Journal of Physics Special Topics
An undergraduate physics journal

P5_9 Sunstorm

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November 29, 2017

Abstract

In the book "*Sunstorm*", the Earth is bombarded with 7.11x10^{29} J of solar energy, which in the book does not destroy the Earth as the whole human race works together to build a shield to protect the planet. We found that the shield as described in the book would deflect just enough energy to prevent the extinction of the human race, as the remaining 7.76x10^{26} J of energy would not inflict as much damage as suggested in the book.

Introduction

In the book "*Sunstorm*" [1], a solar event is triggered by a race of aliens known as the Firstborn. After watching their own star die, they decided to take it upon themselves to attempt to preserve life in the universe for as long as possible, by preventing what they saw as misuse of energy in the form of inferior life forms. To prevent humans from wasting a large portion of the energy of the whole Galaxy, they launched a huge planet from a nearby star system into the Sun causing a chain reaction in the core. Assuming that this does not cause any major increases in solar activity until the year 2042 [1], this would result in a resonant peak causing an immense sunstorm that would wipe out all life on Earth. In this paper we will analyse the extent of the damage caused, and how effective the shield that humans created to redirect as much of the storm as possible would be.

Theory

The energy released during the sunstorm was said to be a year's worth of solar energy all directed at the Earth in a single day. The total energy output of the Sun was found to be estimated at 3.846x10^{26} Js^{-1} [2], and over one year this is a total of 1.21^{34} J. Assuming that the Sun beams this energy out in the direction of Earth in a cylinder with radius R_S, the fraction of this energy which actually hits the Earth is R_E^2/R_S^2 which is 8.39x10^{-5} as shown in Figure 1.

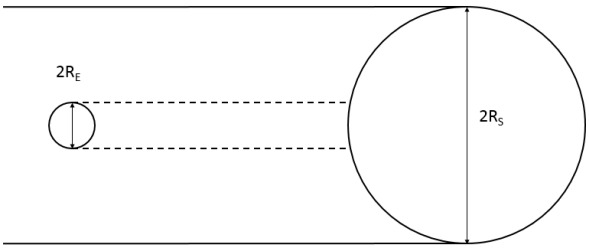

Figure 1: Simplified figure showing the proportion of the Sun's energy during the sunstorm hitting the Earth

This means the total energy striking the Earth is 1.02x10^{30} J. Over the 24 hours of the sunstorm

[1], the power delivered to Earth was found to be 1.17x10^{25} Js^{-1}. Using the total output of the Sun, we found the normal amount of energy incident on the Earth, to compare with the energy during the sunstorm. This was done by spreading the total output over a sphere at the distance of the Earth from the Sun, and finding how much of this sphere the Earth takes up.

$$E = T\frac{\pi R_E^2}{4\pi(1AU)^2} \quad (1)$$

E is the energy hitting the Earth and T is the total output from the Sun per second. It was found that the normal energy incident on the Earth is 1.74x$10^{17}$$Js^{-1}$, so during the sunstorm the energy incident on the Earth is 6.72x10^7 times what it normally would be.

The Earth's atmosphere can absorb about 30 percent of the Sun's power [3], meaning the power reaching the Earth's surface during the sunstorm is 8.21x10^{24} Js^{-1}, and the total energy is 7.11x10^{29} J. The shield that is created between the Earth and the Sun is said to absorb all but 1/1000th of the storm [1], leaving a total of 7.11x10^{26} J inflicted upon the Earth.

Discussion

By creating the shield, the damage inflicted on the Earth was reduced massively, and according to the book this was enough to stop the destruction saving 9/10 of the human race, while evaporating the oceans and damaging the environment almost beyond repair. However, as the energy remaining is 7.11x10^{26} J this is not enough energy to evaporate Earth's oceans. The energy required to raise the temperature of the oceans to boiling point is 5.33x10^{26} J [4], and the energy required to actually evaporate the water can be found using the latent heat of vaporisation of water which is 2.26x10^6 J kg^{-1} [5] and Equation (2):

$$Q = mL \quad (2)$$

Where Q is the energy required, m is the mass of water and L is the latent heat of vaporisation of water. The mass of water is assumed to be 1.391x10^{21} kg [4], meaning the energy required is 3.14x10^{27} J. Combined with the energy needed to raise the temperature to boiling means that the sunstorm now only provides 23% of the energy required for this effect. Without the shield, the 7.11x10^{28} J would be enough to melt the crust of the planet completely [6], meaning the entire planet would be incapable of supporting life at all.

These calculations assume all the solar energy is directed at Earth, due to a description in the book of "a pillar of light" [1] aimed at Earth, however effects are felt on all of the planets of the solar system. We also assumed that none of the energy leaves the Earth during this 24 hour period as the huge amount of energy in the column from the sun would restrict or even prevent this for the duration of the event. As the results show that the shield would affect the results of the sunstorm on the Earth, it was deemed appropriate for the simplified model to be used.

Conclusion

Further analysis could be done working out the proportion of energy that is spread out to the rest of the solar system to determine whether or not the shield was in fact necessary in order for the Earth to survive.

References

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[5] `https://link.springer.com/referenceworkentry/10.1007%2F978-90-481-2642-2_327`

[6] `http://www.projectrho.com/public_html/rocket/usefultables.php`