An experimental set up for detecting Weber's second order of magnetic force

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Abstract. Weber's equation of electrodynamics predicts a force which is proportional to the second order of relative velocity between charges in motion. However it is still debated on the existence of this force. This article proposes an experiment that could detect and measure this force.

Keywords - Charges, magnetism, Weber's force, experiment

Introduction

Weber's equation of electrodynamics gives the force **F** between two point charged particles q_1 and q_2 as (Eq. 1)

$$\mathbf{F} = \frac{q_1 q_2 \hat{\mathbf{r}}}{4\pi\varepsilon r^2}\left\{1 - \frac{(dr/dt)^2}{2c^2} + \frac{r\,(d^2r/dt^2)}{c^2}\right\} \qquad (1)$$

Where, $q_1$and q_2 are the two point charges, **r** is the vector connecting $q_1$and q_2 and ε is the permittivity of free space.

From which the force due to the second order of relative velocity can be written as (Eq. 2)

$$\mathbf{F} = \frac{q_1 q_2 \mathbf{Vr}^2 \hat{\mathbf{r}}}{8\pi\varepsilon r^2 c^2} \qquad (2)$$

Where, **Vr** is the relative velocity between them.

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Now, figure- 1 shows a current carrying wire KL (with a current I flowing through it) and a flat metallic strip OP placed near it. The conducting electrons in KL are moving with a drift velocity v in the wire KL.

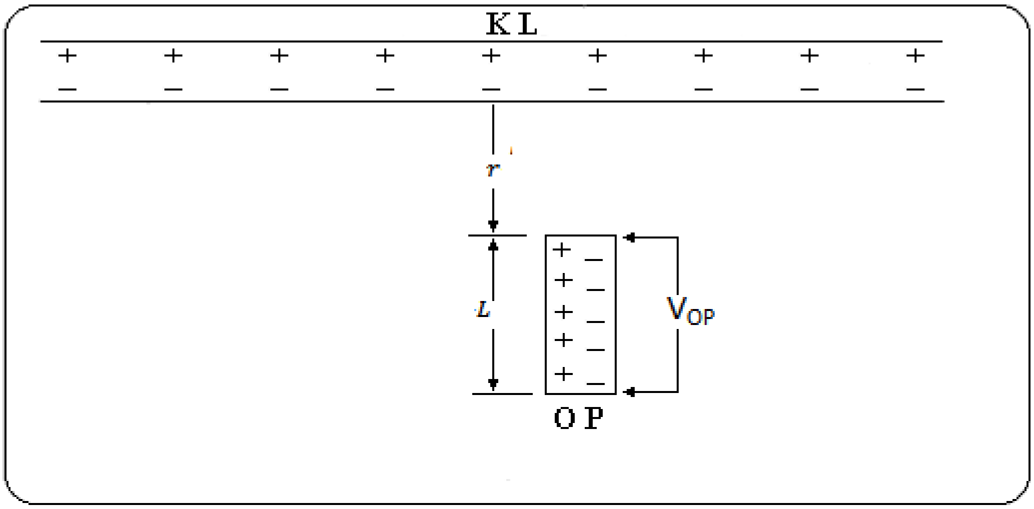

Fig. 1 shows a current carrying wire K-L and placed near it is a metallic strip O-P. According to Weber's electrodynamics, a potential is developed across OP as shown.

Accordingly, from Weber's equation, this results in a potential to be developed across OP , the magnitude of which is given by equation 3.

$$V_{OP} = \int_{r}^{r+L} \frac{\mu}{4\pi r} n A e v^2 dr. \qquad (3)$$

Where, n = no of conducting charges in unit volume in KL
A = area of cross section of the wire KL
e = charge of the current carrier
v = drift velocity of the current carrier
I = $nAev$

(Equation 3 can also be derived from the effects of Lorentz contraction on moving charges under similar situation. Hence, these two goes hand in hand with each other.)

The Experiment.

The following experiment is based on equation 3 that this force on the electrons is proportional to square of the relative velocity and sign of the concerned charges. So materials with different drift velocity (or with different current carriers) should exert different forces on charges placed near to them.

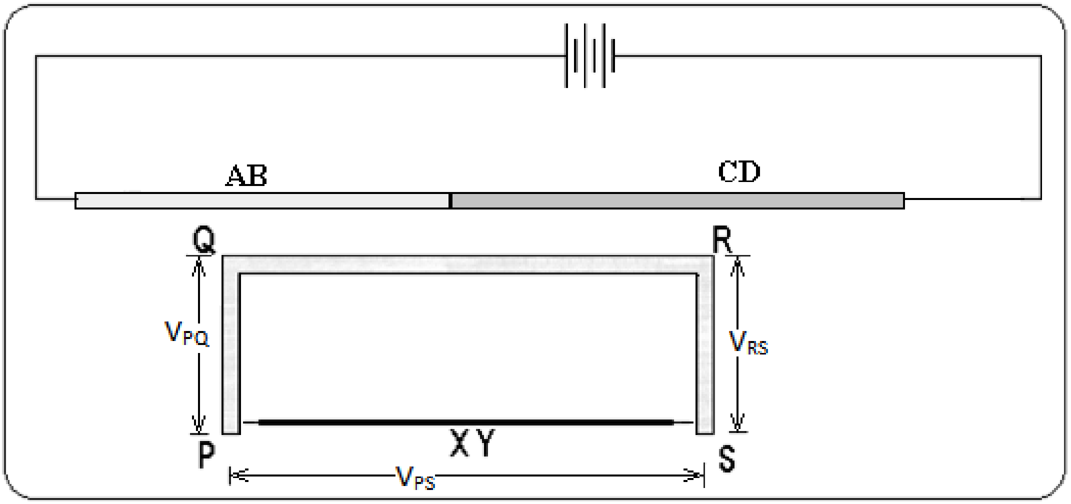

Fig. 2 One end of a normal resistive metallic wire AB is connected to CD in which the conducting charges are either positive or has a different drift velocity. So when a steady current is passed through AB-CD arrangement, the electrons in sections PQ and RS are repelled/ attracted quite differently thereby creating a potential difference between P and S.

Description of the experimental setup with reference to Fig. 2: - Portion AB and CD are made of two different conducting materials such that they have opposite charges as current carriers or the current carriers has different drift velocities (or both). AB-CD is connected to the end of a battery so as to make a closed circuit. PQRS is a piece of wire or a metal plate shaped as shown and is placed near this (AB – CD) arrangement. Therefore, electrons in sections PQ and RS are attracted repelled towards it differently. This causes a potential to be developed across PS.

Initially, a constant and steady current is passed through ABCD and a net potential difference is developed in PQRS (V_{PS}) which is due to the sum of–

1. Potential associated with Ohmic resistance and the 1st order of current flowing through ABCD (V_{PS1}) and
2. Potential associated with the 2nd order of current flowing through ABCD (V_{PS2}).

$$\text{I.e., } V_{PS} = V_{PS1} + V_{PS2} \quad (4)$$

Then, PQRS is closed with the help of metallic wire XY. Now, concerned with the Ohmic potential V_{PS1}, - as soon as the metallic wire forms a closed circuit, an initial current rushes from higher to lower potential which in turn nullifies this static potential and the associated current ceases to zero. Furthermore, as long as all parameters concerned with ABCD- PQRS set-up remains the same, there will be nothing to drive this potential up. Thus, $V_{PS1} = 0$. Therefore $V_{PS} = V_{PS2}$. Hereafter, XY is removed from the circuit.

With regarding the potential V_{PS2}, the conducting electrons in AB and CD attract/repeal electrons in sections PQ and RS with different magnitudes, this causes a steady potential to be developed across PS. Closing PQRS with XY causes a steady and continuous current to flow through the circuit. Now that PQRS is opened, this results in a potential being developed across PS which is given by the equation 5.

$$V_{PS} = V_{PQ} + V_{RS}$$

$$V_{PS} = \int_P^Q \frac{\mu}{4\pi\, r} n_1 A_1 e_1\, \boldsymbol{v_1}^2\, dr \quad + \quad \int_R^S \frac{\mu}{4\pi\, r} n_2 A_2 e_2\, \boldsymbol{v_2}^2\, dr \tag{5}$$

Here in equation 5, the subscripts 1 & 2 correspond to that of conductor AB and CD respectively.

Thus, V_{PS} being the only potential developed across PS, can be measured easily.

Summary.

Contradictory to the “once popular belief”, O.D.Jefimenko’s experiment has proved and lead to an increasing awareness that a conducting wire is charged in the lab frame and that there is a force on a charged particle placed near it which is proportional to the current flowing in the wire. However it is still disputed about the force which is proportional to the square of the current (or relative velocity) that might exist between them. It’s hoped that this could be one such experiment that could prove the existence of this force of second order.

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