

# The Magnetism as an Electric Angle-effect

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**Abstract** The magnetic force can be described very simply as a result of relative velocities of electric charges. Transformations in inertial reference systems are very well described by special relativity. However, magnetism nevertheless is simply regarded as given. There isn't an explanation for the emergence of magnetism yet. I have found a quite simple way to explain the emergence of magnetism, that is, I have discovered, how the electric field changes so that magnetism is created. I would like to introduce this idea here.

**Keywords:** special relativity, electric field, magnetism

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## 1. Introduction

The magnetic force is really somehow strange: Whenever an electric charge has a velocity, a magnetic field arises, which is both perpendicular to this velocity and perpendicular to the electric field of this charge. And whenever a charge has a velocity perpendicular to a magnetic field, a magnetic force arises, which is both perpendicular to this velocity and perpendicular to the magnetic field.

Both the source of the magnetic field and the charge on which the magnetic field has an effect must be moving. And the magnetic force is *always* perpendicular to the velocity.

This law on magnetism had been discovered soon, and as soon as that a problem was discovered: by changing into a reference system in which the source or the receiver (that is the charge on which the magnetic field has an effect) doesn't move the magnetic force disappears, of course. But a force cannot simply disappear. Einstein finally could solve the problem in a brilliant way by showing that not only the magnetic force but also the electric force depends on the reference system [1]. But, of course, he had to postulate that the speed of light is equal for all inertial observers or reference systems. And this means that space and time must be relative.

So, it was understood *when* a magnetic force arises - that is, whenever electrical charge is moving (both the one which produces the magnetic field and the one on which the magnetic field has an effect). But, *how* is the magnetic force actually being created? Why does a magnetic force arise, when charge is moving? This is still unknown. Einstein also has regarded the magnetic force simply as given.

Well, I think I can explain, how the magnetic force is being created. And it is astonishingly simple.

I must make two assumptions (in the meaning of postulates). These two assumptions can explain in an astonishingly simple way, how magnetism is being created.

I will introduce this two assumptions now.

I would like to anticipate that only the combination of *both* assumptions yields correct results.

In addition, the constancy of the speed of light is provided.

## 2. The Velocity-dependence of the Electric Force

The electric field moves or propagates with the speed of light. This electric field exerts an electrostatic force on a motionless electric charge which is calculated by Coulomb's law [2]. While the electric field exerts a force on the electric charge the electric field passes the electric charge with the speed of light. In a certain way the electric field flows along the charge while the electric force arises.

In a certain way it is possible to imagine that the flow of the electric field is the cause of the electric force. If this is so, then it seems logical that, among other things, the electric force also depends on the velocity with which the electric field flows. Thus, when the charge, on which the field has an effect, moves with its own velocity, then the velocity with which the field flows relatively to the charge changes, and therefore the electric force also changes.

Of course this is only a figurative portrayal which shall help to imagine the relations better. From this portrayal I derive the first assumption (in the meaning of a postulate):

The electric force depends on the velocity between the charge and the electric field.

This applies to both the charge on which the field has an effect, and the charge which produces the field.

This is the first of the two assumptions which I must make to explain magnetism.

Let us consider the electrostatic case.

The electrostatic force between two charges is calculated according to Coulomb's law: 
$$F_S = \frac{q_1 \cdot q_2}{r^2 \cdot \epsilon_0 \cdot 4\pi}$$

where  $q_1$  and  $q_2$  are the electric charges,  $\epsilon_0$  is the electric permittivity of free space, and  $r$  is the distance between the charges.

Now the electric force shall also depend on the velocity between the charge and the field. In the electrostatic case the velocity of the field relatively to the charge, on which the field has an effect, always is the speed of light. Thus the electrostatic force can be represented as:  $\vec{F}_S = \frac{q_1 \cdot q_2}{r^2 \cdot \epsilon_0 \cdot 4\pi} \cdot \frac{1}{c} \cdot \vec{c} \Rightarrow \vec{F}_S = F_C \cdot \vec{c}$ ,

where  $F_C = \frac{F_S}{c}$ .

This is the electrostatic case.

Now we consider the case that the charge, which produces the field (from now on I will call this charge source), is motionless, and the charge, on which the field has an effect (from now on I will call this charge receiver), moves with the velocity  $\vec{v}_E$ . Due to the velocity  $\vec{v}_E$  of the receiver the electric force ( $F_E$ ) changes: The electric force declines when the charge moves away from the field, and it increases when the charge moves towards the field.

So we get:

$$\begin{aligned}\vec{F}_E &= F_C \cdot (\vec{c} - \vec{v}_E) \\ \Rightarrow \vec{F}_E &= F_C \cdot \vec{c} - F_C \cdot \vec{v}_E = \vec{F}_S - F_C \cdot \vec{v}_E.\end{aligned}$$

At the addition of the vectors,  $-\vec{v}_E$  has to be used since the force increases when the receiver moves towards the field. We can see here that not only the magnitude of the electric force changes but also the direction (when the receiver moves with  $\vec{v}_E$ ).

We can quite generally state: Due to the  $\vec{v}_E$  of the receiver an additional electric force results in addition to the electrostatic force, and this additional electric force is proportional to  $\vec{v}_E$  and it points in the direction of  $-\vec{v}_E$  (that force is  $-F_C \cdot \vec{v}_E$ ).

In the portrayal of the field flowing along the charge it is that the  $\vec{v}_E$  produces an additional flow of its own. But, though, this additional force (generated by the additional flow) only can arise because there already exists an electric field which has an effect on the receiver, and to which the receiver can have a relative motion.

Now we consider the source. The postulate just stated says: The electric force depends on the velocity between the charge and the field. This statement doesn't only apply to the charge on which the field has an effect (that is the receiver) but also to the charge which produces the field, that is the source. So now it is all about the velocity of the source.

This means: The force of the electric field on a charge depends on the velocity with which the charge, which produces the field, moves. Or said differently: the strength of the field depends on the velocity with which the charge, which produces the field, moves.

When a charge doesn't move then its field moves with the speed of light away from this charge. In this case the force of the electric field on a charge corresponds exactly to the electrostatic force.

When the source moves, the relative velocity between the source and the field changes: in the direction in which

the source moves the field moves slower away from the source and in the opposite direction the field moves faster away from the source (compared with a motionless source). This means: in the direction in which the source moves, the force of the field (on a charge) is smaller and in the opposite direction it is greater (compared to the electrostatic force).

Actually, the velocity of the source is subtracted from the speed of light of its field.

The same is also valid for the direction of the field that moves perpendicular to the velocity of the source: the velocity of the source is subtracted from the speed of light of the field. But here the velocity of the source is perpendicular to the speed of the field. This means: not only the magnitude of the electric force of the field (on a charge) changes but also the direction of the electric force. It in principle is a simple vector addition. The resultant vector from the speed of light of the field of the source minus the velocity of the source is proportional to the force of the field on a charge. And of course this applies to all directions in which the electric field of the source spreads.

When the source moves with the velocity  $\vec{v}_Q$ , then the force  $F_E$  of this source on a motionless charge ( $\vec{v}_E = 0$ ) is:  $F_E = F_C \cdot (\vec{c} - \vec{v}_Q)$ .

To say it clearly: the field *always* moves with the speed of light, completely independently of the velocity of the source. Only the velocity with which the field moves away from the source depends on the velocity of the source, of course (for an observer who moves with the same velocity as the source the field moves away from the source just with the speed of light, of course). From this relative velocity then the force (on a charge) or strength of the field arises in the corresponding direction.

Here, there is an important aspect now: The change of the force of the field on a charge (that is the strength of the field), which results due to the velocity  $\vec{v}_Q$  of the source, *doesn't* change the direction in which the field moves.

Let us consider again the part of the field which moves perpendicular to the velocity of the source: the velocity of the source changes the direction in which the force of field acts but it *doesn't* change the direction in which the field moves (because the field continues to move with the speed of light perpendicular to the velocity of the source, of course).

This means: the direction, in which the force of the field acts (has an effect), doesn't coincide any more with the direction, in which the field moves.

With a little different words: the effect-*direction* of the field (that is the direction in which the field has an effect or acts) arises when the speed of light  $\vec{c}$  of the field is added up to the velocity  $-\vec{v}_Q$  of the source. The direction in which the field *moves* (with the speed of light  $\vec{c}$ ) doesn't change by this, of course.

Here perhaps it helps to imagine the effect-direction of the field as a kind of tension state. The field of a motionless source has a tension state which is proportional to  $\vec{c}$ . When the source moves with  $\vec{v}_Q$ , then the tension state changes by  $-\vec{v}_Q$ . But, this tension state continues to move with the  $\vec{c}$  of the field, of course.

In any case, an angle  $\phi$  arises between the effect-direction of the force and the direction in which the field propagates (that is the propagation-direction of the field). The direction and strength of the force arises, as said already, from the vector addition of the velocity  $-\vec{v}_Q$  of the source and the speed of light  $\vec{c}$  of the field. To calculate the angle  $\phi$  it suffices to use the component of  $\vec{v}_Q$  which is perpendicular to the direction of the speed of light of the field, this is  $\vec{v}_{Q\perp}$ . So we get:  $\tan(\phi) = \frac{v_{Q\perp}}{c}$ .

For the part of the field which moves exactly perpendicular to  $\vec{v}_Q$  it is  $\vec{v}_Q = \vec{v}_{Q\perp}$ , of course. The magnitude of the force ( $F_E$ ) of the field can be calculated very simply here:  $F_E = F_C \cdot \sqrt{v_Q^2 + c^2}$ . For the electrostatic force between two charges which don't move ( $\vec{v}_Q = 0$ ) it is, as said already:  $F_E = F_C \cdot c$ .

So we recognize here that the force of the field (on a charge) which moves perpendicular to  $\vec{v}_Q$  is also greater than the electrostatic force (because  $\sqrt{v_Q^2 + c^2} > c$ ).

I will later describe the case that both move the source (with  $\vec{v}_Q$ ) and the receiver (with  $\vec{v}_E$ ).

From the angle  $\phi$  between the force of the field (or the effect-direction) and the  $\vec{v}_Q$  I will derive the magnetic force.

But seriously: It is completely impossible that the electric force depends on the velocities of the charges in the way just described. For that reason the second assumption (postulate) which I must make for the explanation of magnetism is important: the anti-field.

### 3. The Anti-field

When the receiver moves with the velocity  $\vec{v}_E$ , then the electric force which is exerted by the field of a motionless charge ( $\vec{v}_Q = 0$ ) on this receiver is:  $\vec{F}_E = F_C \cdot (\vec{c} - \vec{v}_E)$ .

If the receiver moves exactly towards the source, then  $F_E = F_C \cdot (c + v_E)$ . But we know that this is completely impossible.

For that reason I define the anti-field. The anti-field cancels the effect which the  $\vec{v}_E$  has on the electric force, when the source is motionless ( $\vec{v}_Q = 0$ ).

What is the anti-field? The anti-field is a field which always arises when a field has an effect on a charge. It resembles a reflection. The anti-field acts in the same direction as the field, and it has, at motionless charges, the same strength as the field. The most important difference is, that it moves exactly in the opposite direction to the field!

In the electrostatic case the field and the anti-field have exactly the same effect. This means: the force on a charge comes exactly half from the field and half from the anti-field.

The force due to the field is:  $\vec{F}_E = \frac{1}{2} F_C \cdot \vec{c}$ . The field and the anti-field move in exactly opposite directions.

When the field moves with  $\vec{c}$ , then the anti-field moves with  $\vec{c}' = -\vec{c}$ . At the same time the anti-field acts in the same direction as the field. Thus the force  $\vec{F}'_E$  due to the anti-field is:  $\vec{F}'_E = -\frac{1}{2} F_C \cdot (-\vec{c}) = \frac{1}{2} F_C \cdot \vec{c}$ . And so the overall (resultant) force  $\vec{F}_{ER}$  from the field and the anti-field is:  $\vec{F}_{ER} = \vec{F}_E + \vec{F}'_E = F_C \cdot \vec{c}$ . This is the normal electrostatic force.

When the charges move, it is a little different.

When the receiver moves with  $\vec{v}_E$  while  $\vec{v}_Q = 0$ , then the electric force  $\vec{F}_E$  of the field on the receiver changes due to this velocity:

$$\vec{F}_E = \frac{1}{2} F_C \cdot (\vec{c} - \vec{v}_E) = \frac{1}{2} F_C \cdot \vec{c} - \frac{1}{2} F_C \cdot \vec{v}_E.$$

The force  $\vec{F}'_E$  of the anti-field on the receiver also changes and is:

$$\begin{aligned} \vec{F}'_E &= -\frac{1}{2} F_C \cdot ((-\vec{c}) - \vec{v}_E) \\ &= -\frac{1}{2} F_C \cdot (-\vec{c}) - \frac{1}{2} (-F_C) \cdot (+\vec{v}_E) \\ &= \frac{1}{2} F_C \cdot \vec{c} + \frac{1}{2} F_C \cdot \vec{v}_E. \end{aligned}$$

We recognize here that the electrostatic part of the field and the anti-field is exactly the same as in the case when  $\vec{v}_E = 0$ . Therefore it suffices to look at the additional part of the force which arises due to  $\vec{v}_E$ . For the field that is  $-\frac{1}{2} F_C \cdot \vec{v}_E$  and for the anti-field that is  $+\frac{1}{2} F_C \cdot \vec{v}_E$ .

The sum of these two parts yields zero ( $\frac{1}{2} F_C \cdot \vec{v}_E - \frac{1}{2} F_C \cdot \vec{v}_E = 0$ ).

So, when the force of the field changes by  $-\frac{1}{2} F_C \cdot \vec{v}_E$ , then the force of the anti-field changes by  $+\frac{1}{2} F_C \cdot \vec{v}_E$ .

This cancels each other out exactly mutually.

So we recognize: due to the fact that the field and the anti-field move in opposite directions a  $\vec{v}_E$  of the receiver doesn't cause any force. But, of course, only as long as  $\vec{v}_Q = 0$ .

So let us now see, what happens when the source moves with the velocity  $\vec{v}_Q (\neq 0)$ .

The field moves away from the source with the speed of light, therefore it moves away from the place of its origin. The anti-field moves exactly in the opposite direction. Thus it always moves exactly towards the place of the origin of the *field*.

The anti-field always appears then when the field has an effect on a charge. However, taken exactly the existence of the field can also be proven only when it is in interaction with a charge. The field is assumed to always exist principally. I am making the same assumption for the anti-field here now. The anti-field shall be always existing, too. In this sense, the anti-field cannot be regarded as a

reflection (of the field). Here now the anti-field would rather be a field of its own which always appears together with the field. The anti-field is exactly as the field a characteristic of space. Both characteristics, the one of the field and the one of the anti-field always appear together.

I am sure that there are connections between the anti-field and the anti-particles or the anti-matter [3]. But I am still not clear about these connections. However.

If the anti-field always exists, then its force (or strength) changes due to  $\vec{v}_Q$  exactly as the force (or strength) of the field changes due to  $\vec{v}_Q$ . But, though, the field and the anti-field move in opposite directions.

Let us at first consider the force of the field and of the anti-field on a motionless charge ( $\vec{v}_E = 0$ ).

The force of the field on a motionless charge due to  $\vec{v}_Q$  is  $\vec{F}_E = \frac{1}{2} F_C \cdot (\vec{c} - \vec{v}_Q)$  and the one of the anti-field is  $\vec{F}'_E = \frac{1}{2} F_C \cdot ((-\vec{c}) - \vec{v}_Q) = \frac{1}{2} F_C \cdot (\vec{c} + \vec{v}_Q)$ . Just as in the case in which the receiver moves with  $\vec{v}_E$ , while the source is motionless, in this case here ( $\vec{v}_E = 0, \vec{v}_Q \neq 0$ ) also only the electrostatic force ( $\vec{F}_{ER} = F_C \cdot \vec{c}$ ) remains.

At next we consider the case that both the receiver and the source move ( $\vec{v}_E \neq 0, \vec{v}_Q \neq 0$ ).

#### 4. The Angle $\phi$ of the Electric Field

When the source moves with the velocity  $\vec{v}_Q$ , then the vector addition of  $\vec{c}$  and  $-\vec{v}_Q$  yields the angle  $\phi$  ( $\tan(\phi) = \frac{v_{Q\perp}}{c}$ ) for the effect-direction of the field. For the anti-field the vector addition of  $-\vec{c}$  and  $-\vec{v}_Q$  yields the angle  $\phi'$ . At first this yields the angle  $\phi' = 180^\circ - \phi$ . But although the anti-field moves in the opposite direction to the field it still acts in the same direction as the field. Thus the effect-direction is turned by  $180^\circ$  so that:  $\phi' = (180^\circ - \phi) + 180^\circ = 360^\circ - \phi$ .

So the field has the angle  $\phi$  and the anti-field has the angle  $\phi'$ . These angles appear due to the  $\vec{v}_Q$  of the source.

The question is now: How do the angles  $\phi$  and  $\phi'$  have an effect when the receiver moves with  $\vec{v}_E$ ?

Well, due to  $\vec{v}_E$  the additional force  $\Delta\vec{F}_E = -\frac{1}{2} \cdot F_C \cdot \vec{v}_E$  results for the *field*. Due to  $\vec{v}_Q$  the effect-direction of the field is turned by  $\phi$ . Thus the additional  $\Delta\vec{F}'_E = -\frac{1}{2} \cdot F_C \cdot \vec{v}_E$  is also turned by the angle  $\phi$ . Due to the *anti-field* the additional force  $\Delta\vec{F}'_E = +\frac{1}{2} \cdot F_C \cdot \vec{v}_E$  is created which is turned by the angle  $\phi' = 360^\circ - \phi$ .

Now we form the resultant force from  $\Delta\vec{F}_E$  and  $\Delta\vec{F}'_E$ .

At first we consider the direction.

We know that electric forces can be either attractive or repulsive. In the case of repulsion the electric force acts in the same direction in which the field propagates with the speed of light  $\vec{c}$ , and it acts in the opposite direction to the speed of light  $\vec{c}' = -\vec{c}$  of the anti-field. This means that, at repulsion, the direction of the additional force ( $\Delta\vec{F}_E$ ) of the *field* arises directly from  $\Delta\vec{F}_E = -\frac{1}{2} \cdot F_C \cdot \vec{v}_E$  (the direction is given due to  $\vec{v}_E$  and the sign). This can be realized easily if, at repulsive electric force, a receiver is considered who moves with  $\vec{v}_E$  directly towards the source, while  $\phi = 0$  ( $\vec{v}_Q = 0$ ). In this case the repulsive electric force of the field must increase due to  $\vec{v}_E$  (and the one of the anti-field decreases accordingly). In the case of attraction the forces point exactly in the opposite directions.

At first now we consider the repulsion more exactly.

The additional force of the *field* ( $\Delta\vec{F}_E$ ) has a negative sign. This means that  $\Delta\vec{F}_E$  is turned by  $180^\circ$  relative to  $\vec{v}_E$ . And to the  $180^\circ$  the angle  $\phi$  is added up. So the angle *from*  $\vec{v}_E$  *to*  $\Delta\vec{F}_E$  is  $180^\circ + \phi$ . And the angle *from*  $\vec{v}_E$  *to*  $\Delta\vec{F}'_E$  is  $360^\circ - \phi$ . The magnitudes of both forces are equally grate, thus the angle of the resultant from  $\Delta\vec{F}_E$  and  $\Delta\vec{F}'_E$ , this is  $\Delta\vec{F}_{ER}$ , is exactly in the middle  $\frac{(180^\circ + \phi) + (360^\circ - \phi)}{2} = 270^\circ$ . Therefore, at repulsive forces, the angle *from*  $\vec{v}_E$  *to*  $\Delta\vec{F}_{ER}$  is  $270^\circ$ .

At attractive electric forces (between charges of opposite signs) the forces point exactly in the opposite direction. Therefore, at attractive electric forces, the angle *from*  $\vec{v}_E$  *to*  $\Delta\vec{F}_{ER}$  is  $270^\circ - 180^\circ = 90^\circ$ .

This also can be seen at the  $F_C$ . If  $F_C$  is positive at charges of opposite signs, then  $F_C$  is negative at like charges.

Let us check by a small example whether we have done it correctly: If like charges move in the same direction, then the magnetic force weakens the electric repulsion. So the  $\Delta\vec{F}_{ER}$  must point in the direction towards the source. This is  $270^\circ$ , exactly as it should. The  $270^\circ$  is measured clockwise. If all angles had been measured anticlockwise, then it would have been  $-270^\circ$ .

Now we consider the magnitude of  $\Delta\vec{F}_{ER}$ . Since  $\Delta\vec{F}_{ER}$  is exactly perpendicular to  $\vec{v}_E$ , this means, that the components of  $\Delta\vec{F}_{ER}$ , which are parallel to  $\vec{v}_E$ , cancel each other out exactly mutually. Therefore it suffices to add up the magnitudes of the components of the field and the anti-field which are perpendicular to  $\vec{v}_E$ . The magnitude of the component of the field which is perpendicular to  $\vec{v}_E$  is  $\Delta F_{E\perp} = \tan(\phi) \cdot \frac{1}{2} F_C \cdot v_E$ , and the one of the anti-field is  $\Delta F'_{E\perp} = \tan(\phi) \cdot \frac{1}{2} F_C \cdot v_E$ . The sum is

$$\Delta F_{ER} = \tan(\phi) \cdot \frac{1}{2} F_C \cdot v_E + \tan(\phi) \cdot \frac{1}{2} F_C \cdot v_E = \tan(\phi) \cdot F_C \cdot v_E .$$

$$\text{And } \tan(\phi) = \frac{v_{Q\perp}}{c} . \text{ Therefore } \Delta F_{ER} = F_C \frac{v_{Q\perp} \cdot v_E}{c} .$$

A little remark: the angle between  $\Delta \vec{F}_E$  and  $\Delta \vec{F}'_E$  is  $(360^\circ - \phi) - (180^\circ + \phi) = 180^\circ - 2\phi$  . Thus the angle between  $\Delta \vec{F}_E$  and  $\Delta \vec{F}'_E$  isn't zero. This means that  $\Delta \vec{F}_E$  and  $\Delta \vec{F}'_E$  cannot cancel each other out mutually.

The  $\Delta \vec{F}_{ER}$  corresponds to the magnetic force, so I call it shortly  $\vec{F}_M$  ( $\vec{F}_M = \Delta \vec{F}_{ER}$ ).

## 5. The Magnetic Force

So we get a force of magnitude  $F_M = F_C \frac{v_{Q\perp} \cdot v_E}{c}$  which is always perpendicular to the velocity  $\vec{v}_E$  . At like charges the angle between  $\vec{v}_E$  and  $\vec{F}_M$  is always  $270^\circ$  , and at charges of opposite signs it is  $90^\circ$  .

This meets exactly the conditions of the magnetic force.

The angle  $\phi$  of the electric field corresponds to the idea of the magnetic field here. Now one doesn't have to speak any more about the magnetic field, which is regarded as given, but one can speak about the angle  $\phi$  , whose way of emergence is known.

We know that the magnetic force depends on the relative velocities. This means that the magnitude of the magnetic force depends on the reference system. And this means that the magnitude of the angle  $\phi$  also depends on the reference system.

I had described that the angle  $\phi$  yields from the addition of the vector  $-\vec{v}_Q$  of the velocity of the source and the vector  $\vec{c}$  of the speed of light. We know from special relativity (SR) that the speed of light is equally big for all inertial observers. Of course, the velocity  $\vec{v}_Q$  of the source depends on the reference system. So, while  $\vec{v}_Q$  changes,  $\vec{c}$  remains constant; this means: the angle  $\phi$  changes (in dependence of the reference system).

This is actually fascinating: the magnitude of the angle  $\phi$  depends on the observer. The angle  $\phi$  isn't an abstract construct. The angle  $\phi$  is an really existing angle. It is the angle between the propagation-direction of the field (with  $\vec{c}$  ) and the effect-direction of the field. And still, different observers will see different angles. But such phenomena are known from SR. For instance the really existing dependence of space and time on the velocity of the observer.

Of course, the transformations between inertial reference systems are carried out quite normally according to SR. Not only the angle  $\phi$  but also the electric force changes so that the sum of both forces yields the right acceleration.

In this work here I have described the magnetic force as a result of the angle  $\phi$  of the electric field. So it makes sense to express the magnetic force by means of the electric force.

The magnitude of the electrostatic force ( $F_S$ ) is (as described already):  $F_S = F_C \cdot c$  . So the magnitude of the magnetic force ( $F_M$ ) is:  $F_M = F_S \frac{v_{Q\perp} \cdot v_E}{c^2}$  .

So we can calculate the magnetic force directly through the electrostatic force. We must neither calculate a magnetic field nor the cross product from  $\vec{v}_E$  and the magnetic field.

For instance the  $F_M$  of a current, flowing through a straight conductor, on a test charge can be calculated by calculating the  $F_S$  and the  $v_{Q\perp}$  for the respective angle and then integrating over the whole length of the conductor.

In the case that  $v_{Q\perp} = v_E = c$  we get  $F_M = F_S$  . At the speed of light the magnitude of the magnetic force is equally to the magnitude of the electric force. In the case that the source and the receiver move parallel, the magnetic and electric force cancel each other out mutually. This means: if charges could move with the speed of light, then they wouldn't exert any forces on each other. So, such charges could move together as a group. But, though, their masses could only exist in form of energy, as in the case of photons.

## 6. Electrodynamics

An electromagnetic wave is created when an electric dipole oscillates. When the distance between the charges is at its maximum the motion directions of the charges changes, in this moment the charges are motionless. And in this moment the angle of the field is zero ( $\phi = 0$ ) , while the electric field is at its maximum. When the charges pass by each other (the distance between them is zero), the electric field is (almost) zero for a moment (perpendicular to the motion direction), while  $\phi$  is at its maximum, because the velocity  $v_Q$  of the charges is at its maximum in this moment. This is the way, the alternating electric and magnetic field arises.

About this there is the very well known statement: A changing electric field produces a magnetic field and vice versa. This is in principle the central statement of electrodynamics [4]. It shall explain why e.g. a photon can exist so far away from its source.

In this work here I have defined the magnetic field by the angle  $\phi$  . The problem is: I couldn't explain why a change of the angle  $\phi$  should produce an electric field. This question must remain open.

However, I have an idea how it could be, of course.

Let us consider a single oscillating electric charge. Due to the oscillation, energy is transferred to the electric field. The energy amount which is transferred to the field per time is limited. In the consequence, the space area of the electric field which is exerted to oscillate also is limited. Said differently: the spatial limitation of the oscillation of the electric field arises from the amount of energy per time available. The reason for that is simple: a certain frequency of the oscillation of the electric field *requires* (!) a certain energy amount, for a certain space area. If only a

limited energy amount is available, then this will excite only a limited space area to oscillate, of course.

If the charge oscillates only for a limited time-*period*, then the oscillation of the field is limited spatially also in motion direction (its length in motion direction ( $\vec{c}$ ) is limited); this then would be an energy quantum, that is e.g. a photon.

The magnetic part, that is the angle  $\phi$ , arises automatically. When a charge oscillates, then it moves, of course, and due to this motion the angle  $\phi$  is created naturally.

So, due to the oscillation of a charge at first only a limited oscillation of its electric field arises, and this oscillation of the field is stamped with the angle  $\phi$ , which arises from the motion of the charge.

Usually a charge doesn't oscillates alone. Usually dipoles oscillate. But that's the same thing: here too, actually only the electric fields oscillate while  $\phi$  arises automatically due to the motion. The mutual dependence in the appearance of the electric and magnetic fields arises because the angles  $\phi$  are always then at their maximum, when the electric fields cancel each other out mutually. So one could assume that the electric field and the magnetic field *don't* produce each other mutually but that they appear alternately due to the way they are created. The stability of the formation arises from the energy amount which a space area must contain for an oscillating electric field.

So e.g. a photon is the spatially limited oscillation of an electric field, which contains the angle  $\phi$ .

The statement of the electrodynamics that a changing electric field produces a magnetic field and vice versa arises by the fact that changes of the electric field are always accompanied by motions of charges, and this motions produce  $\phi$ . All electrodynamic processes are based in principle on events which are similar to these which create the electromagnetic waves - with similar consequences regarding the alternating electric and magnetic fields.

In this sense the angle  $\phi$  can be applied to electrodynamic processes, too. The angle  $\phi$  is suitable to explain the emergence of magnetism here, too.

## 7. Conclusion

I think that I could show that the angle  $\phi$  of the electric field suffices completely to describe the emergence of the magnetic force.

I had to make 2 assumptions (postulates): the velocity-dependence of the electric force and the anti-field. This two assumptions permit to describe the electric and magnetic forces completely and consistent.

I think that the success justifies these two assumptions.

The description of the electromagnetic waves isn't complete yet. However, there isn't anything wrong with the angle  $\phi$ . The angle  $\phi$  is in principle not suitable to describe the propagation behaviour of the electric field in space. The angle  $\phi$  describes only the emergence of the magnetic force. For the description of the electromagnetic waves other connections will be probably necessary.

However, I think that I could show that the magnetic field isn't a field of its own but that it is only an angled electric field.

## References

- [1] A. Einstein, *Zur Elektrodynamik bewegter Körper Annalen der Physik* 17, 891-921 (1905).
- [2] Dieter Meschede: *Gerthsen Physik*. 23. Auflage, Springer, Berlin/Heidelberg/New York 2006.
- [3] PAM Dirac: *The Quantum Theory of the Electron. In: Proceedings of the Royal Society of London. Series A, Containing Papers of a Mathematical and Physical Character*. A, Nr. 778, 1928, S. 610-624.
- [4] James Clerk Maxwell, *A Dynamical Theory of the Electromagnetic Field*, Royal Society Transactions 155, 1865, Seiten 459-512.