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A5_6 The Holdo Maneuver

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Abstract

The Holdo Maneuver was a suicidal battle tactic employed by Vice-Admiral Amilyn Holdo in the movie Star Wars: the Last Jedi, in which she rammed the Raddus into another spaceship to destroy it. In this paper we will find the relativistic kinetic energy imparted onto Holdo's target to be 1.9×10^{29} J. Using this number, we will discuss and compare the efficacy of such a maneuver to a superweapon like the planet destroying Death Star and will find that it would take ≈ 1000 simultaneous Holdo Maneuvers to completely destroy a planet of similar size to the Earth.

Effective as a Tactic?

In the second sequel movie Star Wars: The Last Jedi, Vice-Admiral Amilyn Holdo pioneered a battle tactic that would be named after her, in a last ditch effort to give the resistance a chance to escape their pursuers. The Holdo Maneuver is analogous to the kamikaze tactics employed by the Japanese empire during the second world war. A suicidal tactic in which Holdo navigated her cruiser into the First Order's dreadnought at relativistic speeds. In the movie, the maneuver caused immense destruction and was employed to great effect, destroying the dreadnought and the fleet accompanying it.

To analyze the destructive potential of the Holdo Maneuver, we calculate the kinetic energy that the Raddus (an MC 85 Star Cruiser) [1] would impart on its target and compare this to the gravitational binding energy of Earth as well as large meteors.

Relativistic Kinetic Energy

To make the necessary calculations, we need to make some assumptions. The method of faster than light (FTL) travel in Star Wars is the hyperdrive. As there is nothing in reality that is comparable to it, we will assume that the collision occurs while the ship jumps into hyperspace, choosing a velocity close to the speed of light (c) which would be passed during the jump [2]. We took the velocity of the Raddus to be $0.99c$ as it is close to the speed of light without adding an unreasonable amount of significant figures. Next we calculated the mass of the Raddus using its specifications [1] and assuming the cruiser is a semi-ellipsoid (because it looks like one. See [1] for a visual of the vessel). Density and volume are required to calculate the ship's mass. We assume the ship's density is similar to that of an Airbus A380 [3] also having a three-metre thick outer layer of armor made of solid steel (the walls of the ISS are much thinner than this)[4].

The volume of a semi-ellipsoid is given by: $\pi/12 \times W \times L \times H$ [5] (using the width, length & height of the shape) and comes to 5.8×10^8 m^3, using the aforementioned specifications. To find the total mass, we add together the masses of the hull and the interior. We take the density of

the hull to be 7700 kgm^{-3} [6] and the interior to be 510 kgm^{-3}(calculated from the average mass and volume of an Airbus A380 [3][4]). This gives a total mass of 3.4×10^{11} kg.

We can now input these values for mass and velocity into the equation for relativistic kinetic energy below [7]:

$$E_k = \frac{mc^2}{\sqrt{1-(\frac{v}{c})^2}} - mc^2 \tag{1}$$

where m is mass and v is the velocity of the vessel. This gives an energy of $1.9{\times}10^{29}$ J for a single ship of the size of the Raddus colliding with a target at 99% the speed of light, which is equivalent to $4.5{\times}10^{11}$ Gt of TNT.

Destructive Potential

So, can this maneuver be used to destroy an Earth-like planet? No. The gravitational binding energy that needs to be overcome is of order 10^{32} J [8] which is $\approx 1000\times$ larger than what the Holdo Maneuver is capable of.

That being said, is this maneuver a powerful tactic? Yes, it can cause significant devastation to a planet's surface. To put its destructive power into perspective, the meteor that was responsible for the Earth's largest mass extinction event, is estimated to have had an impact energy of 10^5 Gt of TNT [9]. This is $\approx 10^6\times$ weaker than the Holdo Maneuver. On a planet with an ecology similar to Earth, this would lead to an ice-age, many times longer and more devastating than what caused the extinction of the dinosaurs. On a planet spanning city such as Coruscant or Taris this would kill hundreds of billions of inhabitants, in addition to the destruction of vital infrastructure that keeps the planet inhabitable. From this we can see that the Holdo Maneuver would make for a potent battle tactic, able to annihilate local and global ecology, and infrastructure. If one were to take a large piece of material rather than a fully functional ship and strapped the FTL travel method to it, one could bombard planets and only one would be sufficient to paralyze the target for an extended period of time. It is important to note that the latter situation on a planet spanning city is mere conjecture relevant only to the Star Wars universe.

Conclusion

The Holdo Maneuver would make for an incredibly potent wartime tactic, many times more powerful than the weapons of mass destruction that are keeping major powers on Earth from going to war with each other. While not capable of destroying planets, Vice-Admiral Holdo would have been capable of causing extreme devastation to the surface of a planet. In our opinion, it would be more than sufficient to replace the Death Star and satisfy the mutually assured destruction doctrine of warfare. It is an effective maneuver that causes inordinate destruction to its target.

References

[1] *Raddus* `http://tiny.cc/9dh0vz` [Accessed 26 October 2022]

[2] `http://tiny.cc/fdh0vz` [Accessed 24 October 2022]

[3] `http://tiny.cc/1dh0vz` [Accessed 25 October 2022]

[4] `https://www.aerospace-technology.com/projects/airbus_a380/` [Accessed 25 October 2022]

[5] `https://www.omnicalculator.com/math/ellipsoid-volume` [Accessed 27 October 2022]

[6] `http://tiny.cc/8dh0vz`[Accessed 25 October 2022]

[7] `http://hyperphysics.phy-astr.gsu.edu/hbase/Relativ/releng.html` [Accessed 25 October 2022]

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