NEW INSIGHT INTO CLASSICAL ELECTRODYNAMICS

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It is demonstrated that the magnetic field surrounding a chain of uniformly moving charges does not constitute a sum of magnetic fields of single charges but is a result of interaction between a test charge and all chain charges. A single moving charge is not surrounded by any magnetic field. Electromagnetic radiation and inductive effect are considered with the assumption that there is no magnetic field at all. It is pointed out that the classical electrodynamics can be based on the electric field formula of the charge moving arbitrarily.

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In the middle of the XIX century J.C. Maxwell composed a system of equations that theoretically generalized all then-known results of experiments with charged bodies, current-carrying conductors and magnetic needles. The system allowed the unified position explanation of almost all then-known pieces of evidence and introduced such new concept as a "displacement current" initially applied only to material media and then also to vacuum thanks to Lorentz.

Problems with the theory of ether led in 1905 to the relativity theory. On its basis Leigh Page reduced in 1912 [1] the number of "essentialities" and explained appearance of the magnetic forces previously reckoned to be a manifestation of a special "magnetic" field, using relativistic effects and the Coulomb's law.

Modern textbooks [2,3] give a conclusion of magnetic forces for at least parallel current-carrying conductors. But only [2] also shows a case of perpendicular motion of a single charge towards a chain of other moving charges in a quality manner. Hence, this matter should be considered hereunder in detail.

Fig. 1 illustrates a chain of equal charges moving along *x* axis with the velocity of $V_{c.ch.}$. Across to it and along *z* axis a similar test particle is moving with the velocity of $V_{t.ch.}$ (test charge velocity). The charges forming a chain will move in the frame of reference associated with it at the velocity of $\mathbf{V}`_{c.\ ch}$ at an angle of α to x axis and a straight line being equal to electric field intensity of current charges and will become oval as set in accordance the formula:

$$E = \frac{q}{r^2}\frac{1-\beta^2}{(1-\beta^2\sin^2\theta)^{3/2}}$$

where: q is the particle charge;

r is the spacing between a test particle and current particle in consideration;

θ is the angle between the vector velocity direction of current particle ($\mathbf{V}'_{t.ch.}$) in the new frame of reference and direction to a test particle;

$$\beta = \frac{V'_{c.ch.}}{\mathbf{c}}$$

c is the velocity of light.

The right upper part of the figure depicts electric field vectors of two symmetrically placed current particles at the test particle location.

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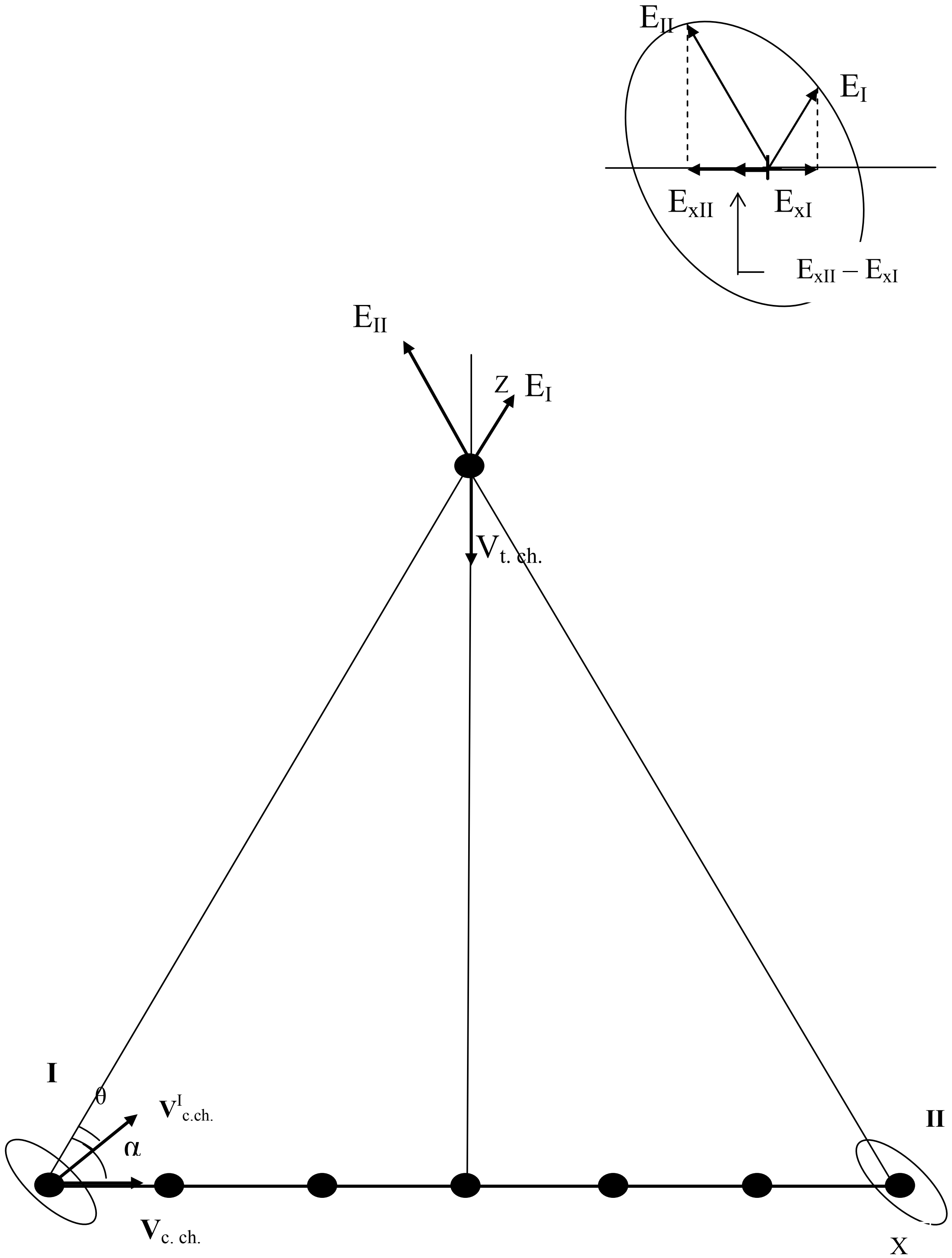

Fig. 1

Their projections on x axis are denoted by E_{xI} and E_{xII}. Since under review frame of reference these vectors are not equal, their projections on x axis will be not equal either. Their difference indicated as $E_{xII} - E_{xI}$ will lead after the transition to continuous of charges distribution and integration of all charges of the chain to appearance of a lateral force affecting a test particle:

$$F_x = -\frac{q\lambda}{z} \cdot \frac{\beta^2 \cdot \sin 2\alpha}{\sqrt{1-\beta^2 \sin^2 \alpha}}$$

where: λ is the charge density;

z is the coordinate of a test particle;

Upon recalculation of the force to laboratory frame of reference, it is easy to be convinced that it is equal to Lorentz force exerted by the magnetic field, generated by a chain of current charges, for trial charged particle, or, in other words, this time everything also comes to the Coulomb's law and relativity theory effects. And if electric field z-component of the chain of charges in consideration is compensated with an ion core charge of metal grid, then we will obtain a magnetic field of metal conductor with “pure” current, who served as the object of numerous studies of physicist of the XIX century.

Moreover, whereas the conclusions above are also true for attracting particles and the nature of interacting forces is of no significance here, the gravity-magnetic field appeared in the general relativity theory can be explained the same way.

A key feature resulting from the above conclusions is to be highlighted here: to generate an additional force affecting the moving test particle perpendicularly to its motive direction, at least two current particles are necessary, between which, upon transition to other frame of reference a spacing or direction of equivalent force operating on a test particle due to deformation of electrical fields of current particles should be changed. Single current particle is not surrounded by any magnetic field; it means that no matter how test particle is moving, the direction of force affecting it on the part of a current particle is always directed along a straight line through both particles [2] and any force perpendicular to the velocity direction of a test particle does not appear, as seen on Fig. 1.

In other words, magnetic field surrounding a chain of charges does not constitute a sum of magnetic fields of single charges but is a result of interaction between a test charge and all chain charges generating the current.

On the other hand, according to the present-day concepts [3], electric field is available around a single moving charge; it means that magnetic field also exists around a single moving charge:

$$\mathbf{H} = \frac{1}{\mathbf{c}}[\mathbf{v}\,\mathbf{E}]$$

and a force on a test particle from the current affect perpendicular to its velocity. It results in a paradox since when considering two moving perpendicular to each other charged particles [3] leads to violation of the Newton`s third law (Fig. 2). The particle I is moving within the magnetic field of the particle II and it is affected by full Lorentz force respectively. Meanwhile the particle II is affected in a certain period of time only by electric force, since the particle I don’t generate the magnetic field in its line of motion.

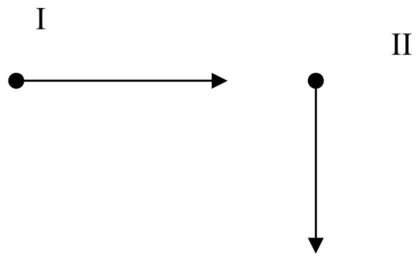

Fig. 2

Another paradox occurs when trying to apply to the Maxwell equation for **rot H** to a single moving charged particle. A certain L circuit around the trajectory of such particle and two surfaces I and II based on this circuit (Fig. 3) are demonstrated below:

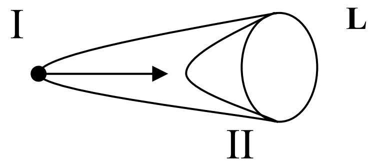

Fig. 3

Equation for **rot H** (circulation on L circuit):

$$\mathbf{rotH} = \frac{1}{c}\frac{\partial \mathbf{E}}{\partial t} + \frac{4\pi \mathbf{j}}{c}$$

In the right part, by Stokes' theorem there is a sum of two summands, where the first one accounts the time-related change of electric field over a certain surface based on the L circuit (displacement current) and the second one – current of charged particles flowing over similar surface. Fig. 3 shows how a single charged particle is crossing the surface I at a time. Therefore, both summands are available for this surface in the right part of the equation since the entire surface I is also exerted to changes of the electric field.

On the other hand, on the surface II is only a changed electric field and the second term on the right side of the equation is missing. Since the surface II used can be however similar to the surface I and changes of electric field thereon will be virtually identical, so as a result two values for rot H are obtained.

Furthermore, when deriving the well-known Rutherford formula for differential cross-sections of particle scattering:

$$\sigma(\theta) = \frac{1}{16}\frac{(e_1 e_2)^2}{E^2}\frac{1}{\sin^4\frac{\theta}{2}}$$

they pass into the frame of reference of the center of mass of both colliding particles; a particle being stationary in the laboratory frame is also moving in this frame, therefore, it should be surrounded by the magnetic field. But the deriving the formula, only the Coulomb`s interaction of particles is considered and correct result is obtained.

All these paradoxes can be explained with the assumption that the uniform motion of a charged particle and related electric field do not cause the appearance of a special “magnetic field” and the forces involved between two charged particles are always directed along a straight line connecting these particles.

Moreover, the Maxwell equation for ***rot H*** *obtained from experiments with metal conductors, i.e. where large ensembles of charged particles are moved, is not applicable to a single particle and a particle uniformly moving is not surrounded by any magnetic field.*

But supposing the magnetic field does not exist at all, then conflicts immediately emerge with contemporary concepts of electromagnetic wave propagation, according to which a wave is the venue of constant conversion of electric and magnetic fields into each other (Fig. 4).

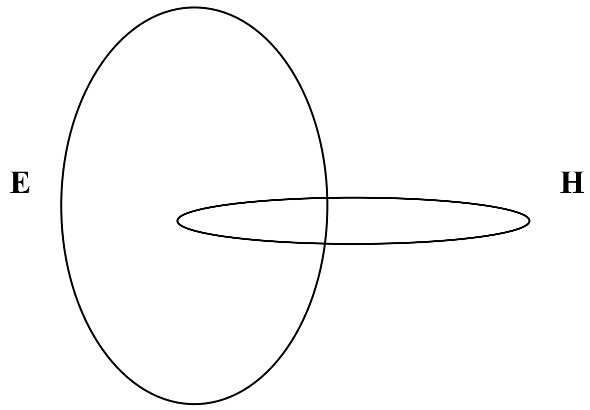

Fig. 4

If we have explained the forces appearing between the current-carrying conductors and attributed to the magnetic field effect using the Coulomb's law and relativity theory [1,2,3], i.e. it is proved that in this case a special “magnetic field” does not exist, but it is still not clear what the electric field is transformed into during the electromagnetic wave propagation.

In the sources of electromagnetic waves represented as a rule by various oscillating dipoles (sticking to the classical physics, the atomic and nuclear radiation are not considered here), electric charges are stationary at a certain time and spread to a maximum possible spacing, then an accelerated motion phase of these charges follows until they reach the maximum velocity in a quarter-period and finally the charges are inhibited and stopped. Their electric field at a given point is described by the equation [4].

$$\mathbf{E} = e\frac{\left(1-\frac{\mathbf{v}^2}{c^2}\right)}{\left(R-\frac{\mathbf{vR}}{c}\right)^3}\left(\mathbf{R}-\frac{\mathbf{v}}{c}R\right)+\frac{e}{c^2\left(R-\frac{\mathbf{vR}}{c}\right)^3}\left[\mathbf{R}\left[\mathbf{R}-\frac{\mathbf{v}}{c}R,\frac{\partial\mathbf{v}}{\partial t}\right]\right] \qquad (1)$$

where: **E** is the electric field of charge;

v is the charge velocity;

R is the radius-vector between a charge and observation point; (*R* is its length)

e is the elementary electric charge.

The second summand due to accelerated motions of electric charges has a dominant role at sufficiently large distances from the dipole,
outside the wave zone. It is this electric field extending in all directions from a dipole emitter reaches the receiving antenna and drives the electrical charges in them.

There is no need to suppose that between transmitting and receiving antennas is some transformation of the electric field in a magnetic field and back. In other words, the radio waves are simply oscillations of electric field with the wavelength equal to the spacing between the maximum points of this field.

If we refuse of the magnetic field concept, then the phenomenon of electromagnetic induction is to be explained. Basically, there is no big difference from the above case of charge interaction in two dipoles. Fig. 5 depicts two conductors, the lower of which is carrying alternating current, i.e. electric charges are moving therein with the acceleration $\partial \mathbf{v}/\partial t$.

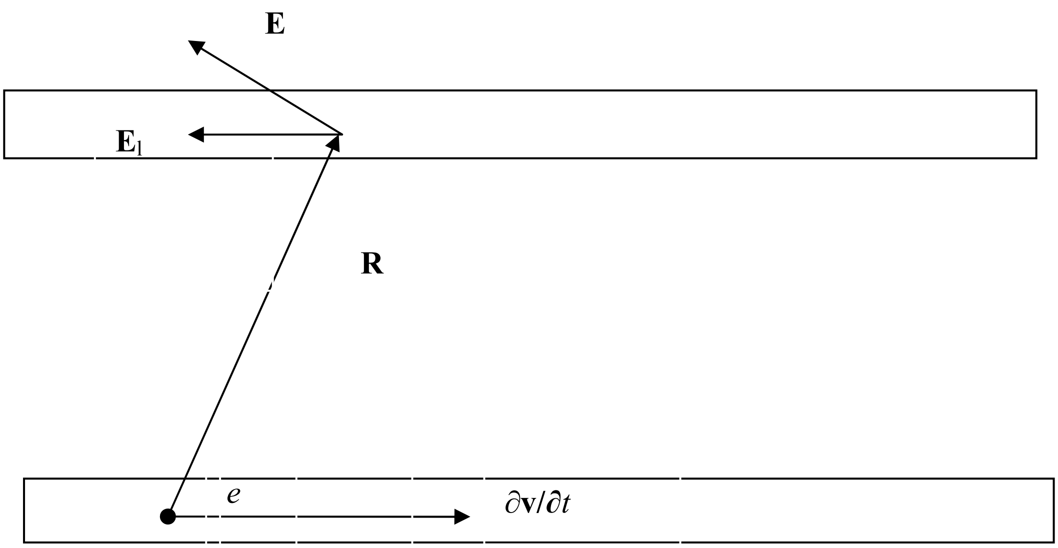

Fig. 5

For small in comparison with *c* velocity of the charge the formula (1) is considerably simplified:

$$\mathbf{E} = \frac{e\mathbf{R}}{R^3} + \frac{e}{c^2 R^3}\left[\mathbf{R}\left[\mathbf{R}, \frac{\partial \mathbf{v}}{\partial t}\right]\right]$$

Fig. 5 shows the field **E** determined only by the second summand of the last formula. The field component directed along the upper conductor $\mathbf{E}_l$, will ensure the charge motion therein and appearance of electromotive force at its ends, being the phenomenon of induction.

The self-induction phenomenon is explained the similar way. But in this case the parts of one and the same conductor wound into a coil are being interacted. In this case, the inductance inherent in the direct and guide as the above arguments about the mutual induction of two conductors remain valid for different charges of the same conductor.

The charges of the upper conductor are surely affected with the field determined by the first summand of the formula (1) too, but upon calculation of forces operating on these charges on the part of the lower conductor's charges everything is averaged due to the symmetry and the resultant force turns out to be directed across the upper conductor. Moreover, metal conductors are overwhelmingly applied in practice that is why the field of electrons determined by the first summand appears to be neutralized by ion core charge of the metal grid.

As far as the second summand depends only on the acceleration of charged particles, it follows that only alternating current can be transformed. Besides, it is seen from Fig. 5 that the electric field direction of the upper conductor is opposite to the charge acceleration direction of the lower conductor and it can serve as explanation for the fact known in the electrical engineering that in the transformer secondary phase voltage is turned 180 °. The same ground also relates to the Lenz's rule.

A short description of significance of the ferromagnetic cores is stated below. Taking into account the point of view represented here, it might be necessary to recognize that due to interaction between the lower conductor's electric field and ferromagnetic atomic current, it is the electric field they strengthen at the location of the upper conductor at Fig. 5.

It is assumed that the entire system of charged particles arbitrarily moving with different velocity and acceleration and interacting with each other and we are interested in the force exerted on any particle from all other particles. To calculate such force it is required to move from the laboratory frame of reference to system associated with this particle (i.e. to the one where the particle is stationary and, hence, not involved in magnetic interactions). In this case, change the speed and direction of motion of all particles in the system will inevitably.

Then using the formula (1), the electric interaction forces between this particle and all other particles of the system should be calculated in turn and vectorially summed (superposition principle). The resultant force derived will be the interaction consequence of the particle chosen and the rest of the particles in her frame of reference. Upon return to the initial, laboratory frame of reference, the force derived should be recalculated based on this frame of reference. In general, the recalculated force will differ from the initial both by the rate and direction to a difference vector. This is a general rule of the relativity theory used for all forces. But this difference vector is attributed in the classical electrodynamics to the effect of "magnetic field".

In general, from the philosophic point of view only the electric field exists. Between two electrically charged bodies there is "something" called the electric field and assuring a force interaction there between. To explain the forces being active between two current-carrying conductors, there is no need to enter another subject matter – the "magnetic field", because everything can be explained using the available electric field and relativity theory effects.

Though the concepts of magnetic field and its vector potential are applied to for the formula (1) derivation, the appearance in itself of additional electric field at accelerated motion of electric charges represented a separate law of nature and only due to our restricted knowledge and zigzags of historical development of science forced to bring to obtain a second term in formula (1) conception of a special "magnetic" field.

From this point of view it is interesting to consider the classical trials that led to formation of Maxwell equation system. First of all it is examining the trial showing the phenomenon of electromagnetic induction, which varies the distance between the two coils, one of which, fixed, constant current flows, and the other ends are connected to a galvanometer.

The electromotive force appeared in the second coil fully corresponds with the situation described on Fig. 1. When moving the coils closer, free conduction electrons of the moving coil appear in the position of a trial particle on this figure and they are affected by the force stated above and setting them in motion, while current is flowing in the circuit formed by the coil and galvanometer. Due to the relativity of motion nothing will be changed provided that the current-carrying coil is being moved, while the second coil is not disturbed.

The current changed in the first coil also causes the electromotive force appeared in the second coil. The reason of this phenomenon – the electromagnetic induction – is described above.

The classical electrodynamics founders made their trials just with the coils leading hereby to occurrence of a false concept on appearance of the electric field vortices at changing the magnetic field and magnetic field vortices at changing the electric field. Supposing that the magnetic field does not exist at all and all electromagnetic phenomena are explained with the Coulomb`s law, relativity theory and occurrence of supplementary electric field (specified by the second summand of the formula (1)) at accelerated motion of charges, then all Maxwell equations containing the magnetic field lose their meaning. In particular, when considering the electric phenomena in vacuum the “displacement current” is not needed any more. The term “displacement current” is only effective for electric phenomena in material media. Maxwell theory is a purely phenomenological theory, though allowing practically valuable results but not corresponding with the reality. Eventually Ptolemy theory of planetary motion also enabled the ships to safely enter the ports of destination, though having little common with the true Copernican theory.

But nowadays a powerful mathematical tool based on Maxwell theory and allowing valuable results of the electrical and radio engineering, and theoretical physics is designed. The magnetic field visualization of permanent magnets and current coils relates to the strengths of this theory. However, the situation here is similar to the case of planetary motion – in full accordance with Ptolemy theory, all celestial bodies seem to encircle the Earth.

In summary, it is to be noted as follows:

- a conundrum was created in physics where the forces affecting a particle moving near a current-carrying conductor are explained by two methods – either by influence of a special “magnetic field” or by the Coulomb’s law and relativity theory effects;
- attempting to apply the classical concepts to single charged particles paradoxes occur;
- contrary to the classical concepts, a single charged particle is not surrounded by any magnetic field;
- propagation of radio waves (and electromagnetic waves in general) and electromagnetic induction phenomenon can be explained not even using the “magnetic field” concept;
- “vortices” of electric and magnetic fields do not exist;
- “displacement current” is not available in the vacuum;
- *all electromagnetic phenomena specified in Maxwell theory can be clarified from a unified position on the basis of the relativity theory and formula (1) considered as a basic law of nature.*

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