

As I explained in an earlier article, “A short introduction to the history of physics, and string theory as a ‘Theory of Everything,’” Einstein derived his theory of special relativity from the observation that the speed of light is constant. In this article, I will explain the “reason” why the speed of light is constant regardless of the relative motion of any observers. Of course, we can never know the reason behind the reason; why was it God’s will to create the universe in this way? After all, He could have made our universe obey Newtonian mechanics, in which the speed of light is not constant and simple arithmetic works for adding and subtracting velocity.¹ Nevertheless, we can try our best to humbly guess why God chose to sacrifice the simple addition and subtraction rule for velocity in favor of maintaining the constancy of the speed of light.

To this end, let us recall that light is an electromagnetic wave, as postulated by James Clerk Maxwell. Maxwell calculated the speed of the electromagnetic wave and found that it coincided with the speed of light, and as Hertz later confirmed experimentally.² Loosely speaking, if an electric field fluctuates, a magnetic field is induced, and if a magnetic field fluctuates, an electric field is induced. When an oscillating electric field induces an oscillating magnetic field that in turn reinduces the oscillating electric field, the cycle generates and propagates an electromagnetic wave. An important implication of this picture, verified by Maxwell’s calculation of the speed of light, is that the speed of light depends on two constants: the ratio between how rapidly the electric field fluctuates and the strength of the induced magnetic field, and the ratio between how rapidly the magnetic field fluctuates and the strength of the induced electric field. (The strength of each induced field is proportional to how rapidly the other field oscillates.)

As God decided to make these two ratios constant regardless of the speed of any observers, the speed of light is constant. In other words, if the speed of light were not constant and our universe obeyed Newtonian mechanics, these two constants would depend upon the velocity of the observer. Apparently, God preferred not to have the velocity of the observer influence how strongly the electric field and the magnetic field induce each other.

Moreover, if God had chosen the speed of light not to be constant and the naïve addition rule to work for velocity, it would mean that there would be a special observer who alone would observe the speed of light as it is.

Let me clarify what I mean. When we say that the speed of sound is 340m/s, we mean that somebody who is not moving with respect to the air will measure the speed of sound to be this value. If you are travelling in the same direction as the sound wave, you will observe its speed as less than 340 m/s. If you are moving in the opposite direction as the sound wave, you will observe its speed as greater than 340 m/s. In these latter cases, you can say that you don’t observe the speed of sound as it is. Therefore, as far as

¹ Remember my discussion in the above-mentioned article. According to the theory of special relativity, 300,000 km/s “minus” 290,000 km/s is still 300,000 km/s; in a world following Newtonian mechanics, the result would be 10,000 km/s.

² Lorentz won the Nobel Prize in part for his successful calculation of the trajectory of light undergoing reflection and refraction based on the assumption that light is an electromagnetic wave.

the speed of sound is concerned, there is a special observer who measures the “correct value” of the speed of sound. Namely, the observer not moving with respect to the air does so. Similarly, if the simple rule of addition and subtraction of velocities worked and the speed of light were not the same regardless of the observer, it would imply that there is a special observer who could measure the value of the speed of light more correctly than those who are moving could. Recall that, in fact, the speed of light is constant whether you are traveling in the same direction as the light or moving opposite to the light. This was experimentally proven by American physicists Michelson and Morley in the late 19th century.

Let me explain how they found it. Similar to the way that air is the medium that transfers sound, physicists used to think that there is a medium that transfers light. They named it “ether,” (which has nothing to do with the chemical substance “ether,” despite the same name.) Therefore, if ether existed, and the Earth were moving relative to it, the speed of light would depend on the direction it was moving relative to the Earth. Think of our earlier examples. If the Earth were not moving relative to ether, the speed of light measured on the Earth would be same regardless of its moving direction, just as the speed of sound would be same regardless of the direction in which the sound propagates for someone not moving relative to air. However, if you are on a moving cruise, i.e. moving relative to air, you will feel a wind blowing. Say, if this wind is blowing toward you the speed of the sound approaching you will be greater than the one moving away from you. Similarly, physicists expected that the effect of “ether wind” would be found by carefully comparing the speeds of light moving different directions. However, no such effect was found. Moreover, still no such effect was found even in other seasons. Physicists naïvely expected that such effects would be found as the Earth rotates around the Sun, the direction the Earth is moving depends on seasons, making its relative velocity to ether change; even though “ether wind” was not observed in a certain season, it could be observed in another season when the direction the Earth moving changes. Apparently, that was not the case, and God didn’t want to single out any one observer who could measure the “correct value” of the speed of light. There is no such thing as ether wind. (Of course, it is possible that God singled out Earth, but that is as unlikely as geocentrism.) Every observer is equivalent.

I could give you now yet another strong piece of evidence in favor of this equivalence that was important for Einstein that he mentioned it in his famous paper. Nevertheless, this I postpone to another article of mine “Faraday’s law of induction from the point of view of magnetic force on moving charge,” as it requires the knowledge of Faraday’s law of induction.

Summary

- God preferred not to have the velocity of the observer influence how strongly the electric field and the magnetic field induce each other.
- God didn’t want to single out any one observer who could measure the “correct value” of the speed of light.