P5 3 Until the Sky Turns Green

E. Cross, T. Boyce, H. Charman, T. Chu

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

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Abstract

In the popular Stone Roses song, Sugar Spun Sweetheart, there is a lyric "Until the sky turns green, and the grass is several shades of blue". In this paper we will be examining whether it would be possible to witness a green sky, firstly, by discussing whether particles exhibiting Rayleigh scattering can cause a green sky instead of blue, and secondly, what speeds a person would need to travel to redshift the sky's natural blue colour to green. We find that there are no conditions under which Rayleigh scattering can produce a green sky, however if an observer accelerates to an approximate speed of $0.2c$, then they will observe a green sky, due to the Doppler effect.

Rayleigh Scattering Background

Sun light that enters the Earth's atmosphere experiences scattering as it hits different particles that make up air, primarily nitrogen and oxygen. Due to the size of the gas molecules interacting with the EM waves, sun rays experience Rayleigh scattering. This type of scattering is governed by the equation [1]:

$$I = I_0 \frac{8\pi^4 N\alpha^2}{\lambda^4 R^2}(1 + cos^2\theta) \qquad (1)$$

Where I is the intensity incident on the observer, I_0 is the intensity of the radiation from the sun, N is the number of scattering particles, R is the distance between an observer and the scattering particle, θ is the angle between the incident radiation and the scattered radiation and α is the polarizability of the particle. From the equation we can see that incident radiation on an observer has a strong dependence on wavelength due to the $1/\lambda^4$ factor. This means that, even though the sun emits white light, lower wavelengths are more easily scattered and incident on an observer on Earth, resulting in the blue sky we are all familiar with.

Doppler Background

Similarly to sound, light can experience wavelength shifting due to the doppler effect when either the source or an observer is moving at high speeds. Given that Rayleigh scattering results in light being scattered radially, we can use the doppler equation for a radial source [2]:

$$\frac{\lambda}{\lambda_0} = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}} \qquad (2)$$

We can use this equation to figure out the speed and direction an observer would need to be moving to observe blue light as being green and therefore turning the sky green for that observer. This is another potential option under which we can turn the sky green.
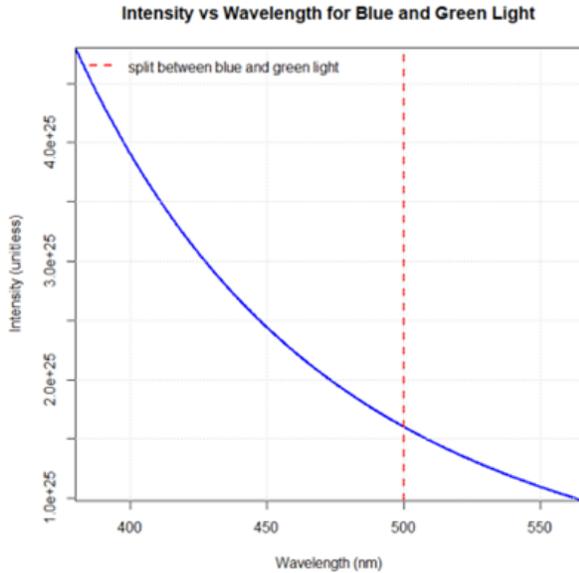
Intensity vs Wavelength for Blue and Green Light

Figure 1: a graph showing how intensity scales with wavelength for blue and green light

Results

Standardly blue light has a wavelength between 380 nm and 500 nm while the green spectrum is between 500 nm and 565 nm [3]. If we take midpoints of these ranges, we can take blue light to be 440 nm, and green light to be 533 nm. By analysing these values in the context of equation (1), we can calculate that on average blue light scatters with an intensity that is approximately 2.15 times larger than green light when all other factors such as particle size and type, and number of scattering particles, stay the same.

From equation (2) if we take our desired observed wavelength to be 533 nm (green) and our incident wavelength to be 440 nm (blue), we find that an observer would need to be moving at $0.189c$ (3.s.f) away from the light source for the required red shift to observe a green sky.

Conclusions

While we calculated that blue light scatters at intensities 2.15 times stronger than green light on average, this does not mean that blue light is 2.15 times more prevalent in the sky. The blue spectrum has a much larger range with lower wavelength blues that will scatter much more than higher wavelength greens and so on, as the $1/\lambda^4$ causes a large shift in intensity for a small shift in wavelength. This is shown clearer in Figure 1, which shows both the larger range of wavelengths present in blue light as well as the much higher intensities that lower wavelength lights are scattered at. With the range of green wavelengths sitting to the right of the red line and the range of blue wavelengths sitting to the left. Ultimately, this has no major effect on our conclusion as explained below.

If we endeavoured to change any of the other conditions of the Earth's atmosphere, for example the size of the elements it is comprised of, or the density of the atmosphere, this would be changing the N and α values in equation 1. For any given atmospheric conditions, blue light will always scatter to intensities approximately 2.15 times stronger than green light, as conditions are constant for all wavelengths scattering off of gas particles. The only thing controlling the rate of scattering is the $1/\lambda^4$ relationship. Therefore, there is no way that light can undergo Rayleigh scattering and produce a predominantly green sky.

Therefore, to turn the sky green, the observer must travel at a velocity of $0.189c$ away from the light source so that the blue light incident on them is red shifted to green. Additionally, It should be noted that if the observer shifts their direction of viewing so that they are looking in the same direction as their velocity, the light would be blue shifted by the same change in wavelength. This new wavelength would be 347 nm. The human eye can only detect wavelengths between 380 nm and 750 nm [2], Thus the primarily scattered blue light would be blue shifted into ultraviolet frequencies rendering it not visible to the observer. All the other lights that are usually not as visible in our sky, due to the previously discussed Rayleigh scattering, would also be blue shifted however, resulting in what would most likely be a violet coloured sky.

References

[1] Nayakshin, S. (2025). PA4604: Radiative Processes Lecture Slides Unit 1, School of Physics and Astronomy, University of Leicester [Accessed 25 November 2025]

[2] `http://www.hyperphysics.phy-astr.gsu.edu/hbase/Relativ/reldop2.html` [accessed 21 October 2025]

[3] `https://sciencenotes.org/visible-light-spectrum-wavelengths-and-colors/` [accessed 21 October 2025]