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A6_2 How Hot is Tatooine?

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Abstract

Tatooine is a fictional terrestrial planet from the Star Wars universe which orbits a set of binary stars. By considering the classification of its Suns, Tatoo I and Tatoo II, and the planets orbital period we were able to find the radius of Tatooine's orbit, 1.15 Au. It was then possible to work out the varying solar constants for Tatooine depending on its position relative to both Suns, allowing us to calculate an average daytime temperature range of 42.3^oC to -10.7^oC.

Introduction

In 1977 George Lucas created Star Wars: A New Hope. The first planet introduced in the film is Tatooine, home of Luke Skywalker. Tatooine is a desert planet with 1 % surface water orbiting a set of binary stars; Tatoo I and Tatoo II, which are G1 and G2 classification stars respectively [1]. Tatooine also has an orbital period of 304 days [2]. In this paper, we calculate the temperature of the surface of Tatooine and answer whether humans could indeed survive there.

Discussion

Firstly, we calculated the orbital radius of Tatooine using a rearranged form of Keplers 3rd law,

$$a = \left(\frac{T^2 GM}{4\pi^2}\right)^{\frac{1}{3}}, \quad (1)$$

Where a is the orbital distance (m), T is the orbital period of Tatooine (s), G the gravitational constant and M the mass of the orbited star (kg). We assumed that the distance between the two Suns is much less than the orbital distance of Tatooine. This allows us to treat Tatooine's orbit around a single point of combined mass of both Suns. Since we know the classification of both Suns we know the masses to be 1.10 $M_\odot$ and 1.07 $M_\odot$ for Tatoo I and Tatoo II respectively [3], leading our total M to be a value of 2.17 $M_\odot$. Inputting all values into equation 1 yielded an orbital distance of $1.71 \times 10^{11} m$, equal to 1.15 AU.

To ultimately find out how much power the Suns provide to Tatooine we then calculated the specific power of each of the Suns using the Stefan-Boltzmann law,

$$\frac{P}{A} = \sigma T^4, \quad (2)$$

Where $\frac{P}{A}$ is the specific power (Wm^{-2}), σ the Stefan-Boltzmann constant and T the effective temperature (K), which is 5900 K and 5800 K for G1 and G2 classified stars respectively [3]. Inputting these values into equation 2 gave us a specific power of 6.87×10^7 Wm^{-2} for Tatoo I and 6.42×10^7 Wm^{-2} for Tatoo II.

We were then able to calculate the effective power of each star by multiplying the specific powers with each stars surface area, given by

$4\pi R^2$, where R is the radius of the stars (m). Since our own Sun is a G2 star and the size difference between a G2 and G1 star is minute, we assumed both Tatoo I and II had a radius of $R_\odot$. Multiplying both specific powers by the stars surface areas gave us an effective power of $4.18 \times 10^{26}\ Wm^{-2}$ for Tatoo I and $3.90 \times 10^{26}\ Wm^{-2}$ for Tatoo II. The power received by Tatooine is dependent on the orbital positions of its Suns. Its minimum received power would be when Tatoo I is totally eclipsed by Tatoo II, $3.90 \times 10^{26}\ Wm^{-2}$. Conversely, its maximum received power is when neither star eclipse one another, resulting in Tatooine receiving the effective power of both stars, $8.17 \times 10^{26}\ Wm^{-2}$.

We then calculated the effective power received at Tatooine's distance, otherwise known as its solar constant, $S_\odot$, by dividing the effective powers of each star by the spherical surface area at Tatooine's radius, using Tatooine's orbital radius for R. Depending on Tatooine's power received, $S_\odot$ was found to range from $6.4 \times 10^7\ Wm^{-2}$ to $1.33 \times 10^8\ Wm^{-2}$.

From the Solar constant we used the planetary effective temperature equation,

$$T = \sqrt{\frac{S_\odot(1-\alpha)}{4\pi^2}}, \quad (3)$$

to find the surface temperature of Tatooine, where T is the effective planetary surface temperature (K), $S_\odot$ the solar constant (Wm^{-2}) and α the planetary albedo. Since Tatooine is a desert planet with 1 % surface water we used the albedo for sand, 0.4. This however does not account further warming from the greenhouse effect. Since humans are fully able to live, move and breathe normally on the planet we assumed Tatooine has an Earth like atmosphere, resulting in the same percentage increase from effective to actual temperature as that on Earth, 14.29 %, which we multiplied on top of Tatooine's effective temperature. Considering this, and inputting our solar constants into equation 3, we found the average daytime temperature of Tatooine to range from 42.3 ^oC to $-10.7\ ^oC$. In figure 1 we can see how Tatooine's daytime temperature varies with the amount of power the planet receives.

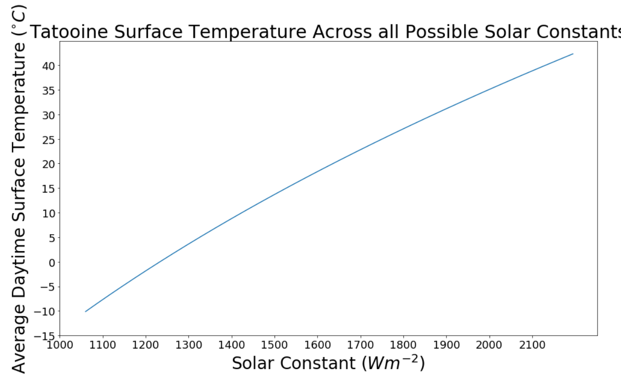

Figure 1: Average daytime surface temperature of Tatooine depending on the power received from its Suns.

Conclusion

The minimum and the maximum average surface temperatures on Tatooine are similar to those seen on Earth, and humans live under either conditions with the aid of technology. Since the Star Wars universe is technologically advanced, people should be able to survive on Tatooine like on Earth. However, both these temperatures are only averages, which means that certain locations on Tatooine would be much colder and hotter than our calculations, suggesting living in some areas would be difficult.

References

[1] Alan Dean Foster and George Lucas. *Star Wars Episode IV: A New Hope novel*. Ballantine Books, November 1976.

[2] Adam Bray, Kerrie Dougherty, Cole Horton, and Michael Kogge. *Star Wars: Absolutely Everything You Need To Know*. DK Publishing, September 2015.

[3] I.M.Vardevas and F.W.Taylor. Radiation and climate: Atmospheric energy budget from satellite remote sensing. *International Series of Monographs on Physics*, 138:130, 2011.