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A4_11 Thunderbirds Are Go!

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Abstract

Thunderbird 5, the space station belonging to International Rescue, is a secret that only the members of that organisation know about. As such, this paper investigates whether the station could have an apparent magnitude that is too faint for the naked human eye to discern from Earth. The luminosity of Thunderbird 5 is calculated using this assumed value, and a value for the implied albedo of Thunderbird 5 is found by comparison with the International Space Station. The albedo that is found is compared with the albedo of Comet 19P/Borrelly to examine its feasibility. The albedo required for Thunderbird 5 to be invisible from Earth is found to be impractically low and as such it is concluded that Thunderbird 5 would be visible from Earth.

Introduction

The Thunderbirds are vehicles used by International Rescue (IR) in the television series that shares their name. IR attends to disasters around the world, being notified of events by eavesdropping on various communications across the world using their space station, Thunderbird 5. IR are a very secretive organisation and their secrecy extends to Thunderbird 5. As a result, it would seem logical to assume that it would be desirable for this secret space station not to be visible from Earth with the naked eye.

This paper aims to consider the limits of the naked eye's ability to discern objects in space and apply that limit to see how dark Thunderbird 5 needs to be to escape detection by an observer, unaided by telescope or binoculars, on Earth. The International Space Station is visible under these circumstances around dawn and dusk, and this fact is used to calculate a value for the albedo of Thunderbird 5 and then examine whether this is feasible, and, as a result, whether the space station could be invisible to the naked eye.

Magnitude

It is possible to relate the apparent magnitude m (the magnitude of the object as it appears to an observer on Earth) to the absolute magnitude M (the magnitude of the object as it appears to an observer at a distance of 10 parsecs) using the following equation, where d is the distance from the object to the observer in parsecs [1]:

$$M = m + 5 - 5\log_{10} d. \qquad (1)$$

A relation can be stated that relates an object's absolute magnitude M to its luminosity L [2], where $M_\odot = +4.83$ is the sun's absolute magnitude [3] and $L_\odot = 3.846 \times 10^{26}$ W is the solar luminosity [3].

$$M = M_\odot - 2.5\log_{10}\left(\frac{L}{L_\odot}\right). \qquad (2)$$

Then, Eq. (2) can be rearranged:

$$L = L_\odot \exp\left(\frac{M_\odot - M}{2.5}\right). \qquad (3)$$

Discussion

The faintest objects that can be observed in the night sky have an apparent magnitude $m = +6.0$ [4]. As such, this is the value assumed for the apparent magnitude of Thunderbird 5, m_{T5}. The apparent magnitude of the International Space Station (ISS) when it is fully illuminated at perigee is found to be $m_{\mathrm{ISS}} = -5.9$ [5].

The ISS is in Low Earth Orbit and receives regular visits from the Space Shuttle. Because Thunderbird 5 is demonstrated to be able to intercept transmissions from around the world, and due to the ability of a single-stage rocket (Thunderbird 3) to reach the space station, it is assumed that Thunderbird 5 is also in that orbit. ESA says that the ISS orbits at an average height d = 390 km = 1.3×10^{-11} pc [4]. Using this value with $m_{\mathrm{T5}} = +6.0$ and $m_{\mathrm{ISS}} = -5.9$, Eq. (1) gives the absolute magnitudes:

$$M_{\mathrm{T5}} = +6.0 + 5 - 5\log_{10}(1.3 \times 10^{-11}) = +65.4. \qquad (4)$$

$$M_{\mathrm{ISS}} = -5.9 + 5 - 5\log_{10}(1.3 \times 10^{-11}) = +53.5. \qquad (5)$$

Using these absolute magnitudes, Eq. (3) gives us the space stations' luminosities:

$$L_{\mathrm{T5}} = L_\odot \exp\left(\frac{M_\odot - 65.4}{2.5}\right) = 1.2 \times 10^{16}\ \mathrm{W}. \qquad (6)$$

$$L_{\mathrm{ISS}} = L_\odot \exp\left(\frac{M_\odot - 53.5}{2.5}\right) = 1.3 \times 10^{18}\ \mathrm{W}. \qquad (7)$$

Luminosity is a measure of the emitted radiation from an object per square metre, and albedo is the ratio of the incident radiation to the reflected radiation. As such, the two are directly correlated assuming that the incident radiation is the same (as it is in this case). Therefore, using the values above we can calculate the albedo of Thunderbird 5 A_{T5} in terms of the albedo of the ISS A_{ISS}:

$$A_{\mathrm{T5}} = \frac{L_{\mathrm{T5}}}{L_{\mathrm{ISS}}} A_{\mathrm{ISS}} = 0.009 A_{\mathrm{ISS}}. \qquad (8)$$

Conclusion

Some of the darkest objects in the solar system are comets. For example, the darkest areas of comet 19P/Borrelly were found to have an albedo as low as 0.012 by the Deep Space 1 spacecraft in 2001 [6]. If it is assumed that the ISS has an albedo of 1.0 (that is to say, assuming that it is perfectly reflective) Thunderbird 5 would require an albedo of 0.009 to remain invisible to the naked eye at an apparent magnitude $m = +6.0$.

Fig. 1: Image of Thunderbird 5, showing (amongst other things) reflections on the space station body [7].

Given that the albedo of ISS is not that high, the required albedo is even lower than 0.009. Considering that the darkest places in the solar system have higher albedos than the required value of A_{T5}, and also considering that Thunderbird 5 can be seen to be reflective in images from *Thunderbirds* (see Fig. 1), the space station must clearly be visible from the Earth with the naked eye.

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