Three systems show Lorentz force law clashing with special theory of relativity

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Abstract: Based on classical electromagnetic theory and special theory of relativity, three thought experiments are conducted and analyzed here. In all these cases, the Lorenz force law clashes with special theory of relativity.

Introduction

In 2012, Masud Mansuripur, claimed that the Lorentz force law—clashes with relativity, the theory that centers on how observers moving at a constant speed relative to one another will view the same events [1, 2]. To prove it, he concocted a simple "thought experiment" in which the Lorentz force law seemed to lead to a paradox. Later in 2013, four physicists independently said that they had resolved the paradox in comments in press at PRL [3]. To resolve this paradox, a concept of "hidden angular momentum" was introduced.

Before demonstrating our thought experiments, let's introduce a very popular case in which the paradox is claimed to be resolved by special relativity [2]. As shown in figure 1, a positively charged particle moves parallel to a wire carrying current in the same direction (see figure1, top left). The current produces a magnetic field around the wire. As the particle crosses the field, it feels a magnetic force attracting it toward the wire. In the frame of the particle, the wire still produces a magnetic field, but because the particle has no velocity it feels no magnetic force. Yet relativity requires that if an observer in one frame of reference sees a force, an observer in another frame should see an equal force. However, the special relativity predicts that observers moving at different speeds perceive lengths differently. In the particle's frame, the wire moves and its ions appear more closely spaced than they are in the lab frame. But the oncoming electrons move faster still and appear even closer together. The wire thus has a net negative charge (see figure 1, top right). That charge draws the particle with electric force equal to the magnetic force seen in the lab frame. Thus, the paradox was averted.

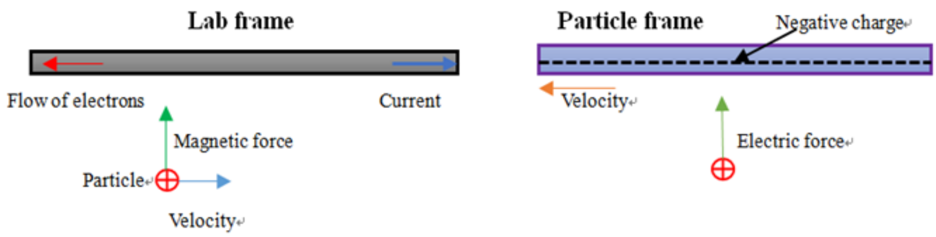

Figure1. A positively charged particle moves parallel to a wire carrying current in the same direction

Here in this paper, we present three "thought experiments", in which it is so obvious that the Lorentz force law clashes with special relativity. The paradoxes cannot be explained even if with the "hidden angular momentum". Followings are the details of the three “thought experiments” and analysis on how the Lorentz Force law clashing with special relativity.

Thought experiment 1

In this thought experiment, the wire is placed in a conductor cover, shown in figure 2. The conductor cover will screen any electric interaction between the positively charged particle and the wire (if any charges appear in the wire due to relativistic length contraction).

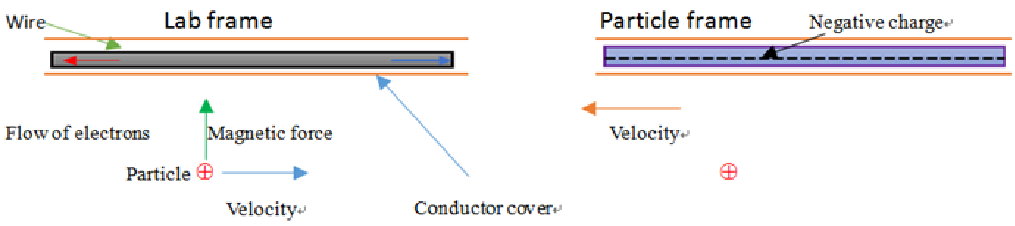

Figure2. A positively charged particle moves parallel to a wire carrying current in the same direction and the wire is placed within conductor cover

In this situation, according to classical electromagnetism Lorentz force law, the particle feels a magnetic force pulling it toward the wire in the lab frame, but feels no magnetic force in the moving frame where the particle has no velocity. Because of the conductor cover’s screening function, the so called extra negative charges in the wire due to relativistic length’s contraction does not cause any interaction between the current wire and the positively charged particle. So, there is no any force between the wire and the particle in particle frame. So, here the Lorentz force law—clashes with relativity. Actually, in an experiment [4], we already proved that the magnetic force is not a relativistic side effect of Electrostatics.

Thought experiment 2

In this though experiment, we consider two positively charged lines suspended in the space. The two lines are placed in conductor covers, as shown in figure 3.

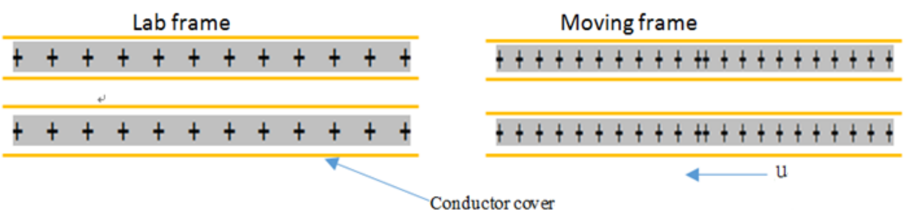

Figure4. Two charged lines wrapped within conductor covers are suspended in the space.
Left: The observer in lab frame sees that both the charged lines are stationary
Right: The observer in a frame which moves to right in a velocity of u will see that the two charged lines are both moving to left in the velocity of u.

In lab frame, because they are stationary there is no magnetic interaction between the two charged lines and because the conductor cover screened the electric field there is no Coulomb force between the two lines, either. In the moving frame, the charged lines are both moving to left with a velocity u. It looks like two parallel electric currents, so there will be an attractive magnetic force between the two charged lines according to electromagnetic theory. So in this system, there is no interaction between the two charged lines in lab frame, but there is a magnetic attractive force in moving frame. This violates special relativity.

Thought experiment 3

In terms of the two positive charged particles system, each is wrapped in a conductor box, as seen in figure 4. In the lab frame, both the particles are stationary, so there is no magnetic interaction between them and the Coulomb force is screened by the conductor box. But in the moving frame, we will see the two particles are parallel moving to right in a velocity of v. According to the classical magnetism theory, there will be an attractive magnetic force between the two particles. In two inertial frames, there is a force between the two particles in one frame but there is no force in the other. So, this violates special relativity, too.

Figure4. Two positively charged particles are wrapped within conductor boxes.

a. The observer in lab frame sees that both the particles are stationary

b. The observer in a frame which moves to left in a velocity of v will see that the particles are both moving to right in the velocity of v.

Conclusion:

From the above analysis on the three systems, we can clearly see that the classical electromagnetism Lorentz force law clashes with special theory of relativity.

References:

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