The special theory of relativity

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In the early twentieth-century, the scientific world was turned upside down by a revolutionary theory set up by a young physicist, Albert Einstein, in his patent office in Bern, Switzerland. The special theory of relativity is based on two postulates: the laws of Physics are the same in all inertial reference frames and the speed of light is the same for all observers in uniform motion[1]. At that time, it seemed to defy the laws of classical mechanics proposed by Sir Isaac Newton, more than two hundred years before.

Newton's theory stated that space and time are absolute. But, Einstein succeeded to prove that this theory does not apply when you approach the speed of light. Time beats at different rates in our Universe depending on your velocity[2]. The faster you move, the slower time beats. It is like the flow of a river, it sometimes speeds up, but it also slows down. One of the famous examples is the twin paradox: two 15 year old twins experience the time flow differently, one travels with a rocket at 80% of the speed of light, while the other stays on the Earth. After 30 years spent in space (on his watch), the twin returns and, surprisingly, discovers that his brother is now 65 years old, whereas he is only 45.

Another consequence of the special relativity theory is the length contraction in the direction of motion. The objects travelling with velocities close to the speed of light appear to shrink to an observer at rest. For example, a round football travelling very fast will look like an egg-shaped ball, like a rugby ball, as seen by an observer at rest.

$E=mc^2$ is, perhaps, the most famous equation known to mankind[3]. Einstein used relativity to show that as you approach the speed of light times beats slower, space contracts and you get heavier. The faster you move, the heavier you get. Energy of motion made you become heavier. This is called mass-energy equivalence. For instance, imagine a flashlight emitting a light beam. You know how much energy is released from the flashlight and, therefore, you can observe that the flashlight is lighter. This is, also, how the stars shine; they lose mass while emitting radiation.

There is, actually, an enormous quantity of energy in a small mass of matter, even at rest: 1 kilogram of matter is equivalent to $(3\text{x}10^8)^2=9\text{x}10^{16}$ Joules! But, can the energy be released? Yes, in nuclear reactions, the total energy is conserved and thus, the mass defect is released as energy from the reaction. Likewise, whenever energy is added to an object, the mass increases: if we heat 1 kg of water (specific heat capacity c=4,180 J/Kg K) by 1°C, its mass increases by $4.6\text{x}10^{-14}$ kg. Therefore, neither mass, nor energy is gained or lost by the system; it is just transformed from one to another[4].

The special theory of relativity has the reputation of being difficult. It is not difficult mathematically, but it sometimes seems to defy common sense, by contradicting experience. However, it turns out to be correct and, now, plays a tremendous role in understanding our Universe.

520 words

References

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