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Short Communication

A New Paradox Using Electrodynamics and Relativity

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ABSTRACT

The laws of physics including the laws of electrodynamics and relativity have worked very well so far when applied within their proper domain. But the history of physics hasn't always been smooth. Various philosophical, mathematical and physical consequences have sometimes led scientists to face arguments leading to paradoxes. Here, using the laws of electrodynamics and relativity, I propose a thought experiment which leads to a paradox challenging the common conception of reality. In this thought experiment, the two inertial observers will end up with paradoxical consequences while analyzing the measurement, taken from their own frame, from a force measuring device.

Keywords: Reference frame, observer, special relativity, paradox

INTRODUCTION

Observers play vital role in physics and especially in Special Relativity. [1] The observations of an observer must render valid within the domain of laws of Physics. Thus, observations are not arbitrary or a kind of illusions but are genuine consequences of the laws of Physics. Another important thing to introduce here is 'Measuring Device'. In physics, we define measuring device as a tool that is bound to some physical law or laws and is capable of giving data to certain degree of accuracy and precision. Such instrument in its perfect working condition must give the measurement of the required parameter for which it is designed for. And, it is a valid argument that such instrument will function properly for both kind of observer- moving or stationary.

Hitherto, I hope that the concepts of observer, observation and measuring device are clear as long as we are within the domain of Special Relativity.

The thought experiment

Thought experiments have always been an effective way for interpreting crucial arguments in history of physics so far. My thought experiment is like this.

Let's imagine an empty space (By empty space I mean, no forces are there.) Then, let there be two infinite lines of charges of uniform linear charge density ($+\lambda$), separated by a distance 'a'. Also, let there be a force measuring device between those two lines of charges which is designed to measure the force between two lines of charges.

Now, imagine there is a stationary observer assigned to a stationary frame 'K'. Similarly, there is also an observer assigned to K′-frame moving parallel and between the lines with velocity 'V'.

From the point of view of K- frame, there will be only an electric field. Magnetic field is zero in this frame as charges are at rest. The corresponding equations for electric and magnetic forces per unit length in this frame are; [2]

$F_{oE} = \frac{\lambda^2}{2\pi\epsilon_o a}$ (1)

$F_{om} = 0$ (2)

But, from the point of view of observer in K′-frame, there are both magnetic as well as electric field because charges are moving in this frame. Using the relativistic approach, the equations of electric and magnetic force per unit length between two lines of charge are; [3]

$F'_{oE} = \frac{\lambda\lambda'}{2\pi\epsilon_o a}$(3)

Where, $\lambda' = \gamma\lambda$ and $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$

$F'_{om} = I' \left(\frac{v\lambda}{2\pi\epsilon_o a c^2}\right)$ (4)

Where, $I' = \gamma\lambda v$

Since, current is of same nature, the magnetic force will be attractive whereas the electric field will be repulsive. Overall, the net force in general is somewhat different than that calculated with respect to the stationary frame. So, for both observers the fields and forces are different.

Now, what if we place a force measuring device (let it be digital) between the line charges and at rest relative to K-frame then let the two observers take reading from the device. The observer in K-frame will see a certain reading on device's screen. But what about the reading the observer from K′-frame will observe. Since, we have calculated different forces for these two frames, it is conceivable that both observers should see different readings. But, it will be something that breaks the boundary of our common sense as one can think that how the same device is going to show two different readings for two different observers. Meanwhile, our definitions of 'observation' and 'measuring device' and trust in the universality of laws of physics-whether it be relativity or be electromagnetism-favor the argument of different readings.

The paradox of two readings

At this point, it is clear that the device will either show different values of force or the same. But, what about the reality, the conception of which we construct on the basis of our perception. Reality is not what we perceive; what we perceive is reality. [4] Since both of the observers in this experiment have kind of their own world and whatever they perceive should be the reality for them-doubtlessly. In as much as the laws work in one observer's world, will also work in other observer's world.

The case of seeing different readings do seems more plausible as per the laws of electrodynamics and relativity and it also ensures the validity of the postulates of relativity. But, as long as we are normal, the notion of perceiving a different reading from the same device at the same time is somewhat ridiculous and indigestible. That how can a same digital screen show different measurement readings to two different observers?

Both cases stand equally strong in their arguments regarding the conception of reality and perception of our common sense, consequently leading to a paradoxical situation.

CONCLUSION

The theory of special relativity has passed almost every experimental test so far and thus seems flawless. But the paradoxical situation is also genuine. Since a measuring device (digital) is playing central role for the arguments of the paradox, there are possibilities for the experimental verification of this paradox. Therefore, a successful resolution of this paradox-either theoretically or experimentally-will prove a crucial move in the history of special relativity as well as to our conception of reality. Several other configurations-fundamentally the same with a measuring device-leading to the same arguments as this one are also possible.

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