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P1_6 “Let the Old Gods flow through me one last time!”

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Abstract

This paper investigates whether the Bifrost, a magical beam of light that the Asgardians use to travel between realms, can act as a spaceship transporting the Hulk across space by looking at the time and energy required to send him back to Earth in Marvels; Infinity War. We calculated that at $0.999 c$ the Hulk would take 2.52 ± 0.14 million years with a kinetic energy of 1.01×10^{21} J and a total energy of 23.5×10^{21} J.

Introduction

Marvels, Avengers: Infinity war, begins with an Asgardian ship being ambushed by the evil titan Thanos in his quest to retrieve all the infinity stones. In a final attempt to warn Earth of the dangers approaching, Heimdall uses the power of the Old Gods to summon the Bifrost, a magical light bridge that is used by the Asgardians to quickly travel between the nine realms, sending an unconscious Hulk hurtling in the direction of Earth. The next shots in the film show a beam of light carrying the Hulk hurtling through space at extremely high velocity. In this paper, we look at the time taken for the Hulk to travel to Earth using the Bifrost as a mode of transport and the energy of this journey.

Theory

In the film, Thor: Ragnarok, Valkyrie tells Thor that they can be in Asgard from Xandar in 18 months [1]. Xandar is said to be in the galaxy Andromeda which is 2.52 ± 0.14 million light-years away [2]. This would suggest that Asgard must have been located somewhere close before its destruction in Ragnarok and that when the

ship was ambushed it was travelling through Andromeda. This is also supported by the fact Thor is later rescued by the Guardians of the Galaxy who are said to be flying around this galaxy [3].

Using the assumption that the Bifrost is travelling at speeds very close to the speed of light, $0.999 c$, in the reference frame of the Earth, the Hulk would get to Earth in 2.52 ± 0.14 million years using Eq. (1).

$$t = \frac{d}{v} \quad (1)$$

Where t is the time, d is the distance and v is the velocity. To work out the energy of the Hulk travelling at this speed, his relativistic mass must be calculated. This is done using Eq.(2) where m is the relativistic mass, m_0 is the rest mass, and γ is the Lorentz factor which is shown in Eq.(3).

$$m = \gamma m_0 \quad (2)$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (3)$$

γ is calculated to be 22.4. The rest mass of

the Hulk is 521 kg [4] therefore we calculated the relativistic mass to be 11.7×10^3 kg.

The relativistic mass can then be used to find the kinetic energy as using Eq. (4) [5].

$$KE = mc^2 - m_0c^2 \quad (4)$$

We calculate the kinetic energy to be 1.00×10^{21} J. We can also work out the total energy of the Bifrost transport and to do this we need the momentum which can be calculated from Eq. (5) [5].

$$\rho = \gamma mv \quad (5)$$

We get a value of $7.85 \times 10^{13} \text{ kgms}^{-1}$ for the momentum. Eq. (6) [5] uses the relativistic mass and the relativistic momentum to calculate the total energy.

$$E = (\rho^2 c^2 + m^2 c^4)^{1/2} \quad (6)$$

This gives a total energy of 23.5×10^{21} J. To put this into comparison the energy of the Fat Man atomic bomb dropped on Nagasaki was only approximately 84.0×10^{12} J, the energy of the biggest man-made explosion was the Tsar Bomba was approximately 210×10^{15} J and the impact of the Chicxulub meteor which triggered mass extinction during the age of the dinosaurs had an energy of approximately 418×10^{15} J [6].

Discussion

We calculated that in order to reach Earth it would take 2.52 ± 0.14 million years to get back to Earth. The Hulk manages to get there in a matter of minutes suggesting that the Bifrost can travel faster than the speed of light. This violates Einstein's postulates of special relativity which state that the speed of light is constant in all inertial frames of reference and that nothing can travel faster [5].

The energy increases exponentially as the velocity converges on the speed of light meaning the faster the Bifrost is travelling the higher the total energy. This suggests that the Bifrost must decelerate in order to minimise the damage caused as the Hulk crashes into New York and it is unclear how this deceleration is achieved.

Conclusion

In conclusion, considering the distance the Bifrost has to travel, the shots of the light bridge appearing to move as a mode of transport through space must be incorrect as it would take far too long for the Hulk to get back to Earth. In addition, the energy of the Bifrost at these speeds and with the mass of the Hulk would be enough to cause catastrophic damage to Earth and the human race making it easier for Thanos to claim the infinity stones.

References

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