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P4_2 The Destruction of the DS-1

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Abstract

In this paper we aim to investigate the demise of the DS-1 (Death Star I) Orbital Battle Station over the planet Yavin in the film "Star Wars: A New Hope" and propose any effects the explosion would have on Yavin IV. Kepler's 3rd law and Pythagoras Theorem are used to find the distance between Yavin IV and the Death Star, showing at the time of the explosion the Death Star is 1.17×10^{11} m away from Yavin IV. The flux density (irradiance) at the surface of Yavin IV is also calculated giving a value of 1.17×10^{9} W m^{-2}, which we believe would be more than enough radiation to cause mass extinctions on Yavin IV, even at this extreme distance.

Introduction

In the film "Star Wars: A New Hope", we see the Imperial DS-1 Orbital Battle Station [1] moving into range of the forest moon of the planet Yavin [2] to attack the Rebellion holdings on that moon (Yavin IV) [3]. Just as the battle station is ordered to destroy the moon, the forces of the Rebel Alliance manage to land a critical blow on the hypermatter reactor of the DS-1, causing it to be destroyed in the resulting explosion. We investigate the power output of this explosion and the effect it would have on the surrounding planet of Yavin and the moon Yavin IV.

Investigation

We make a number of assumptions here to bring the DS-1 into our own reality and to help attribute to the otherwise missing variables that are not available to the viewer of the film. We assume Yavin IV has a composition similar to the Earth as both are of a similar diameter. Another assumption is that the Death Star has to make $\frac{1}{4}$ of its orbit to charge its laser. As we know the charge time is 24 hours [1], we assume one orbit of Yavin would take the Death Star around 92 hours, and that the Death Star fires when it forms a right angle between itself, Yavin and Yavin IV. Our final assumption is that the explosion takes 1 second, as this is around the difference in time between the first frame of the explosion in the film, to the Death Star no longer being visible.

Using the value for energy output of the DS-1 from "That's no moon" [4] we can see that the Super Laser of the DS-1 was capable of outputting an energy of 2×10^{32} J. We propose that as the laser is preparing to be fired, the Rebel assault on the DS-1 causes a reaction that then results in that energy feeding back into the core of the DS-1 causing it to almost instantaneously explode as we see in the film. To find out how the explosion effects Yavin IV, the amount of radiation reaching the surface needs to be found. To do this the distance between the Death Star and Yavin IV at the point of firing must first be calculated.

This was done by using Kepler's 3rd law [5], as shown in equation (1) to find the orbit of both the Death Star around Yavin and the orbit of Yavin IV around Yavin. These two distances, a_{ds} and a_{yiv} can be used with Pythagoras' theorem, equation (2), to find the distance d. At distance d, the Death Star forms a right angle between itself, Yavin and Yavin IV.

$$T = 2\pi\sqrt{\frac{a^3}{\mu}} \quad (1)$$

$$a_{ds}^2 + a_{yiv}^2 = d^2 \quad (2)$$

This gives us a value of d $= 1.17 \times 10^{11}$ m, which is very close to 1AU, where $\mu = GM = 3.6 \times 10^{17}$ m^3 s^{-2} (where M is the mass of Yavin, 5.54×10^{27} kg) and the orbital period is given by T, in seconds (92 hours for the Death Star and 4818 days for Yavin IV).

To find the irradiance at Yavin IV, the radiant intensity needs to be calculated from the total power of the explosion as given in equation (3).

$$I = \frac{d^2E}{dtd\Omega} = \frac{P}{4\pi} \quad (3)$$

This gives a value of I $= 1.59 \times 10^{31}$ W Sr^{-1}, where P $= 2 \times 10^{32}$ W, the energy dispersed by the explosion in 1 second. Equation (3) can then be used to calculate irradiance at the surface of Yavin IV (F_{yiv}).

$$F_{yiv} = \frac{Icos\delta}{d^2} \quad (4)$$

This gives a value of $F_{yiv} = 1.17 \times 10^9$ W m^{-2}, where d is taken from equation (2) and I is taken from equation (3) and $\delta = 0^o$ (the angle between the moon and the Death Star on the plane of the solar system).

Discussion

Consolidating all of the above calculations together shows us that the destruction of the DS-1 would be an event of extinction level proportions, with a power output six orders of magnitude more than the Sun. The flux density hitting the surface of Yavin IV would also be far larger than the flux density hitting Earth from the Sun. For reference the flux density from the Sun at the surface of Earth is equal to 1366 W m^{-2} [7]. Therefore the magnitude of flux at the surface of Yavin IV is 6 orders of magnitude larger. This kind of radiation would likely destroy any atmosphere the planet had and boil away any liquid water on the surface, rendering the planet barren and uninhabitable.

It is reasonable to assume that even at a distance of nearly 1 AU, this explosion would disrupt the Yavin planetary system as the explosion would radiate outwards in all directions, transferring much of the energy produced by the explosion onto any surface it touched, the closest of which would be the gas giant Yavin.

Conclusion

The internalisation of the energy of the DS-1 Super Laser into itself would have a disastrous effect on the inhabitants of the station, immediately vaporising everybody on board. It would also damage the atmosphere of Yavin IV irreparably as a result of the radiation being transferred onto the moon, causing mass extinctions and the planet to be completely uninhabitable. Due to the way explosions travel in space, the remnant matter and shockwave of the DS-1 would radiate outwards in all directions, dispersing all remaining energy across the entire system around it [8].

References

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