one “wavelength” more than the opposite wave does. And wave picture repeats over and over again.

3) About slit diffractions. May be, you know how a wave which passes through 2 slits generates a periodic interference image (a “comb”) at the “target”. “Good” and “bad” directions are alternating for two parts of the wave which have passed through slits (we mean that in "good directions" at the outlet in this direction the phase coincidences of the both parts do occur).

4) Now let’s turn to our case when we have 2 waves which are longitudinal to the line of motion of wave object, "direct" and "inverse" with a slightly different "wavelength". (The "direct" wave "is overtaking " the "object", so its "wavelength" should be less). Passing of the object is determined not by one wave but by two longitudinal opposite waves at coincidence of the both waves’ "good" direction. Let’s assume that there is a certain direction wherein **"good" conditions both for direct and inverse waves coincide**. A particle can move in this direction after the target. Now let’s deviate from this direction. At first, "good" and "bad" directions alternate for the both waves **almost** identically. Here we have a type of a "common" "comb". Afterwards, the conditions cease to coincide due to the difference of wavelengths. When a “good” condition is performed for one wave, it will not be performed for another, and vice versa. If a particles passes in these directions it can do it but in a bad way. But now the conditions begin to coincide as before, and we have a common “comb” again. I.e., difference of directions between the two combs will correspond just to de Broglie "wavelength" for slits, the angle wherein phase difference of two longitudinal waves accumulates a whole additional cycle.

If we assume that individual "cogs" of "combs" "are not resolved", i.e. merge with each other, then these "combs" will not be seen. Zones of passing corresponding to de Broglie "wavelength" will alternate.

Picking up way to Gravitation.

1) A couple of words about motion of particles in the gravity field. The fact that big cosmic masses bend photons’ trajectory ("as if" attracting them) can be treated as motion of waves in a field wherein the wave speed "**c**" diminishes while approaching the mass (i.e. when we examine the problem in terms of optics). As for formation of the gravity field itself, we can suppose that "masses" with their vibration energies can change (decrease or, say, reduce the medium elasticity) "**c**" in the adjacent space (and not only).

2) Now we think that while "falling" in the gravity field, a particle will increase its “kinetic energy” (and speed) due to decrease of “potential energy”. In reality, the following can take place. Neither objects without mass nor objects with a mass, while passing in the gravity field (like in an optical medium), do not change their total wave energy. We can suppose that "inside" gravitation, i.e. at a lesser value of "**c**", the same particle with a mass possesses **a lesser** wave energy of "**at rest**" state. In case of "falling", **the total** wave energy of the particle remains unchanged, while difference between "rest energies" is transformed into the form of a "moving particle" due to increase of Lorentz’s factor **β**.

3) A particle which possesses a lesser rest energy inside the gravity field will also possess lesser frequencies. So, atoms inside gravitation radiate photons with lesser frequencies. This phenomenon is referred to as "inner red shift". I remind you that we,

being built from wave particles, are not able to locally notice a change of "**c**".

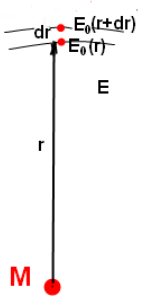
4) **Let's discuss one more important aspect relating to the category of "momentum" as such**, which is not quite well understood for wave objects. It will be useful when we account changes of "c". It would be logical if instead of **p** vector as a pair to **energy** E we chose the vector of **wave energy Flow**, for photon **Flow**=E·**c**. Why? There is a concept of m (mass) and concept of "mass **flow**" m·**v**, which we refer to as **p momentum**. There is a concept of **q** charge, and there is a concept of **flow** (transfer) of charge q·**v**, which we refer to as element of **j current**. You understand meanings of these concepts quite clearly. If we regard **m** and **q** as certain real matters, then their flows are real too, and laws of their conservation will have sense in definite conditions.

For an object of "**traveling wave**" type, **p momentum** in its conventional sense is equal to p=E/c, while the proposed **Flow**=E · **c**. I.e., we have the following relation of vector values: **Flow/p**=c^2. Please note that the relation is same as in the formula $E_0/m=c^2$. The formula for "standing wave" objects is **p**= (E·**v**)/c^2, which have been obtained by us earlier, and we automatically come to: **p**=**Flow**/c^2=(E·**v**)/c^2, as **by the definition itself** the flow of wave energy for these objects with mass will look like **Flow**=E·**v** . And the sense of conservation of **Flow** for a closed system is clear. It is similar to the law of conservation of **momentum**, for waves only. In "our" conditions, "**c**" will not practically change, so there is not difference in use of concepts **p** and **Flow**. And if "**c**" changes with gravitation? In this case transfer to the concept of **Flow** is inevitable.

5) In this interpretation of Special Theory we can show the proposed "optical variant" of the mechanism of a particle "drawing in" into the gravity field, i.e. into the zone with a lesser "**c**" value, and it is simple to obtain a radius of the so-called "black hole". Similarly to the way a trajectory of a photon is supposedly optically curved towards "cosmic Mass", **each harmonic** will curve in our "wave object with a mass" towards "Mass" optically. All curved harmonics increase the momentum of the wave object.

Let us try to understand how "c" can diminish with diminishing of r. At a certain value of r, "c" will convert into zero. We can suppose that elasticity of the medium will disappear at that.

We will suppose that **at state of rest** only frequency will change in an object with a lesser r (i.e. "c" will change, while dimensions and amplitude of vibrations will not change). There is one more supposition that Planck's law is complied here **E**= ν·**h** (ν ~1/**c**). Let's examine falling of the object from the state of rest from position of r+dr in position of r with **β**= $\frac{1}{\sqrt{1-v^2/c^2}}$. And now see some very simple computations.



$$\frac{E_0(r+dr)}{E_0(r)} = \frac{c(r+dr)}{c(r)} = \frac{c(r)+c'\cdot dr}{c(r)} = 1+\frac{c'\cdot dr}{c(r)} \quad (1)$$

$$\frac{E_0(r+dr)}{E_0(r)} = \beta = \frac{1}{\sqrt{1-v^2/c^2(r)}} \approx 1+\frac{v^2}{2c^2(r)} = 1+G\frac{M}{r^2}\cdot\frac{dr}{c^2(r)} \quad (2)$$

$$\frac{c'\cdot dr}{c(r)} = G\frac{M}{r^2}\cdot\frac{dr}{c^2(r)} \quad \text{or} \quad c(r)\cdot c'\cdot dr = G\frac{M}{r^2}\cdot dr \quad (3)$$

$$2\cdot c(r)\cdot c'\cdot dr = 2\,G\frac{M}{r^2}\cdot dr \quad \text{We integrate with respect to r.}$$

$$c^2(r) + \text{Const} = -2\cdot G\frac{M}{r} \quad (4)$$

$$c^2(r) = c_0^2 - 2\cdot G\frac{M}{r} \quad \text{or} \quad c(r) = \sqrt{c_0^2 - 2\cdot G\frac{M}{r}} \quad (5)$$

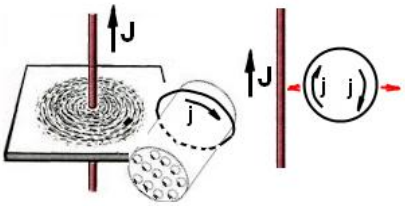
$$r_0 = 2\cdot G\frac{M}{c_0^2} \quad (6)$$

The ratio of rest energies in terms of **c (r)** (1). Thereafter – just the same but in relation to the gravitation law (2). Let's note that there is **c(r)** here. We equate the both relations and obtain a simple differential equation. We integrate it, defining a constant, in order to obtain **c(∞)=c0** at infinity. The radius of the "black hole" will be defined by the term **c(r)=0**. So, we obtain a generally accepted value of the "black hole" radius **r0**.

Opportunity of various approaches in gravitation. Apart from Special Theory of Relativity, Einstein (together with mathematicians) created General Theory of Relativity. Its essence is explanation of gravitation by "curvature" of our space (4D). I hope you understand that "space curvature" and "local depth" of this space can be created also by changing of optical properties of the wave medium. GTR is a very complicated thing, nothing but mathematics, tensor analysis. Only some particular cases may be examined "manually". In physics various models are frequently possible. The matter is a degree of

their adequacy and, preferably, simplicity.

I'd like to show you once again even not an idea but just a thought where from the so-called magnetic field (force) can be taken, that it is just a manifestation of Relativity. A picture of the magnetic field is formed by direction of iron **saw-dust**. As it was found, **position of saw-dust** is defined by the fact that they behave similarly to a "loop" or "coil" with current. It occurs due to ordering of electron structure in "saw-dust" atoms. So, we can restrict ourselves by examining a "closed loop" with current in the field of a conductor with current.



Ampere's law: conductors with identical direction of current are attracted to each other, those with opposite directions are repelled from each other. This very law defines position of "saw-dust". It is oriented in such a way that sections of the loop, taking into account direction of current therein, be positioned optimally in relation to the conductor current. Let us derive Ampere's law from Relativity.

We will take two positive charges, at rest and in motion with speed **v**. In the both cases mutual repelling and accelerated " runaway" of charges occur. At rest, Coulomb's force F_0 will be engaged. According to Relativity, time is retarded in **β** times in a moving system. It means that for an observer at rest **observed speed** of scattering charges will be diminished in **β** times, while **acceleration** will be diminished in β^2 times. But due to the fact that "inner energy" of charges will increase in **β** times, **inertia** (m) shall increase in **β** times.

So, while examining the problem in terms of the classical physics, $F=ma=(m_0\beta)(a_0 1/\beta^2)=F_0/\beta$. But instead of speaking about decrease of force F_0 at motion, physic scientists feel more comfortable when they formulate it in such a way that **F** of repelling would remain Coulomb's force = F_0, but here a certain "additional force" of " attraction" is added. $F=F_0/\beta \approx F_0 (1-(v^2/c^2)/2)) = F_0 - F_0(v^2/c^2)/2$. That is, apart from Coulomb's force at motion, the **attractive** force of two **one-directional currents qv** appears. When the opposite charges are counterbalanced in conductors with current, part of Coulomb's force will "disappear"; "addition" force in form of attraction of one-directional currents will remain and manifest itself.

If charges have different signs, then F_{add} the same in magnitude as we have obtained, but directed to repelling. Additional forces have, for clear reasons, the direction which is opposite to Coulomb's force between charges.

The alleged conclusion: a magnetic field is just a convenient method to describe certain phenomena.

And now a simple task which has to show weakness of formal approaches in SRT. Two planes are standing one behind another at a distance of 500 m. By a dispatcher's signal they begin to move at the same time and in the same manner, accelerate up to a certain speed v and fly with this speed. Everything is the same. What is the time in each of them from the dispatcher's viewpoint? Obviously, it is the same. But from the viewpoint of SRT, in a system which moves with speed v in the front plane the time should be retarded.

A. Einstein. On the Electrodynamics of Moving Bodies. Ann. d. Phys., 1905.
A. Einstein. Does the inertia of a body depend upon its energy-content? 1905.