P5_7 Fire Cannot Kill a Dragon

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Abstract

In Game of Thrones, there is a legend that states that there used to be two moons in the sky, one of which was a dragon egg. This then hatched when it got too close to the sun, leaving only one moon in the sky. We calculated the intensity of fire in Game of Thrones, using footage of a gold belt melting, as we assumed that it is different than that of fire on Earth. This intensity was found to be 195 kW m^2. Keeping this value constant, we calculated that the dragon egg moon would have to have an orbital radius of 137×10^6 km around Earth to experience the same intensity from the Sun and hatch. In order for the dragon egg to appear the same size as the moon at this distance it requires a radius of 6.24×10^5 km.

Introduction

In Game of Thrones a legend is spoken of where is was stated "the moon was an egg, Khaleesi, that once there were two moons in the sky. But one wandered too close to the sun and it cracked from the heat..." [1]. In this paper we are calculating the intensity required to hatch the dragon egg and using this, the distance from the sun at which this intensity would be reached. We are also calculating the size the dragon egg would have to be to have the same angular radius as the moon.

Theory and Results

In the Season 1 finale of the show, three dragon eggs hatch in a large fire [2]. For the purposes of this paper we are assuming the intensity of fire in the show is a constant and varies from that of an average fire on Earth. In order to calculate the intensity of fire in the show we calculated the energy required to melt a gold belt in Season 1 Episode 6 [3] and have assumed that this inten-

sity is equal to the intensity required to hatch the dragons eggs. The mass and surface area of the belt are estimated to be 2 kg and 0.1 m^2 respectively. The latent heat of gold is 62.8 kJ kg^{-1}, the specific heat capacity is 0.126 kJ kg^{-1} K^{-1} and the melting point is 1336 K [4]. Using Equations 1 and 2 the total energy required to melt the belt is calculated to be 389 kJ, assuming the belt is solid gold and the initial temperature is standard room temperature (294 K).

$$Q = mc\Delta T \tag{1}$$

$$Q = mL \tag{2}$$

m is the mass of the belt, c is the specific heat capacity of gold, ΔT is the change in temperature between the melting point and room temperature and L is the latent heat of fusion of gold. To calculate the power, the energy required is divided by the time taken for the belt to melt. In the episode it takes 20 seconds for the belt to

melt completely [5] therefore the power required is 19.5 kW. The intensity of the fire is calculated by dividing the power by the surface area of the belt: we calculated this to be 195 kW m^{-2}.

We have assumed that this is the same intensity required to hatch the eggs in the show and therefore the intensity required to hatch the moon dragon egg. At Earth's average distance from the Sun; 150×10^6 km, the intensity of the Sun is 1.36 kW m^{-2} [6]. This is 143 times smaller than the intensity required for the egg to hatch. Intensity of the Sun is related to the distance away from it by the inverse square law. In order for the intensity to be 143 times larger than that experienced by Earth, the egg has to be $\sqrt{143}$ times closer to the Sun. We found that to have the required intensity perpendicular to the surface of the egg it would have to be 12.5×10^6 km away from the Sun and therefore orbiting the Earth with an orbital radius of 137×10^6 km.

In order for there to be "two moons in the sky" we are assuming that the dragon egg has the same angular radius as the Earth's moon. The angular radius describes how large a sphere or circle appears from a given point of view [7]. The angular radius of the Moon from Earth α is known to be 0.26° [7]. Using trigonometry and the orbital radius calculated, the radius of the dragon egg is found to be 6.24×10^5 km.

Discussion

There are several assumptions made in this paper due to the limited information provided in the original content. It is shown in the Season 1 finale of Game of Thrones that dragon eggs need to be heated by fire in order to hatch. At another point in the first season, a gold belt is shown to melt in only 20 seconds when being heated on a fire. Therefore, we assume that fire in the Game of Thrones universe is much more intense than fire on Earth. In the first part of the investigation we have calculated this intensity by using the footage of the gold belt melting, and have assumed that this intensity is equal to that of the intensity required to hatch dragon eggs.

George R.R Martin (the author of the series and contributor to the show) has stated that the planet is slightly larger than Earth [8]. Due to the habitable nature of the planet we have assumed the distance from the Sun is a good representation for the distance between the planet in the show and a star of similar intensity to the Sun. The dragons can survive on the planet in the show and this poses the question as to whether the dragons would survive at a distance of 12.5×10^6 km from the Sun.

The dragon egg is also assumed to be spherical in our model however we would expect it to be egg shaped, similar to the eggs in the show. We determined that this change would be negligible. There is also the suggestion in the show that a life must be given in order for dragon eggs to hatch, however as this is not a quantifiable measurement we have only considered the physical intensity required for the process to take place.

Conclusion

We have found that in order for a giant dragons egg to appear as a second moon in the sky, it would have to be at a distance of 12.5×10^6 km away from the Sun and therefore at an orbital radius of 137×10^6 km away from Earth. In order for this to appear the same relative size as the moon from an observer on Earth's point of view the radius of the egg has to be 6.24×10^5 km.

References

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