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A2_5 Deck the Halls

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Abstract

Physics often stretches the limits of what is physically possible for entertainment purposes. By applying known physics to these scenarios we often get unrealistic answers. From the 2006 movie "*Deck the Halls*", we calculated how bright a house would have to be to be seen by astronauts on the International Space Station (ISS). We find that the house would need to be at least 10.6×10^3 lm; the equivilent of 2638 LED Christmas lights.

Introduction

In the 2006 movie "*Deck the Halls*", Buddy Hall becomes annoyed by the fact his house cannot be seen on the website "*MyEarth*" which, similarly to Google Earth, shows satellite images from space. This spurs Buddy into making it his goal to make his house visible from space by using Christmas lights. So, we decided to calculate the number of light bulbs that would be required to make this possible. To do this we assumed the point at which the house is visible is at the altitude of the International Space Station (ISS).

Method

In order to make Buddy's house bright enough to be observed from space, we investigated what apparent magnitude the house would need to be observable. We assumed that the house would have to be observable with the naked eye. This assumption meant that the house must have an apparent magnitude of at least +6.5, as this is the minimum value detectable by the human eye [1]. This allowed us to use the ratio of magnitudes (Eq.1) to compare it to another defined magnitude. Taking this further, we found the ratio between their fluxes [2], as given by

$$10^{-0.4(m_1-m_2)} = F_1/F_2, \tag{1}$$

where m_1, m_2, F_1, and F_2 are the magnitudes and fluxes of the objects being compared respectively.

For the purposes of finding the brightness of the house, we compared the house to the Sun. The Sun was the logical choice as the apparent magnitude of the Sun is well defined at the Earth and can be approximated to be the same at the ISS, as the distance between the Earth and the ISS is negligible compared to the distance between the Sun and the Earth. The apparent magnitude for the Sun was taken as -26.7 [1]. This produced a ratio between the fluxes of $10^{-13.28}$, when compared to the magnitude of +6.5 required.

We then determined the flux that was required for the house to be seen from the ISS, assuming a constant solar lux of 10^5 lx [3]. This constant being in lux, as this is the unit used to measure the intensity of light as perceived by the human eye. The solar constant referring to an approximation of the amount of visible solar flux that

reaches the ISS, which equates to the house requiring a lux of 5.25×10^{-9} lx. We then utilised the inverse-square law,

$$L_h = F_h * (4\pi R^2), \tag{2}$$

to find the luminosity of the house as 10.6×10^3 lm, where L_h and F_h are the luminosity and flux of the house and R is the distance from the house to the ISS; the ISS being 400 Km above the Earth.

The luminosity of 10.6×10^3 lm can be converted into the number of Christmas lights required, by taking 4 lm as the luminosity of a single LED [4]; we found that this luminosity corresponded to 2638 LEDs focused on a point.

Conclusion

The values calculated are a rough approximation as we considered an ideal case based around the assumption of zero light pollution. Varying the amount of light pollution would affect the values depending on the set up and location of the house and the observer. This happens in cases such as light pollution limiting the observable apparent magnitude even by the order of one magnitude, as this would increase the required luminosity by ~ 2.51. Distance is also a source of discrepancy as the luminosity is proportional to the distance squared. This produces a relationship where, if the distance was to be doubled, the required luminosity would need to increase by a factor of ~ 4. Given our results regarding whether light from a house's christmas lights could reach the ISS, has proven that for such a distance, it would be possible to make your house bright enough to be seen from space.

References

[1] http://www.astronomynotes.com/starprop/s4.htm [Accessed 20 October 2017]

[2] https://www.phys.ksu.edu/personal/wysin/astro/magnitudes.html [Accessed 20 October 2017]

[3] http://www.edu.pe.ca/threeoaks/teacherpages/dramsay/Solar%20Radiation%20main.htm [Accessed 21 October 2017]

[4] http://blog.holidayleds.com/articles/how-bright-are-led-lights-the-facts-about-lumens/ [Accessed 23 October 2017]