Journal of Physics Special Topics

An undergraduate physics journal

A4_5 That's No Moon...

Matthew Wing, Charlotte Paton, Kaia Thomas and Nat McCabe

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

November 13, 2021

Abstract

In this paper we aim to investigate the visibility of the fictional space station, The Death Star, through the transit observation method of exoplanet detection. It was concluded that through ground based observation the Death Star could be observed orbiting small planetary bodies within our Solar System. Through more robust space-based observations the space station could be detected outside our Solar System about nearby white dwarf stars.

Introduction

On the 27th of December 1977 public audiences of the blockbuster movie 'Star Wars' got the first view of the culmination of the Empire's might, The Death Star, a space station of previously unheard of magnitude. In this paper we aim to take the fictional Death Star, insert it into our Universe and ask the question, would we be able to find it through observation during a transit of another celestial body?

We assumed that the observational conditions on Earth were perfect for telescope observation or through a satellite, this is so that effects such as weather, other bodies of light or obstructions are negated. The Death Star was assumed to fully pass in front of the parent body and limb darkening is taken to be negligible.

Theory

To analyse how detectable the space station would be we investigated the potential brightness drop across numerous stars differing in classification, size and brightness. In order to find the change in brightness for the when the transit takes place we can use the equation below,

$$\Delta f/f = (R_p/R_S)^2 \tag{1}$$

Where Δf is the change in the flux (brightness) due to the transiting planet and f is the parent body's original flux. R_S is the radius of the parent body. R_p is the radius of the body transiting which, for this investigation, will be the Death Star. In Star Wars there is no explicit statement on the Death Star's radius, however some second generation merchandise set the radius to be $160km$ [1] which will be used within this paper.

The Death Star's visibility is analysed in the wider Universe and within our Solar System.

We gathered the information of star radius and brightness from a large database[2]. The planet data was gathered from two separate sources for brightness [3] and radius [4]. As the planetary brightness is given in absolute magnitude it must be manipulated into luminosity to be usable in Eq. (1) through the equation,

$$f = 10^{-m/2.5} \times f_0 \tag{2}$$

Where m is the absolute magnitude and f_0 is a constant defining the brightness of a body having a magnitude 0.

Star Name	Proxima Centauri	The Sun	Sirius A	Sirius B	Betelgeuse	Canopus	Altair
Star Classification	Red dwarf	Yellow dwarf	White main sequence	White dwarf	Red supergiant	White bright giant	White main sequence
Brightness Decrease (W)	4.3×10^{16}	2.0×10^{19}	1.8×10^{20}	1.6×10^{22}	2.3×10^{18}	4.3×10^{19}	8.11×10^{19}
Percentage Brightness Decrease (%)	2.2×10^{-4}	5.3×10^{-7}	1.8×10^{-6}	7.5×10^{-2}	6.7×10^{-12}	1.0×10^{-8}	2.0×10^{-6}

Figure 1: Table displaying the percentage decrease in brightness for different stars in the Universe as observed from Earth

Results

By multiplying Eq.(1) by 100 we gain the percentage decrease in brightness from the transit of the Death Star.

It can be seen in Figure (1) that the transit about a white dwarf star (Sirius B) is the event most likely to be detected providing the greatest brightness decrease. Conversely about a red supergiant star (Betelgeuse) is the least likely to be observed.

Eq. (2) is used to produce luminosity, which is then inserted into Eq. (1) as with the star data.

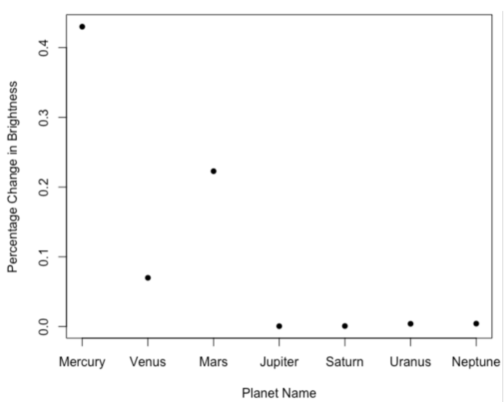

Figure 2: Plot displaying the percentage decrease in brightness for the Death Star's transit about different Solar System planets

Figure (2) displays that the Death Star is most visible transiting about Mercury, with planets Jupiter and beyond having extremely low visibility.

Discussion and Conclusion

Current ground based telescopic technology allows us to detect brightness drops of 0.1% through use of multiple identical telescopes observing the same target [5]. It would therefore be unlikely that ground based observers would detect the Death Star transiting a white dwarf star, much less any star of greater proportions. Detection of the Death Star orbiting about Mercury, Mars and possibly Venus would theoretically be possible by the same method.

To increase the possibility of detection the base of observations would have to be moved to space. The NASA Kepler K2 mission was able to detect transit depths as low as 80 parts per million (0.008%) [6]. Through this method, the Death Star would be detectable about white dwarf stars and about a small amount of planets in our Solar System.

References

[1] https://www.theforce.net/swtc/ds/index.html *Under 'Dimensions' heading* [Accessed 26 October 2021]

[2] https://www.star-facts.com/proxima-centauri/ [Accessed 26 October 2021]

[3] https://promenade.imcce.fr/en/pages5/572.html [Accessed 26 October 2021]

[4] https://solarsystem.nasa.gov/resources/686/solar-system-sizes/ [Accessed 26 October 2021]

[5] A. Smith et al. https://onlinelibrary.wiley.com/doi/full/10.1002/asna.202013768

[6] S. Aigrain et al. https://www.robots.ox.ac.uk/~sjrob/Pubs/K2phot_accepted.pdf