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Group P4_2 A Flashy Outfit

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Abstract

This paper explored the effect Flash's speed would have on the appearance of his uniform. It used the relativistic Doppler effect to analyse the change in colour of his uniform. It was found that when the Flash travelled at $0.9c$ he would only be visible $78° \leq \theta \leq 121°$ and $239° \leq \theta < 283°$ in the x axis. It was also found that the Flash would at times be a source of UV-C photons.

Introduction

The Flash has been a DC comics character since the 1940's [1], many different characters have worn the iconic red suit. The details of the Flash's abilities vary amongst different versions of the character. The key information though is the superhero speed and reflexes. The newer versions of the comics have attempted to ground the character by reducing his speed and introducing the nebulous term "speed force" as a catch all explanation. As a result, this paper will focus on the Flash's classical appearances ignoring the introduction of the speed force and the modern scaling back of his powers. The colour of Flash's uniform is always shown to be red; this paper is going to start with the assumption of a red uniform when he is stationary and investigate how this would change depending on the speed he reaches as well as investigating how the angle of his run affects it.

Equations

All equations mentioned in this section can be found in Ref.[2]. The equation used is the relativistic Doppler effect. When the source is receding from the observer, this is not always the case, however when the source is approaching the observer the negatives will cancel it to create the correct form of the equation.

$$f' = \sqrt{\frac{1-(v/c)}{1+(v/c)}} f_0 \tag{1}$$

Where f' is the new frequency of the wave, f_0 is the frequency of the wave at the source, v is the velocity of the source, c is the speed of light. This equation has been chosen as the Flash has exhibited relativistic effects, this is typically shown during fights when a punch takes a couple of seconds. In a stationary frame a punch takes $60 - 100\,ms$ (assuming a professional boxer is throwing the punch) [3].

$$\Delta t = \frac{1}{\sqrt{1-(v^2/c^2)}} \Delta t_p \tag{2}$$

Where Δt is the observed difference in time between two events, Δt_p is the proper time difference, v and c remain unchanged from Eq.1. A range of values for his speed can be obtained. $0.994c \leq v \leq 0.998c$. This is close enough to the speed of light to require the use of a relativistic approach to the Doppler effect.

Results and Discussion

The model used envisioned the earth as a flat 2-dimensional plane with an observer located at the origin of said plane. The z dimension was not included in the model as it is not a necessary dimension for this analysis although the results found could be extrapolated to also fit the third dimension. The Flash is located an arbitrary distance from the observer. The speed of the Flash is then kept the same whilst the angle the velocity vector makes with the x axis is increased to 360° . Therefore, the velocity changes but not the speed. The speed of the Flash was then increased from $0.1c$ to $0.9c$. The choice of going only to $0.9c$ was done to reflect conditions when not fighting a professional boxer.

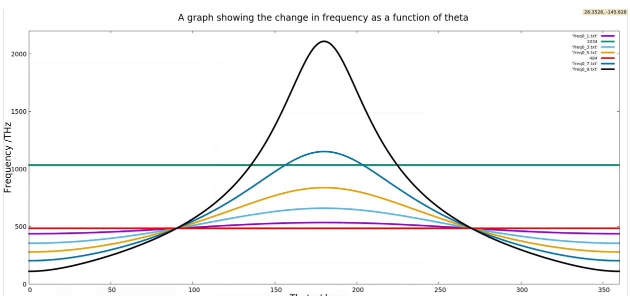

Figure 1: The figure shows several different speeds and how the variance of the vector angle with the x axis changes the frequency of the wave the observer sees. In black a speed of $0.9c$ is shown, in green is the star of UV-C radiation and in red is the original frequency of Flash's uniform.

Figure 1 shows that the colour of the uniform would change drastically depending on the speed and the direction of motion. The black line is of special importance as this is close to the estimated speed of the Flash's run. At the speed of $0.9c$ the Flash's uniform would be visible between $78° \leq \theta \leq 121°$ and $239° \leq \theta < 283°$. At the lower end of these two ranges the uniform would appear red then would gradually shift colours until at the upper end it was violet. Between these two ranges represent an important region when the Flash's uniform would not only not be visible but would begin to be classified as UV-C or above. This could be a danger to humans, as this type of radiation can cause severe burns and eye injuries. So if a person were to observe the Flash running at an angle of about 136° to 209°, they would suffer eye damage and severe sun burns. However, there would be little to no long term effects from this. A rudimentary analysis would suggest that the number of these dangerous photons coming from the Flash's uniform would be about 1000 times less than being exposed to a UV-C lamp for a second. This comes from approximating the Flash as a sphere and saying that the power output of reflected light rays would be half of those incident on him from the sun. Using $1034\,THz$ for the frequency of these photons leads to an estimate of magnitude $10^{22}s^{-1}$ when using this in conjunction with Eq. 2 an estimate for photon exposure would be in the magnitude of $10^{16}s^{-1}$ whereas an exposure from a UV-C lamp for a second would expose you to $10^{19}s^{-1}$. Assuming a lamp of power $30\,W$ for the lamp.

Conclusion

Between $78° \leq \theta \leq 121°$ and $239° \leq \theta < 283°$ the uniform would vary from red to violet back from violet to red. It was also found that the Flash would be a source of UV-C light however with the short exposure time relating to his extreme speeds the occurrence of this light should not be an issue to a human bystander as they should only be 1000 times fewer photons then a UV-C lamp so only minor burns should occur.

References

[1] S.Collura `https://www.ign.com/articles/2014/09/30/comics-history-101-the-flash` [Accessed 4 October 2022]

[2] P.A. Tipler and G. Mosca, Physics For Scientists and Engineers, (W.H. Freeman and Company, New York, 2008), Sixth Edition, p.1325-1327.

[3] Boxing Science `https://boxingscience.co.uk/science-behind-punch/` [Accessed 4 October 2022]