

# Journal of Physics Special Topics

An undergraduate physics journal

---

## P1\_1 An analysis of the feasibility of a Giant Death Beam

K. Roberts, N. Holt, J. Murphy, J. Tranter

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

November 3, 2020

### Abstract

This paper examines the possibility of constructing a giant beam of the Sun's radiation to be focused onto the Earth's surface. The purpose of this was to emanate the weapon of mass destruction from a James Bond film. Our results reveal that the spherical lens required to generate a beam of cross-sectional area  $1m^2$  would have a radius of 141m.

---

### Introduction

The James Bond film "Die Another Day" famously featured an orbital mirror system. The motivation for building the contraption was supposedly innocent, however the more heinous reason was soon revealed: it was a weapon of mass destruction. This paper explores the feasibility of focusing solar radiation into a narrow beam, one with enough power to burn objects on the surface of Earth. Comparisons of heliosynchronous and geosynchronous orbits were made however, the geostationary orbit was found to be more fitting with our proposed idea. Working with a heliosynchronous orbit meant that the Sun's position in the sky was, for the purposes of this paper, unnecessarily complex to calculate. Our system, unlike the film's, is constructed from two Fresnel lenses with no mirrors or diamonds. This design was chosen for simplicity in addition to the practicality of its transport and assembly in space.

### Method and Results

The standard method of achieving a geosynchronous orbit begins with launching the satellite into a geosynchronous transfer orbit (GTO).

This is an elliptical orbit around the Earth and the satellite's rocket engines then boost the satellite into a geostationary orbit at a chosen inclination.

In "Die Another Day" the mirror system targets the Korean Demilitarised Zone (DMZ), which lies on the following coordinates:

Latitude: 37.9536 Longitude: 126.6698.

Although geostationary orbits usually lie above the equator with a 0 degree inclination, using rocket propulsion in a process called station keeping the orbit can be adjusted to an inclination of 37.9536 degrees [1]. We used the following equations to calculate the altitude of the orbit[1]:

$$T = 2\pi\sqrt{R^3/\mu} \quad [1], \text{ where } \mu = GM_E$$

$$R = \sqrt[3]{\frac{\mu T^2}{4\pi^2}} \quad [2], \text{ where } \text{Altitude} = R - r_E$$

Where  $G$  = gravitational constant,  $R$  = orbital radius,  $r_E$  = radius of the Earth,  $T$  = orbital period and  $M_E$  = mass of the Earth. The resultant altitude is 37,786km.

The satellite itself contains a pair of Fresnel lenses which can be disassembled before the journey into space and then reassembled by a team of evil henchmen, who are also highly trained engineers, once the satellite is in orbit.

The lenses' setup is depicted in Figure 1. The radius of the initial orbit can be calculated with the equation below, found by finding the product of incoming solar flux and the power density magnification of the incoming light and equating this the power of the beam, as shown:

$$\frac{Sr_m^2}{r_b^2} = \frac{E}{tA} \quad [3]$$

Where  $S$  is the solar flux on the surface of the initial lens,  $r_m$  is its radius,  $r_b$  is the radius of the beam,  $E$  is the energy required to burn the target,  $A$  is the beam area ( $1m^3$  in this case) and  $t$  is the time designated for the target to burn. We then calculated the necessary flux and thus the area of the lens. The target was chosen to be a  $1m^3$  block of oak wood and the beam diameter was  $1m$ . Our calculations found  $S$  to be  $1373 Wm^{-2}$  and the radius to be  $141m^2$ . Any larger than this and the wood would still be burned but the extra radius would be unnecessary.

Using the specific heat capacity of oak wood ( $2380 Jkg^{-1}K^{-1}$ )[2], its dry flash-point of  $482^\circ C$  [3], and its density of approximately  $750kgm^{-3}$  [4], we determined that the energy required to raise the  $1m^3$  oak cube from an atmospheric  $22^\circ C$  to its flash point is  $821MJ$ . A time of 30 seconds ensured a short enough time to focus on a specific area while being long enough to reduce the diameter of the initial lens.

It has been assumed in these calculations that the lens is free from imperfections. Dispersion of the beam due to atmospheric effects was discarded as the low wavelength infrared radiation would be largely unaffected.

## Optics and Aiming

As mentioned previously, the design chosen is an array of two Fresnel lenses, the primary lens is utilised to focus the Sun's radiation while the second collimates this light into a beam[5]. This can be visualised in *Figure [1]*. A primary benefit of this design was that by having the light focused into a beam on board the array, there was no requirement to have earth as the focal

point of the lens which would require an incredibly precise orbit to ensure a consistent beam.

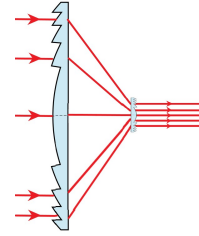


Figure 1: The lens array, consisting of two Fresnel lenses facing opposite directions. Credit: K. Roberts

## Conclusion

From our research we conclude that the beam itself is completely feasible however it would probably require such a large budget such that other weapons would thus be much more destructive at a lower cost. For more drastic destruction, a much larger mirror could be used, as the mirror's destructive power increases with the size of the mirror, however with the current design, a forest fire could be started at the very least.

## References

- [1] <https://solarsystem.nasa.gov/basics/chapter5-1/> [Accessed 07/10/2020]
- [2] <https://theengineeringmindset.com/specific-heat-capacity-of-materials/> [Accessed 06/10/2020]
- [3] [https://www.engineeringtoolbox.com/fuels-ignition-temperatures-d\\_171.html](https://www.engineeringtoolbox.com/fuels-ignition-temperatures-d_171.html) [Accessed 06/10/2020]
- [4] [https://www.engineeringtoolbox.com/wood-density-d\\_40.html](https://www.engineeringtoolbox.com/wood-density-d_40.html) [Accessed 06/10/2020]
- [5] <https://www.qrg.northwestern.edu/projects/vss/docs/power/1-how-do-solar-concentrators-work.html> [Accessed 07/10/2020]