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A2_6 Don't Weight For Me, Lois

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Abstract

This paper details the calculation of time dilation observers would perceive of the fictional comic book character, Superman, were he to fly to the star closest to Earth, Proxima Centauri and back. The Lorentz factor was calculated to be $\gamma = 5.025$, assuming Superman was flying at 0.98 times the speed of light. In addition, we calculated that observers on Earth would perceive Superman flying overhead to be 0.38 m long, given a rest length of 1.905 m. The time Lois Lane would experience stationary on Earth, if Superman were to fly to Proxima Centauri and back, would be 43.7 years. Superman would experience just 8.7 years to have passed. The relativistic mass of Superman, flying at this speed was also calculated to be 522.6 kg from a rest mass of 104 kg.

Introduction

The popular DC Comics hero, Superman, boasts an impressive array of superhuman abilities. In addition to laser vision and super strength, he can also fly at incredible speeds. A paper published in Volume 15 of the Physics Special Topics Journal, University of Leicester [1], calculated that the speed at which superman had to have flown in order to rotate the Earth in opposition to its normal rotational direction, would have to be 98% the speed of light (c). While this is technically, physically possible, travelling at such a speed would result in Superman being at the mercy of Einstein's Relativistic laws. As an object approaches the speed of light, they will experience time dilation, whereby the moving object (or in this case, Superman) would experience the passage of time to be constant, however a stationary observer would 'see' the moving object's time as moving slower. As Superman travels closer to the speed of light, his mass would become relativistic, that is, his mass would increase by a factor governed by his speed. Length contraction is the third relativistic property Superman would undergo. This would cause him to appear, literally, contracted in length, to a stationary observer. With these concepts in mind, we calculated the relativistic mass of Superman, flying at 0.98 c and, calculated the time it would take Superman to travel to Earth's closest star, Proxima Centauri, and back. Lois Lane (stationary on Earth), however would not experience the same passage of time as Superman, so her relative increase in age is also calculated.

Calculations

To ascertain the time dilation and Superman's relativistic weight, we first calculated the Lorentz factor, γ, associated with Superman flying at such a speed. This is given by equation (1), where c is the speed of light (we have taken to be approximately, 3×10^8 ms^{-1}) and v is Superman's velocity . For 98% the speed of light, Superman was calculated to have a Lorentz factor of 5.025.

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \tag{1}$$

The relativistic mass of Superman, his rest mass is multiplied by the Lorentz factor. We first assumed Superman's mass of an athletic-built 6' 3" man (suitable for body building), 104 kg [2]. With this, Superman's relativistic mass was calculated to be 522.6 kg (or 82.3 st!).

For the calculation of length contraction, we set the reference frames to be S' for the moving object, Superman, and S for the stationary reference frame of Earth. Superman's height is 6' 3" [3], which equates to 1.905 m. With the equation for length contraction given by (2) and setting Superman's height in his own rest frame (L'), the observed length of Superman, L, (as seen by the stationary observer) is 0.38 m.

$$L' = \gamma L \tag{2}$$

We then took the scenario where Superman flies to Proxima Centauri, 4.25 Light years from Earth [4], and returns. Travelling at 98% the speed of light, he would complete the outgoing and return journey (assuming he does not take any rest stops) in approximately 8.7 years. Keeping the Superman (moving) frame as the S' frame, the time dilation is calculated using equation (3). In this equation we set $\Delta t'$ to Superman's travel time to Proxima Centauri and Δt to the time Lois Lane, on Earth, experienced.

$$\Delta t = \gamma \Delta t' \tag{3}$$

From equation (3), the time elapsed for Lois Lane on Earth was approximately 43.7 years.

Discussion

When Superman flew at top speed (0.98 c), the laws of general relativity would cause him to appear just 0.38 m tall, to a stationary observer on Earth. This is presuming that an observer could actually perceive an object travelling so fast. When flying out to Proxima Centauri and returning, Superman would experience time dilation, the underpinning concept behind the 'twin paradox'. While Superman would have experienced around 8.7 years to have passed, Lois Lane would have aged by 43.2 years. In addition to these properties, Superman would have also experienced an increase in his rest mass, leading to a relativistic mass of 522.6 kg.

It is worth noting that, in some Superman story arcs, it is stated that his super-human powers are due to Earth's 'yellow Sun' [5]. Therefore it could be speculated that, as Superman flies further from our Sun, his superpowers may diminish. If we were to assume that Superman's powers were directly proportional to the intensity of sunlight he is exposed to, his super powers (including incredible speed of flight) would reduce by $\frac{1}{r^2}$, where r is his distance from the Sun. If this reduction in sunlight intensity to cause a decrease in speed, the trip would take much longer. As Superman slows, the Lorentz factor governing his relativistic properties, would also reduce. This would mean the difference in observed time, between Superman and Lois, would become less pronounced.

References

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[4] https://imagine.gsfc.nasa.gov/features/cosmic/nearest_star_info.html [Accessed 6 December]

[5] https://superman.fandom.com/wiki/Yellow_Stars [Accessed 21 November 2019]