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P3 4 How fast is hyperdrive?

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Abstract

In Star Wars: A New Hope, The Millennium Falcon is seen engaging hyperdrive and travelling at superluminal speed, causing the stars in the sky to stretch into long streaks. In this paper, we investigate the speed necessary to see such stretching, and calculate that the Millenium Falcon was travelling at over 1.5 times the speed of light, confirming that the motion was superluminal.

Introduction

In Star Wars: A New Hope, The Millennium Falcon is seen engaging "Hyperdrive", whereupon the stars visible through the window appear to streak against the night sky before the spaceship flies away. Hyperdrive is claimed to "allow starships to fly faster than the speed of light" [1]. In this paper, we shall determine the speed necessary to see a star become a streak as is seen in the Star Wars clip. We will imagine a spaceship located in orbit around Earth, and choose the star Alpha Centauri A as the target star. We then imagine that the ship engages hyperdrive, and observes the target star stretching the same amount as is seen in Star Wars. In order to estimate the speed, we need only two parameters: the amount of time the ship has been in hyperdrive, and the distance the star is perceived to have moved in that time. We chose to examine the stars in the Star Wars after 1 second had passed (as shown in Fig. 1) to simplify calculating the speed in m/s . To calculate this distance, we use the change in angular size, the distance from Earth to Alpha Centauri A, and trigonometry as shown in Fig. 2.

Figure 1: View from the Millennium Falcon 1 second after entering hyperspace, t=1.[2] The streak used is indicated by the red arrow.

Distance from Alpha Centauri A

We can determine the distance, d, to Alpha Centauri A using the parallax, p, in arcseconds, and the formula:

$$d = 1/p, \quad (1)$$

This will yield the distance in parsecs. Taking the parallax as 751 milli-arcseconds [3], we find that the distance in parsecs is 1.33 pc. Next, we determine the distance the ship has travelled relative to the star. Relativity tells us that this is the same as the distance the star moves relative to the ship; thus, we can construct a model where the star moves backwards a certain distance in a certain time, creating the smear effect we see in Star Wars. This distance can be approximated using the footage from Star Wars to tell us how far the star moves relative to it's own angular size in the sky, which can be converted using trigonometry to a distance.

Length of the streak

In Star Wars, the star circled in red in Fig. 1 starts at 6 pixels across, and the streak corresponding to this star ends up being 29 pixels long (calculated using Pythagoras, measured using GIMP, an image manipulation program), implying that the star has moved 4.8 times its original angular size. We used this same ratio on Alpha Centauri, which has an angular diameter of 8.31 micro-arcseconds, [4], and find that the angular size of the corresponding streak is 39.9 micro-arcseconds. We then used trigonometry to find the actual distance that Alpha Centauri has moved relative to the ship:

$$sin(\theta) = \frac{x}{d} \tag{2}$$

where θ is the new angular size of the star, x is the distance it moved, and d is the initial distance from the star, calculated earlier. Using the small-angle approximation and rearranging for x, we have:

$$x = d\theta \tag{3}$$

where θ has to be converted into degrees: 39.9 micro-arcseconds is equal to $111\text{x}10^{-10}$ degrees. Substituting these values in yields a distance travelled of $1.47\text{x}10^{-8}$ pc. Since 1 pc is approximately $3.09\text{x}10^{16}$ m, x ends up being equivalent to 453,642,000 m.

Conclusion

Since the Millennium Falcon travelled the distance calculated above in just 1 second, we can deduce that the speed of the ship in this interval was 453,642,000 m/s. Meanwhile, the speed of light, c, is known to be 299 792 458 m/s. This means the ship was travelling at approximately 1.51c, though this number fails to account for additional acceleration beyond 1s, however, so the top speed of the Millennium Falcon is probably much higher. In addition, relativistic effects such as length contraction and time dilation are ignored in this assessment, and may have an effect on speed calculations.

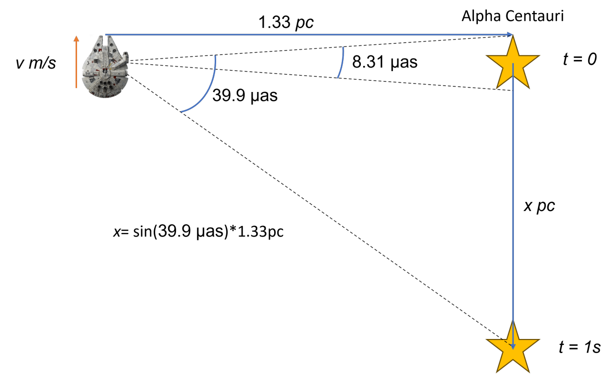

Figure 2: Diagram showing the movement of the star relative to the ship, the angular size of the star and the streak that results, and the distance from the star forming a right-angle triangle, allowing for the calculation of x

References

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