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P4_3 Light Ordnance

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Abstract

In this paper we consider a weapon system that fires a laser at an interplanetary vessel. We calculate the energy required to melt through a vessel's armoured hull, of thickness 0.254 m, from a shot from a laser with a calibre of 16 inches. The energy required is found to be $E = 34,449$ J. Using this energy, the recoil of the laser firing was calculated to be $p = 1.15 \times 10^{-4}$ kgms^{-1}.

Introduction

In this paper we consider the laser weaponry used in many works of science fiction (Sci-Fi) between interplanetary vessels, to do this we will assume the weaponry used is, with the exception of the firing method and 'shell', comparable to a World War II Battleship, as this style of turret is used in many Sci-Fi films and novels (for example, 'turbo lasers' from the Star Wars saga), and the outer hull of these vessels to be similar to that of a modern submarine due to it having to cope with, albeit in reverse, a similar pressure gradient. We will consider both the energy required to melt through such a hull, and the recoil the weapon would generate in doing so.

For this article we will use a *BL 16inch MK I* naval gun, which fires a round approximately 0.203 m in radius [1], and a hull of thickness 0.254m, which is similar to an averagely armoured submarine [2], we assume that the hull is made of titanium, because it is both relatively low density and strong, and thereby seems a likely candidate to be at least a minor constituent of a space-faring vessel's hull.

To calculate the energy required to melt through the hull, we use equation (1).

$$E = \Delta T C_v \rho \pi r_{beam}^2 t_{hull} \tag{1}$$

where ΔT is the temperature change, C_v and ρ are the specific heat and density of titanium respectively, and $\pi r_{beam}^2 t_{hull}$ is the volume of the hull section being heated, if we assume that the heat of space is negligible compared to the melting point of titanium, we can use that as our ΔT giving a value of 1941K [3], as well as using 540 Jkg^{-1}K^{-1} [3] and 4505 kgm^{-3} [3] for specific heat and density, we find that $E = 34449$ J.

Finding the recoil imposed upon the ship simply requires finding the momentum of the emitted photons due to conservation of momentum, so it is given by

$$p = \frac{E}{c} \tag{2}$$

where c is the speed of light, this gives a momentum change of $p = 1.15 \times 10^{-4}$ kgms^{-1}.

As the laser weaponry in Sci-Fi varies greatly in size we have considered a range of calibre that would still transfer the required energy to breach the hull of the ship, as shown in Figure 1. The

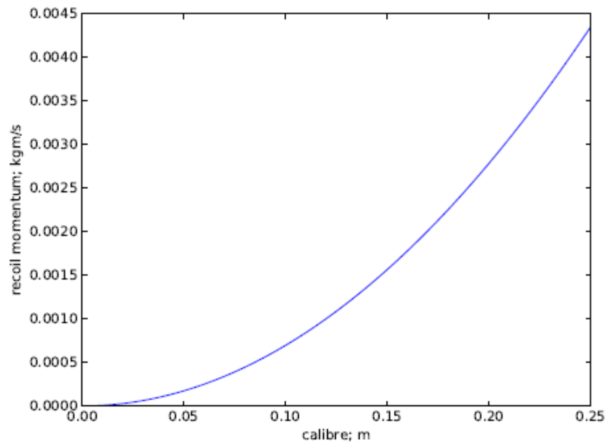

Figure 1: A Graph of the recoil of the weapon versus is caliber, showing a distinct x^2 relationship

lower calibre weapons would most likely be used by infantry, meaning the weapons would be designed to fire through the atmosphere so the energy of the shot will need to be increased to ensure the shot will still be able to penetrate the armour of the vehicles. Whilst this greatly lowers the accuracy of the lower bound of the model the increase in momentum from the shot would likely be more akin to the higher values shown, which would still not be a notable effect for an average human.

Conclusion

In conclusion, for a laser weapon, similar in design to that of a battleship turret battery, fired at titanium armour of thickness 0.254 m. The energy required to melt through the armour was calculated to be $E = 34449$ J. From the energy required we calculated the recoil produced by firing one of the cannons in the battery would be $p = 1.15 \times 10^{-}4$ kgms^{-1}. The energy output of such a laser has already been achieved in real physics [4] and the momentum change is very small meaning that it could be fired by an interplanetary vessel with only a negligible effect on the vessel. However with these energies it might be easier to breach the hulk using a shorter pulse laser with an ablation method, but this article leaves such considerations as a topic for future studies.

References

[1] https://en.wikipedia.org/wiki/Nelson-class_battleship

[2] http://www.madehow.com/Volume-5/Nuclear-Submarine.html

[3] https://en.wikipedia.org/wiki/Titanium

[4] https://en.wikipedia.org/wiki/Laser