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## P3\_1 Forging Stormbreaker

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### Abstract

This article investigates the scene in the film “Avengers: Infinity War” where Thor attempts to harness the energy of a neutron star to forge a new weapon, “Stormbreaker”. We estimate that  $8.4 \times 10^{25}$  J is required to forge the axe and Thor himself would have to withstand  $8.8 \times 10^{24}$  J.

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### Introduction

In the 2018 film “Avengers: Infinity War”, the superhero “Thor” attempts to forge a battleaxe, “Stormbreaker” to defeat the Villain “Thanos”, by harnessing the power of a fictional neutron star, “Nidavellir” [1]. Thor uses a forge along with a Dyson Sphere like structure to focus the energy from the star through an “iris” to create a beam of energy. This is concentrated on to a furnace where a pot of metal ingots is stood. During the scene Thor is pictured holding open the iris and absorbing some of the energy incident on the forge. By comparing the star in the film to one in reality, the amount of energy required to make Stormbreaker can be estimated as well as how much energy Thor is able to absorb.

### Theory

We have made the following assumptions regarding the neutron star: it is a perfectly spherical blackbody and is identical in radius, mass and surface temperature to RX J1856.5-3754; a typical neutron star nearby to Earth. The mass of the neutron star is given as  $1.8 \times 10^{30}$  kg, the radius as 10,000 m and the surface temperature as 500,000 K [2]. To calculate the total power

output of the star we use Equation 1, the Stefan-Boltzmann Equation:

$$L = \sigma A_{Star} T^4 \quad (1)$$

Where  $L$  is luminosity (power),  $\sigma$  is the Stefan Boltzmann Constant,  $A_{Star}$  is the surface area of the star and  $T$  is the surface temperature of the star. We used Equation 2 to calculate the star’s surface area.

$$A_{Star} = 4\pi r^2 \quad (2)$$

Where  $r$  is the radius of a sphere. Using the radius of RX J1856.5-3754 in Equation 2 we get the surface area as  $1.3 \times 10^9$  m<sup>2</sup>. Using this value we found the total radiative power of the star to be  $4.6 \times 10^{24}$  W. We assumed all energy is absorbed and focused through the iris as a side character “Eitri” states “You are about to take the full force of the star” [3]. From this we will calculate how much of that energy is absorbed by Thor and how much is used to forge Stormbreaker. We assumed Thor absorbs all incident energy. An approximation for the surface area of Thors body exposed to the focused energy was made using the Mostellar Equation [4]. The Mostellar equation can be seen below in Equation 3:

$$A_{Body} = \sqrt{\frac{hm}{3600}} \quad (3)$$

Where  $A_{Body}$  is the body surface area of person,  $h$  is the height of person in cm and  $m$  is the mass of person. We assumed the height and mass of Thor to be 100 kg and 200 cm respectively. Inputting into equation 3 gives  $A_{Body}$  as  $2.4 \text{ m}^2$ , whilst this is the total surface area of Thors body, the incoming energy is only incident upon the rear half of his body so the exposed surface area becomes  $A_{Body}=1.2 \text{ m}^2$ . To find exactly how much energy is absorbed by Thor we also need the cross sectional area of the beam of energy. We approximated the beam to have a diameter,  $D$  of 4 m, twice that of Thors height. Finally we assumed the beam to have a circular area.

$$A_{Beam} = \pi r^2 \quad (4)$$

Where  $A_{Beam}$  is the cross sectional area of the beam and  $r$  is the radius of cross section. Using the fact that  $r = D/2$  we used equation 4 to give us the cross sectional area of the beam as  $A_{beam} = 12.6 \text{ m}^2$ . Taking the area of Thors' body exposed to the beam as a ratio of the area of the beam and multiplying this by the power of the beam, we calculate how much power Thor receives and how much goes on to forging Stormbreaker. Using the above values Thor approximately absorbs  $4.4 \times 10^{23} \text{ W}$  or about 10% of the total power output of the star. This means that  $4.2 \times 10^{24} \text{ W}$  carries on in the beam to forge Stormbreaker. However we require the total energy absorbed by Thor and the total energy required to forge Stormbreaker. Using Equation 5 we can calculate the total energy from the values for the power.

$$P = \frac{E}{t} \quad (5)$$

Where  $P$  is power,  $E$  is energy and  $t$  is time interval. As seen above we need the time interval in which Thor is in the path of the beam. Approximating  $t$  is 20 seconds. Using Equation 5

we find that the total energy absorbed by Thor,  $E_{Thor}$  is  $8.8 \times 10^{24} \text{ J}$  and the energy required to forge Stormbreaker,  $E_{Storm}$  is  $8.4 \times 10^{25} \text{ J}$ .

## Discussion

As expected the amount of energy used to forge Stormbreaker and that which Thor absorbed is implausible. We have assumed all energy from the star had been perfectly absorbed by the Dyson Sphere and transferred without heat dissipation into the beam focused through the iris. Realistically, heat dissipation would significantly lower the energy focused through the iris. Also both the furnace and Thor have been treated as perfect absorbers. We also ignored the immense gravitational forces near a neutron star, which would make the whole scenario impossible.

## Conclusion

With our estimates of the neutron star we were able to calculate the amount of energy needed to forge Stormbreaker. This would require  $8.4 \times 10^{25} \text{ J}$ . During this process Thor would absorb  $8.8 \times 10^{24} \text{ J}$ . However, many assumptions have been made regarding the neutron star, the Dyson Sphere and the furnace. We also assumed that Thor has absorbed all energy incident upon him. For further study we suggest investigating the absorption coefficient for a human, as well as considering the efficiency of the process and applying both to the calculation.

## References

- [1] <http://marvelcinematicuniverse.wikia.com/wiki/Stormbreaker> [Accessed 3 October 2018]
- [2] [https://en.wikipedia.org/wiki/RX\\_J1856.5-3754](https://en.wikipedia.org/wiki/RX_J1856.5-3754) [Accessed 3 October 2018]
- [3] [http://transcripts.wikia.com/wiki/Avengers:\\_Infinity\\_War](http://transcripts.wikia.com/wiki/Avengers:_Infinity_War) [Accessed 3 October 2018]
- [4] [https://en.wikipedia.org/wiki/Body\\_surface\\_area](https://en.wikipedia.org/wiki/Body_surface_area) [Accessed 3 October 2018]