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P5_8 None Like It Hot

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Abstract

In season 4, episode 8 of the science fiction series *Futurama*, 'Crimes of the Hot', global warming is reduced in the year 3003 by using the thrust of 1 billion robots to move the Earth further from the Sun [1]. We calculate the distance of the new orbit of Earth, 1.515x10^{11}m, the temperature change for Earth, 1.708 K, and the amount of energy needed to be generated per robot, 6.480x10^{22}J.

Introduction

In the *Futurama* episode 'Crimes of the Hot', previous methods of keeping the climate under control have failed and an urgent new solution is needed. It is revealed that robots emit much more greenhouse gas than expected and all 1 billion are gathered on the Galapagos islands in order to be deactivated. Professor Farnsworth has an idea which saves both Earth and the robots: using thrust from the robots' exhausts to move the Earth further from the Sun. At the end of the episode, it is revealed that Earth years now last one week longer than previously, and this extra week is declared 'Robot Party Week' [1]. We will first use this time difference to calculate the new orbit of Earth, and then calculate the temperature decrease this difference in orbital radius would cause. Finally, we will calculate the gravitational potential energy change between the two orbits and use this to find out how much energy is produced by each robot.

Theory and Results

We first used a rearrangement of Kepler's Third Law, assuming circular orbits, to calculate the new orbital radius of Earth, with the new period of 372 days. The equation is shown below

$$r = \sqrt[3]{\frac{t^2 G M_\odot}{4\pi^2}} \tag{1}$$

where r is the orbital radius, t is the period, G is the gravitational constant, and $M_\odot$ is the Sun's mass. We found that the new orbital radius of Earth is 1.515x10^{11} m, or 1.012 AU. Next, we calculated the effect this would have on the global temperature. We did this by calculating how much solar power is absorbed by Earth in both orbits, and then using the Stefan-Boltzmann Law to find the following temperature. The equation for power absorbed by the Earth is:

$$P_a = \frac{P_s R_E^2}{4r^2} \tag{2}$$

where P_a is power absorbed, P_s is the power produced by the Sun, R_E is the radius of Earth, and r is the orbital radius, as previously. The Stefan-Boltzmann equation was rearranged to find the temperatures:

$$T = \sqrt[4]{\frac{P_a}{\sigma A}} \tag{3}$$

where σ is the Stefan Boltzmann constant, A is the surface area of Earth, T is temperature, and P_a is power absorbed as previously. The temperatures were found to be 278.3 K and 276.6 K for Earth's original orbit and the new orbit respectively, and the temperature difference is found to be 1.708 K.

For the next part of our investigation, we calculated the energy required to move the planet to the new orbit. We did this by using the equation for the change in gravitational energy

$$\Delta U = GM_{\odot}M_E\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \tag{4}$$

where ΔU is energy change, M_E is Earth radius, r_1 and r_2 are the original and new orbital radii, and the other symbols have the same meanings as in the previous equations. The total energy needed and therefore produced by the robots is $6.480\text{x}10^{31}$ J. As there are stated to be 1 billion robots, this means the energy produced per robot would be $6.480\text{x}10^{22}$ J.

Discussion

The average global temperature in 2016 was 14.8°C [2] and has been increasing at a rate of 0.15-0.20°C per decade [3]. Taking the largest value of 0.20°C and assuming it rises at a constant rate each decade, in the year 3003, the average temperature could be estimated as 34.6°C. This means that the temperature drop calculated in this paper, of 1.708 K (or °C), would definitely not be enough to bring the Earth back to a temperature similar to the present. However, in Futurama, there has been measures in place to protect against global warming since 2063 [4], when the temperature would be approximately 15.8°C. If we assume these measures worked perfectly keeping the temperature constant until 3003, then the temperature after the orbit change would be reduced to around 14.1°C, colder than the current global average temperature.

The energy calculated in this paper is $6.480\text{x}10^{22}$ J per robot. This is not likely to be feasible, as the largest nuclear weapon ever tested, Tsar Bomba, released $2.1\text{x}10^{17}$ J [5]. However, in the Futurama canon, incredibly advanced (and impossible) technology has been invented, such as spaceships that travel 99% of the speed of light and run on dark matter with 200% efficiency [6], and therefore perhaps this level of energy generation would be considered normal.

Conclusion

In our investigation, we have calculated the radius of the new orbit that the Earth was moved to in the year 3003 in Futurama. We have also calculated the drop in temperature that this would cause, and see, with some assumptions, that it would work to reduce the global temperature to lower than in the present day. We also conclude that each robot would need to produce much more energy than the largest nuclear weapon ever tested in order to move the Earth into this new orbit.

References

[1] *Futurama*, Season 4, Episode 8: Crimes of the Hot.

[2] `https://www.ncdc.noaa.gov/sotc/global/201613#gtemp` [Accessed 15 November 2017]

[3] `https://earthobservatory.nasa.gov/Features/WorldOfChange/decadaltemp.php` [Accessed 15 November 2017]

[4] `https://theinfosphere.org/Global_warming` [Accessed 15 November 2017].

[5] `en.wikipedia.org/wiki/Orders_of_magnitude_(energy)` [Accessed 15 November 2017]

[6] `https://theinfosphere.org/Planet_Express_ship` [Accessed 15 November 2017]