Elementary Concepts of the Material World 2

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“OSNOVNE OSOBINE SVETA 2”

2.1. Theorem of Asynchronous Interaction

Following the field definitions 1.3 and 1.4, besides the theorem of mass, we can draw the theorem of asynchronous interaction between fields in accelerated motion[1].

Theorem 2.1. Field in accelerated motion affects other fields with forces different from those to which it is exposed itself.

Proof: Let us examine two fields q_1 and q_2 on fig.1. The fields are still on fig.1a.

From a starting moment the central point of field q_1 is being accelerated in the given direction (fig.1b) until velocity $\vec{v}$ is reached. During entire period of acceleration we have the following state:

The central point and parts of field q_1 are being accelerated and they travel a certain distance, while at the same time peripheral parts of the field have not even moved since information that acceleration began has not reached them (outside dotted circle field q_1 is still).

Since information of change in motion travels at finite speed (imposed by definition 1.4), the field q_1 at the position of the center of field q_2 has not yet changed and is the same as before motion began. Until arrival of information to q_2, force with which the field q_1 is affecting the field q_2 is the same as before the motion began.

At the same time, field q_1 is occupying position at a new distance from q_2. Based on changed distance, field q_1 is exposed to different force exerted by q_2, compared with the initial conditions on fig.1a.

Based on this on fig.1b we have $\vec{F}_{12} \neq \vec{F}_{21}$ and also $F_{12} \neq F_{21}$ for the duration of event.
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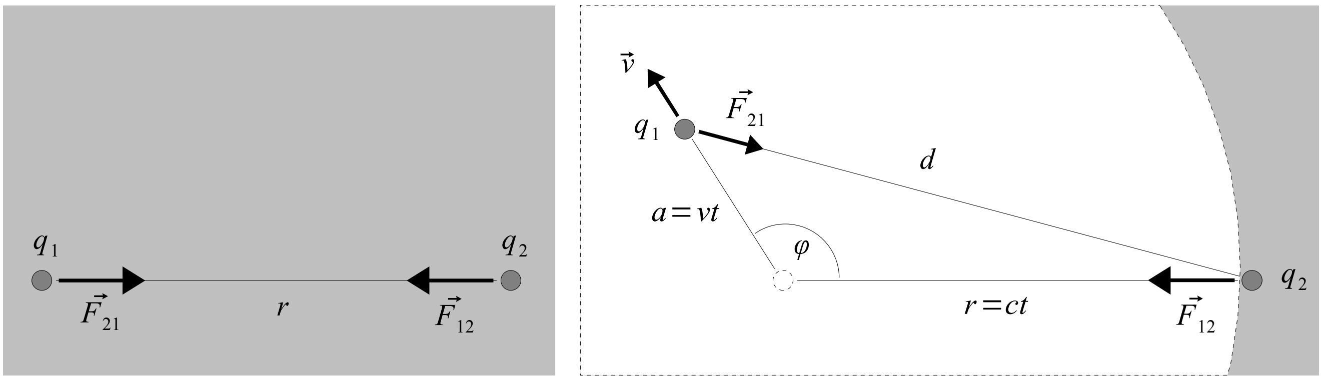

Figure 1. a) We have two static fields equally affecting one another. b) During acceleration of the field q_1, it is continually moving into an area in which strength of the field q_2 is different, while at the same time the field q_2 does not know that change has occurred, and is itself exposed to the unchanged force from fig.1a until information of change reaches it.

1 Theorem of Asynchronous Interaction proves that Third Newton's Law of Motion is not applicable in real time.

2.2. Particle Interactions in Accelerated Motion

Let us analyze interaction of particles at fig.1b. Prior to arrival of information of change we have:

$$F_{12}=k\frac{q_1 q_2}{r^2} \tag{2.2.1}$$

Particle q_1 is at distance d, at position where field of particle q_2 has not changed. Accordingly, particle q_1 is affected by force which now corresponds with distance d. Therefore we also have:

$$F_{21}=k\frac{q_1 q_2}{d^2} \tag{2.2.2}$$

Expressions (2.2.1) and (2.2.2) are valid for the entire period starting with initial change in motion, and up to the moment of arrival of information of this event to the second particle. This means that in this time frame forces F_{12} and F_{21} are not equal.

Distance d can be expressed using other variables from fig.1b,

$$d^2=r^2+a^2-2\,a\,r\cos\varphi \tag{2.2.3}$$

In moment t immediately prior to the arrival of information to q_2 we have $r=ct$ and $a=vt$. This gives:

$$\frac{1}{d^2}=\frac{1}{r^2}\;\frac{c^2}{c^2+v^2-2\,cv\cos\varphi} \tag{2.2.4}$$

or written differently:

$$\frac{1}{d^2}=\frac{1}{r^2}+\frac{1}{r^2}\;\frac{-v^2+2\,vc\cos\varphi}{c^2+v^2-2\,vc\cos\varphi} \tag{2.2.5}$$

Now expression (2.2.2) can be rewritten using (2.2.5), which gives:

$$F_{21}=k\frac{q_1 q_2}{r^2}+k\frac{q_1 q_2}{r^2}\;\frac{-v^2+2\,vc\cos\varphi}{c^2+v^2-2\,vc\cos\varphi} \tag{2.2.6}$$

In case that q_1 and q_2 are electrical charges, the first addend in (2.2.6) is electrostatic, and second addend is magnetic force.

In case that k is gravity constant while q_1 and q_2 are body masses, the second addend is dynamic component of gravity which has been unknown until now, and which is fully analogous with magnetic force in case of electricity.

2.2.1. Magnetic Effects of Conductor With Current

Starting with expression (2.2.6) we will derive expression which describes magnetic interaction of two conductors with current. In order to describe a system consisting of large number of particles, we will consider v^2 in (2.2.6) to be mean square speed of directional motion of electrical charges within the conductor. This comes as consequence of the fact that uniformity and constancy of motion of a large system is not possible. In reality we always have some kind of distribution of speeds - some speeds turn out to be more likely than others. We will not deal with statistical analysis here, but shortly, it is important to remember that root from mean square speed is different from mean arithmetic speed, and in the following analysis we will come across both.

We will first derive an expression for magnetic interaction of an infinitely long conductor with current on a single charged particle.

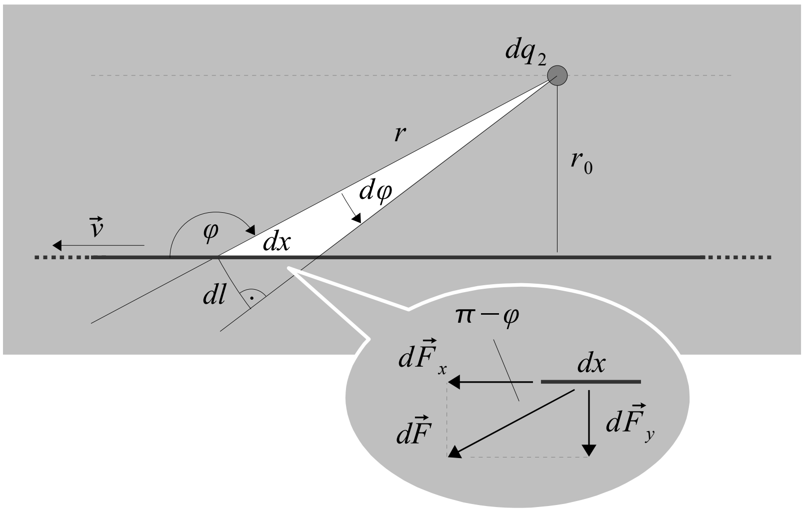

Figure 2. Force exerted by charged particle on an infinitely long, straight conductor with current. Total vertical force is determined by adding together all infinitesimal forces exerted on each portion of the conductor which falls within the angle $d\varphi$.

Using fig.2 we have the following relations:

$dl = dx \sin\varphi$, $dl = r\,d\varphi$ and $r_0 = r\sin\varphi$. From here we find $dx = \dfrac{r_0\,d\varphi}{\sin^2\varphi}$.

Next we have: $dq_1 = \lambda_1 dx$, $dq_1 = \lambda_1 \dfrac{r_0\,d\varphi}{\sin^2\varphi}$ where dq_1 is charge that makes electrical current in the conductor at length dx , while λ_1 is density of this charge expressed in $\dfrac{C}{m}$.

We are looking for integral sum of second addend from (2.2.6) along entire length of the conductor. We have:

$$dF_{21} = k\frac{dq_1\,dq_2}{r^2}\,\frac{-v^2+2vc\cos\varphi}{c^2+v^2-2vc\cos\varphi} \qquad (2.2.7)$$

Separately vertical and horizontal components of this force are:

$$dF_{21y} = dF_{21}\sin\varphi \quad \text{and} \quad dF_{21x} = dF_{21}\cos\varphi$$

Using (2.2.7) and already known relations for r and dq_1, we get:

$$dF_{21y} = k\frac{\lambda_1 dq_2}{r_0}\frac{-v^2\sin\varphi+2vc\cos\varphi\sin\varphi}{c^2+v^2-2vc\cos\varphi}d\varphi \tag{2.2.8}$$

$$dF_{21x} = k\frac{\lambda_1 dq_2}{r_0}\frac{-v^2\cos\varphi+2vc\cos^2\varphi}{c^2+v^2-2vc\cos\varphi}d\varphi \tag{2.2.9}$$

By integrating from 0 to π we find:

$$F_{21y}=k\frac{\lambda_1 dq_2}{r_0}\left(2-\frac{c}{v}\ln\frac{v+c}{v-c}\right) \tag{2.2.10}$$

It can be shown that expression in parenthesis can be written in simpler form $2-\frac{c}{v}\ln\frac{v+c}{v-c}=\frac{2}{3}\frac{v^2}{c^2}$, when $v\ll c$. This condition is always satisfied for electric currents, and we get:

$$F_{21y}=k\frac{\lambda_1 dq_2}{r_0}\frac{2}{3}\frac{v^2}{c^2} \tag{2.2.11}$$

Expression (2.2.11) describes total vertical force of charged particle dq_2 on an infinitely long conductor with current. In this expression, for obvious reasons [symmetry and superposition], point charge dq_2 can be replaced with conductor of unit length, with static charge of density λ_2, to get magnetic interaction of two conductors. Therefore we can write:

$$F_{21y}=k\frac{\lambda_1\lambda_2}{r_0}\frac{2}{3}\frac{v^2}{c^2} \tag{2.2.12}$$

Expression (2.2.12) describes total vertical force of a conductor with unit length, with static electrical charge, on an infinitely long conductor with current.

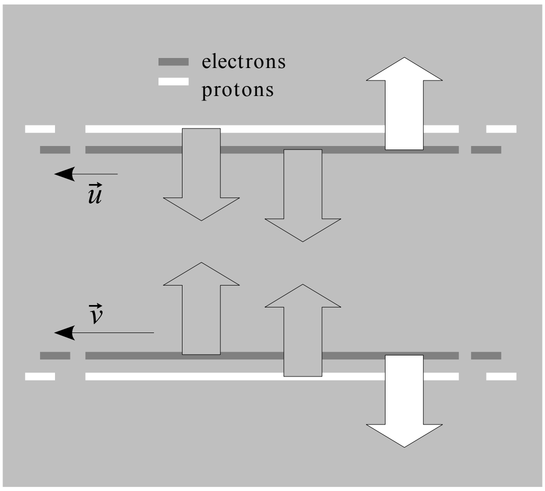

Figure 3. Two infinitely long conductors with current. Electrons are in motion in the directions of the arrows, while protons are static.

When electrical current flows through both conductors, we have the following forces, shown on the figure:

$$F_{21y}=F_{e\to e}-F_{e\to p}-F_{p\to e} \tag{2.2.13}$$

The minus sign denotes attractive force, and plus sign denotes repulsive force. Using (2.2.12), we have

$$F_{e\to e}=k\frac{\lambda_1\lambda_2}{r_0}\frac{2}{3}\frac{(v-u)^2}{c^2}\ ,\ F_{e\to p}=-k\frac{\lambda_1\lambda_2}{r_0}\frac{2}{3}\frac{v^2}{c^2}\ \text{and}\ F_{p\to e}=-k\frac{\lambda_1\lambda_2}{r_0}\frac{2}{3}\frac{u^2}{c^2}\ .$$

By substituting these individual forces into (2.2.13) we get:

$$F_{21y}=-k\frac{\lambda_1\lambda_2}{r_0}\frac{4}{3}\frac{vu}{c^2} \tag{2.2.14}$$

We know that $I_1=\lambda_1\bar{v}$, $I_2=\lambda_2\bar{u}$, where $\bar{v}$ and $\bar{u}$ are mean arithmetic speeds. As we have mentioned in introduction, v and u are roots from mean square speeds, which are in correct proportion with the total force. Between these values there is relationship:

$$v^2=\frac{3}{2}\bar{v}^2 \tag{2.2.15}$$

This relationship is based on Maxwell's distribution of speeds. The same goes for u^2 and $\bar{u}^2$ as they are appropriate speeds for the other conductor. Using this, expression (2.2.14) becomes:

$$F_{21y}=-2\text{k}\frac{\lambda_1\lambda_2}{r_0}\frac{\bar{v}\bar{u}}{c^2} \tag{2.2.16}$$

Knowing $k=\frac{1}{4\pi\epsilon_0}$, and using expression for current, we get the following expression for mutual force [per unit of length] of two conductors with current:

$$F_{21y}=-\alpha\frac{I_1I_2}{r_0} \tag{2.2.15}$$

where $\alpha=\frac{1}{2\pi\epsilon_0c^2}$. Value of this constant is $2\cdot10^{-7}\frac{Nm}{A^2}$.

2.2.2. The Pioneer Anomaly

Pioneers 10 and 11, which were launched in early 1970s and are now on their way outside of the Solar system, have been observed to be at locations which differ by a small, but measurable distance, from those expected by calculations.

This is what Wikipedia article on the anomaly states: “Analysis of the radio tracking data from the Pioneer 10 and 11 spacecraft at distances between 20–70 AU from the Sun has consistently indicated the presence of a small but anomalous Doppler frequency drift. The drift can be interpreted as due to a constant acceleration of $(8.74 \pm 1.33) \times 10^{-10}$ m/s^2 directed towards the Sun. Although it is suspected that there is a systematic origin to the effect, none has been found. As a result, there is growing interest in the nature of this anomaly.”

We have mentioned that expression (2.2.6) will work for gravity too, as the only requirement in its derivation was that information propagates with finite speed, which is true for any force field.

This means that gravity has a dynamic component, which depends on the speed and angle of motion relative to the source of gravity. This component, using (2.2.6) is:

$$F = k\frac{q_1 q_2}{r^2}\ \frac{-v^2 + 2vc\cos\varphi}{c^2 + v^2 - 2vc\cos\varphi} \tag{2.2.2.1}$$

We can write it like this:

$$F = k\frac{q_1 q_2}{r^2}\ \frac{-v^2}{c^2 + v^2 - 2vc\cos\varphi} + k\frac{q_1 q_2}{r^2}\ \frac{2vc\cos\varphi}{c^2 + v^2 - 2vc\cos\varphi} \tag{2.2.2.2}$$

The first addend is very small compared with the second, for $v \ll c$, which is here the case. So we can rely on very approximate expression:

$$F = k\frac{q_1 q_2}{r^2}\ \frac{2vc\cos\varphi}{c^2 + v^2 - 2vc\cos\varphi} \tag{2.2.2.3}$$

We can simplify it further as the denominator is $c^2 + v^2 - 2vc\cos\varphi \approx c^2$, which gives us:

$$F = k\frac{q_1 q_2}{r^2}\ 2\frac{v}{c}\cos\varphi \tag{2.2.2.4}$$

Acceleration alone is:

$$g = k\frac{M}{r^2}\ 2\frac{v}{c}\cos\varphi\ , \tag{2.2.2.5}$$

where we have substituted $q_1 = M$ for mass of the Sun, q_2 being the mass of the spacecraft and φ is angle between velocity vector and position vector.

Pioneer spacecraft coordinates which are available at one of NASA's websites, were used in a computer program to calculate corresponding dynamic component of gravity (2.2.2.5). This gives us the following information:

Distance from Sun (Pioneer 10) [AU]	Speed [m/s]	Dynamic acceleration [$\times 10^{-10}$ m/s^2]
10	17448	66.8
15	15696	20.1
20	14724	8.55
30	13679	2.65
40	13129	1.18
50	12788	0.64
60	12554	0.39
70	12386	0.26

This calculator (available for free at www.masstheory.org) is also used to calculate what would be equivalent constant acceleration to cause the same distance to be traveled towards the Sun. For a suitable range of distances, such as 10 to 70 AU we get 9.3×10^{-10} m/s^2 for Pioneer 10 and 8.2×10^{-10} m/s^2, for Pioneer 11. When start of the range is too high, the effect is too small.

It should be noted that the calculator literally starts taking into account the dynamic effect beginning with the start distance from drop down box. Contrary to that, any experimental finding cannot exclude drift speed that was acquired by spacecraft prior to reaching 20 AU, or whatever the distance was when analysis of data started.

However most importantly, as can be seen in the table above, the magnitude of this force is correct, and it is indeed directed towards the Sun, as this is simply an increase in intensity over existing gravity force.