

On Electric Field Produced by a Steady Current of Magnetic Monopoles

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Abstract—The symmetry of Dirac-Maxwell equations permits a steady current of magnetic monopoles to produce a static curled electric field around the current. An electric charge placed in it experiences an electrical force along the direction of the field about which the field is asymmetric. This asymmetry should reflect into the resulted motion of the charge. The usual electrical force equation $F = qE$, expressed in terms of the test charge and the applied electric field and may be referred as charge-field interaction, do not account this asymmetry. Therefore, it needs a generalization permitting the exertion of the force by the applied electric field on the electric field of the test charge, referred as field-field interaction. It accounts the asymmetry in the applied electric field. The possible effects of such generalization are analyzed. It is found that the behavior of an electric charge placed in a static curled electric field is similar to the behavior of the charge when placed in a static magnetic field. Therefore, it suggests that the true face of magnetic field can be curled electric field. It supports not only to the absence of magnetic monopoles in the universe but also provides a means to remove the magnetic field stuck to the electric charges.

I. INTRODUCTION

Magnetic monopoles, elementary particles with a net magnetic charge, have been a curiosity for physicists, and many of them believe that they ought to exist. These magnetic monopoles were originally proposed by Pierre Curie. Paul Dirac [1] developed a quantum physical theory of monopoles in 1931. Since electrical charges are quantized, Dirac was able to show that the existence of magnetic monopoles is consistent with existing laws of physics. He introduced them in Maxwell's equations [2]. These generalized equations are called Dirac-Maxwell equations [3] making them perfect symmetric with respect to electric as well as magnetic. Many current theories in physics predict that in the high energy state of the early universe, shortly after the big bang, magnetic monopoles would have existed in nature. Recently found that some condensed matter systems show a structure superficially similar to a magnetic monopole, known as a flux tube. The ends of the flux tube form a magnetic dipole. The ends move independently, therefore, they can be treated for many purposes as independent magnetic monopole quasiparticles [4]. Electrically charged particles, such as the electron, are everywhere. In contrast, no magnetic

monopoles, as predicted by Dirac, have ever been observed, despite intensive and prolonged searches. Therefore, it becomes vital to reinvestigate the fields to be produced by magnetic monopoles in order to unravel the secret of absence of magnetic monopoles. Here we analyzed the electric field produced by a steady current of magnetic monopoles. According to Dirac-Maxwell equations, it is a static curled electric field. Such type of field cannot be produced by a static or dynamic distribution of electric charges. Therefore it is not analyzed yet. The analysis shows that the usual force equation does not work as the field is asymmetric about direction of the force. This asymmetry must reflect in the resultant displacement of the charged particle. Therefore, the concept of field-field interaction, first used by [5], is used for the analysis. The analysis shows that the static curled electric field produced by a steady current of magnetic monopoles behaves similar to the field produced by a bar magnet. It implies that the said magnetic field produced by a bar magnet could be simply a static curled electric field.

In the following section the equation for static curled electric field produced by a steady current of magnetic monopoles is obtained. The motion of an electrical charged particle in this field is analyzed using the concept of force through field-field interaction, in the next section. The results are compared with the deflections observed in the field of a bar magnet. In the discussion how the static magnetic field produced by the bar magnet can be equivalent to the static curled electric field is reported.

II. ELECTRIC FIELD OF A STEADY CURRENT OF MAGNETIC MONOPOLES

Dirac-Maxwell's equations in vacuum are:

$$\nabla \cdot \mathbf{D} = \rho^e \quad (1a)$$

$$\nabla \cdot \mathbf{B} = \rho^m \quad (1b)$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} - \mathbf{J}^m \quad (1c)$$

$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J}^e \quad (1d)$$

where ρ^e and ρ^m are the electric and magnetic charge densities and \mathbf{J}^e and \mathbf{J}^m are the electric and magnetic current densities respectively.

Equation (1d) permits a steady current of electric charges to produce a static curled magnetic field and equation (1c) permits a steady current of magnetic monopoles to produce a static curled electric field. The electric field at point P (Fig. 1) produced by a steady current element $d\mathbf{I}^m$ of magnetic monopoles is

$$d\mathbf{E} = -\frac{1}{4\pi} \frac{d\mathbf{I}^m \times \mathbf{r}}{r^3} \quad (2)$$

The electric field produced by a long straight current of magnetic monopoles (Fig. 2) is

$$\mathbf{E} = \frac{1}{2\pi} \frac{I^m}{r} \quad (3)$$

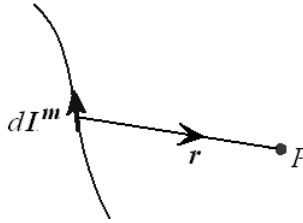


Fig. 1. Electric field of a current element of magnetic monopoles. The field is perpendicular and pointing into the plane of the paper.

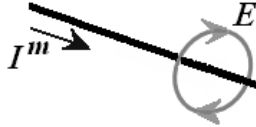


Fig. 2. Electric field producing by a straight, long and steady current of magnetic monopoles.

It is a curled static electric field decreasing away from the wire. Such type of field cannot be produced by a static distribution of electric charges. Therefore, the behavior of such a field for electrical charges is not reported yet. The usual force equation should not work here because the field is not symmetric about the direction of the force. The asymmetry must reflect into the resultant motion of the charged particle. Therefore, one has to use the method adopted in [4] in which the author suggested that whenever the field is asymmetric about the direction of the electric force, the field-field interaction method should be used. It accounts the asymmetry in the field. Fig. 3 shows the applied electric field is parallel and decreasing in upward direction only. An electron placed in it should experience an asymmetric force. Because of field-field interaction, the electron's lower field should experience a greater force (F_A) than its upper field (F_B) due to which it follows a curved path as indicated. This helps to analyze the motion of an electron beam in the curled electric field produced by a current of magnetic monopoles.

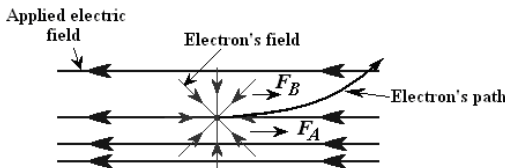


Fig. 3. Applied electric field applies force on the electron's field in terms of field-field interaction. As $F_A > F_B$, the electron follows a curved path.

III. MOTION OF AN ELECTRON IN A STATIC CURLED ELECTRIC FIELD

To examine the motion of an electron in the electric field produced by the steady current of magnetic monopoles, we take a cross section of the field as indicated in Fig. 4a. The field is circular with decreasing away from the monopole conductor wire. An electron gun fires electrons towards the wire. We analyze the force exerted by the field on an electron in the beam at three different points in the field. At point 1, the field of the wire is perpendicular to the velocity of the electron. This field applies force on the electron's field in downward direction. At every time for the analysis, we divide the electron's field through its centre into two parts, one is towards the wire with considering as field **A** and

the other is away from the wire with considering as field **B**. The electric field of the wire is strong in the region of field **A** than in the region of field **B**. Therefore, field **A** should move faster in downward direction than field **B** resulting into the electron to follow the curved path in downward direction. At point 2, the velocity of the electron is parallel to the electric field lines. Obviously, there should be a more strong force on field **A** than on field **B** in the forward direction of motion of the electron. Therefore, field **A** should have a greater velocity than field **B**. It turns the electron to follow the curved path in downward direction. At point 3, the velocity of the electron is again perpendicular to the applied electric field. The electric field of the wire applies force on the electron in upward direction. In this case, field **A** of the electron experiences more strong force than field **B** in upward direction. Therefore, field **A** should be pushed stronger in upward direction than field **B** and because of the forward direction of the electron; it turns in downward direction again. Thus the electron follows the curved path in downward direction though it experiences force of different directions at different places. At point 1 the force was in downward direction, at point 2, it was in the forward direction and at point 3, it was in the upward direction. This explanation is possible only because of the use force through field-field interaction.

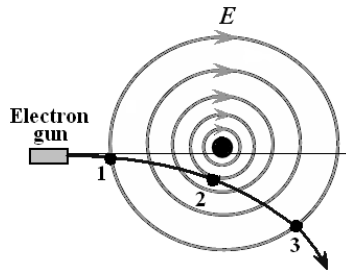


Fig. 4a. Electric field is decreasing away from the centre.

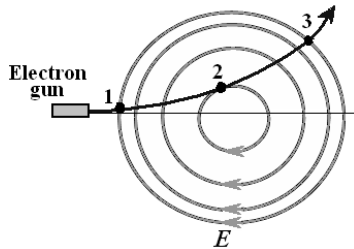


Fig. 4b. Electric field is decreasing towards the centre.

In Fig. 4a the electric field produced by the wire was decreasing away from the wire. It also becomes important to investigate the field when it is decreasing towards the centre. Such type of field and possible deflection of the electron is shown in Fig. 4b. The deflection is entirely opposite in direction of the previous, which can be understood as below.

The field, under examination, is decreasing towards the centre of the circles. For examination of the force and possible deflection of the electron in the beam, we consider three different points. At point 1, the applied electric field is perpendicular to the velocity of the electron. Again we divide the electron's field through its centre into two parts, one is towards the centre of the applied lines as field **A** and another is away from the centre as field **B**. At point 1, the applied electric field applies force on the electron's field in

downward direction. The electron gun has given initial velocity to the electron. At point 1, field **B** will be more pushed in downward direction than field **A**. This tends the electron to move in the upward direction along the curved path. Though the net force on the electron is in downward direction but it moves in the upward direction. This is only because of the imbalance force at the back and front side of the electron's field. At point 2, the applied electric field is parallel to the velocity of the electron. It tries to decelerate the speed of the electron. In region of field **B**, the applied field is strong than in region of field **A**. Therefore, field **B** should be more decelerated than field **A**, which tends the electron to move in upward direction with following the curved path as indicated in the figure. At point 3, applied electric field is again perpendicular to the velocity of the electron. At this time, it applies force on the electron in upward direction. Here field **B** experiences stronger force than field **A**. Therefore, front side of the electron's field experiences strong force than its back side field which turns the electron to move in upward direction along the curved path. At point 1, the force on the electron is in downward direction, at point 2 it is in opposite direction of its motion and at point 3, it is in upwards direction. Though the electron goes through different situations at different places, it follows the same curved path.

IV. DISCUSSION

We desire to search for whether the deflections, like in Fig. 4a and in Fig. 4b, are observed in fields of any type of material that already exist in the universe. Incidentally, we notice that we have observed such type of deflections in the field of bar magnets. It indicates that the bar magnets may have curled type static electric fields indicated in Fig. 4a and Fig. 4b. This coincidence is very important on the occasion of absence of magnetic monopoles in the universe. Further, the magnetic property obtained by a bar magnet is only because of the spin alignment of the unpaired electrons from the atoms in the bar magnet. The unpaired spin alignment must cause to produce the electric fields like in Fig. 4a and in Fig. 4b but we might be treating them as the magnetic field. If this is the fact then there could be a misunderstanding regarding the concept of magnetic field. In [5] author showed that a straight current carrying wire produces a parallel electric field around itself which we are treating as a magnetic field. Using that the attraction and repulsion between two current wires can be understood without invoking any magnetic field. The behavior of current carrying coil is similar to that of bar magnet. In fact, the current carrying coil may be producing circular electric field around itself, then the bar magnets should have same type electric field around themselves instead of the said magnetic field. Such type of fields in [5] is already considered to explain the attraction and repulsion between magnetic poles of bar magnet but the detailed structure has not been reported. The deflections observed in Fig. 4a and in Fig. 4b help us to describe the structure of the electric field of bar magnets.

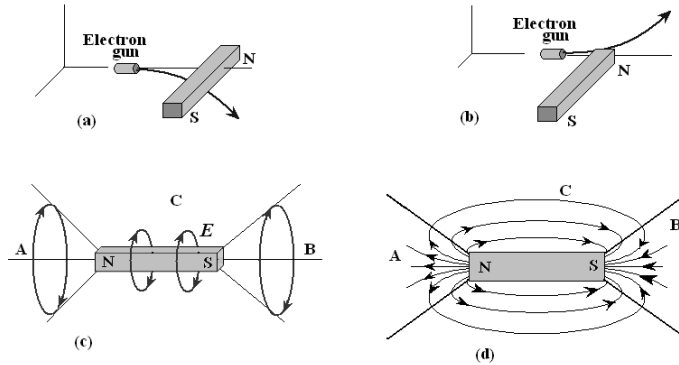


Fig. 5. Motion of an electron (a) in the region between two ends of a bar magnet, (b) at the end of the bar magnet. (c) possible electric field of the bar magnet. (d) magnetic field lines of the bar magnet.

According to the knowledge of the electric field of a current carrying coil, the electric field around a bar magnet should be circular and should have direction along the spin direction of the unpaired electrons as they are responsible to produce the magnetic effect. Obviously, the field should decrease away from the bar magnet. To observe the nature of the field, first we pass the electrons, emitted by an electron gun, in the region between the two ends of the bar and note the deflection as indicated in Fig. 5(a). Comparing with the deflections as discussed in Fig. 4a, the possible electric field directions should be as indicated in region C in Fig. 5(c). It is decreasing away from the bar in the perpendicular direction. Now if we shift the electron gun at one of end of the bar, the deflection gets reversed. It indicates that the field is decreased towards the axis of the bar but its direction is not changed. Therefore, it must have the same structure as discussed in Fig. 4b. No doubt, in regions A and B, the field is decreasing along the axis and away from the bar magnet but it is increasing away from the axis in perpendicular direction and must be max at the surface of the cones. In region C, it is again decreasing away from the surfaces of the cones. It gives answer why the magnetic field lines are reversed at the surfaces of the cones. Actually there is no change in the direction of the electric field in any region of the bar magnet but the way in which the field strength varies determines the deflection of the charged particle. The important point to be noted is that, while analysis, we have not impelled to consider the two end of the bar magnet as different types of ends like we have to consider for magnetic field treatment. Thus this theory may provide a new and realistic way to understand the realities about the said magnetic field of magnetic materials including heavenly bodies.

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