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P6_2 Would the Starkiller Base be able to eat our Sun?

J. Campbell, A. Alam, J. Phelan, B. Warne

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

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Abstract

Star Wars: The Force Awakens (2015) includes a large planet-like weapon fuelled by the intake of entire stars. Its diameter is approximated to be 658 km, and the concept of the Schwarzschild Radius is explored - establishing that a black hole would not be created in its core if it were to 'eat' the Sun.

Introduction

In the 2015 film *Star Wars: The Force Awakens*[1], the sinister First Order develop a super-weapon capable of destroying multiple planets at a time. This "Starkiller Base" positions itself within the proximity of a star and proceeds to consume it, using this energy and mass as a destructive beam. In order to contain the energy and matter within the relatively small volume of the base itself, reference is made to a "thermal oscillator". Though the precise workings of this device are not known, assumptions can be made:

1. The entire mass of the target stars are consumed, given that no trace of these are observed on film afterwards.

2. This mass is conserved when contained within the Starkiller base's core: indicated by the formation of a 'new' star from the contents of the base exploding at the film's finale.

Setting aside the high temperatures involved (the surface of the sun being 5777 K), and exactly how the "eating" process is carried out, would the Starkiller Base be able to eat the Sun without such a large mass density creating a black hole?

Theory

It is implied that the original Death Star is the size of a small moon. In our solar system, the range of moon size is very large: from objects only 10 km across to Ganymede (which orbits Jupiter) being 5268 km wide. In comparison, Earth's moon is 3475 km in diameter.[2]

The accepted consensus is that this original Death Star possessed a diameter of 120 km[3], within this size range. In the film *The Force Awakens*, one is conveniently shown a direct visual comparison between this and the newly constructed Starkiller Base (see figure.1).



Figure 1: A visual comparison of the original Death Star (centre left) and Starkiller Base (right).[1]

This provides an estimated diameter of 658 km for the Starkiller Base. If the core containment zone has half of the diameter of the base itself (see figure. 2), which is a conservative estimate given how close the core appears to the surface on film, then this would in turn possess a *core* volume of $1.87 \times 10^7 \text{ km}^3$ (or $1.87 \times 10^{16} \text{ m}^3$).

One solar mass equates to $1.989 \times 10^{30} \text{ kg}$. [4] If uniformly stored within the core of the Starkiller Base, then the density of this matter will be $1.06 \times 10^{14} \text{ kgm}^{-3}$, occupying a volume of radius 164.5 km.

The *Schwarzschild Radius*, can be found for any mass, and is the radial value (and so is also a determinant of density) at which the escape velocity, v_e , will be equal to the speed of light. If this criteria for the gravitational field is met, then the object will be a black hole. [5] The equation for escape velocity is as follows:

$$v_e = \sqrt{\frac{2GM}{r}}, \quad (1)$$

If v_e is equal to c (i.e. for a black hole) then:

$$r = \frac{2GM}{c^2}, \quad (2)$$

Results

For an object of one solar mass, the Schwarzschild density and radius will be $1.84 \times 10^{19} \text{ kgm}^{-3}$ and 2.95 km respectively: meaning that the previously found estimates for the core containment zone dimensions will be greater than these values and so it will not create a black hole.

Discussion

One may also consider the gravitational force on the surface of the Starkiller Base itself (and those walking upon it). Because the mass of the core when filled is much greater than that of the hollowed-out planet it resides within, one can approximate the total of the two added together as one solar mass. We then find the gravitational acceleration on the base's exterior when filled to be $8.64 \times 10^8 \text{ ms}^{-2}$: around 88 million times greater than on Earth.

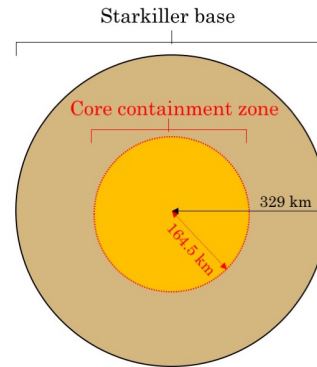


Figure 2: A diagram showing the simplified model of the Starkiller Base: with the “core containment zone” used to store the absorbed star.

Conclusion

Although anyone on the Starkiller Base would be crushed by the gravitational field that arises when it ‘eats’ the Sun, a black hole will not be created while doing so. The base would need a core of diameter 6 km or less for this to happen.

For further consideration on this topic, one may explore whether or not the superweapon in question is capable of energy-matter conversion, meaning that the mass previously discussed could be minimised in lieu of energy storage. [6]

Regardless, the “thermal oscillator” that enables this process must involve technology hitherto unheard of (or perhaps only existed a long time ago in a galaxy far, far away...).

References

- [1] Star Wars: The Force Awakens (2015) Directed by J.J. Abrams [Film]. USA: Disney Corporation.
- [2] <https://goo.gl/GLC15z> (accessed 2016)
- [3] <https://goo.gl/Mgu3> (accessed 2016)
- [4] <https://goo.gl/xccpqj> (accessed 2016)
- [5] D. Mahto, M. S. Nadeem, M. Ram, K. Vi-neeta, *Gravitational Force between the Black Hole and Light Particle in XRBs*, Journal of Gravity, vol. 2013 (2013).
- [6] <https://goo.gl/rZDI2o> (accessed 2016)