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A3_9 Flying Thor

R. Hodnett, M. Capoccia, E. Morton, D. Potts, S. Shingles

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

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Abstract

If Mjolnir can change its mass by controlling gravitons, this may explain how Thor is able to fly. By spinning Mjolnir, angular momentum is gained. Mjolnir loses mass (by manipulating gravitons) as Thor jumps, and so for momentum to be conserved, Thor is able to fly. In order for Thor to fly from the ground to thunder clouds, Mjolnir must have a change in mass of 774 kg.

Introduction

In the Marvel Universe, Thor is able to fly by using the power of Mjolnir. In a Marvel comic [1], it is suggested that Mjolnir can change its mass by using gravitons.

If this theory is correct, then Thor may be able to fly by building up angular momentum as he spins a heavier Mjolnir, and then throwing himself into the air with a lighter Mjolnir. This method is seen in the Marvel films, and has been suggested as a possibility before [2].

By using equations of momentum, the change in mass of Mjolnir can be worked out in order for Thor to fly from the ground to the thunder clouds above him.

Theory and Results

Before Thor can fly, he must build up angular momentum by spinning Mjolnir. Angular momentum is given by equation (1).

$$L = m_i v_i r \qquad (1)$$

L is the angular momentum, m_i is the mass of Mjolnir, v_i is the velocity and r is the radius of the circle. m_i is what we aim to find out, so we can estimate the change in mass of Mjolnir.

The radius of the circle r that Mjolnir is spun in is equal to the length of Mjolnir. This was estimated to be 0.44 m, found from the dimensions of a 1:1 replica [3].

To estimate the velocity v_i, we need to know how many revolutions per second (RPS) Mjolnir undergoes. From the films, it is impossible to tell this value as blurring special effects are used. As such, we estimated a large value of 6,000 RPM (100 RPS). This is equal to 276.5 m s^{-1} (as the radius of the circle is 0.44 m).

When Mjolnir is being spun by Thor, we will assume that the mass m_i is contained in the head of the hammer.

If Thor stops spinning Mjolnir and jumps, whilst Mjolnir loses mass, Thor may be able to fly. We will assume that the initial upward velocity is constant and neglect effects of air resistance. The effect of gravity is insignificant compared to the upward momentum of Thor and so can also be neglected.

The momentum of Thor as he is flying is given by linear momentum, shown in equation (2).

$$p = m_f v_f \qquad (2)$$

p is equal to the linear momentum, m_f is equal

to the mass of Thor and Mjolnir as they are flying and v_f is equal to the velocity at which they are flying.

We will assume that Mjolnir is massless whilst Thor is flying, because if it is able to change its mass, to be most efficient it will have a mass of 0 kg. Therefore, m_f is simply the mass of Thor. We found that in the Marvel Cinematic Universe, Thor's mass is 100 kg [4].

In this scenario, we will say that Thor is going to fly from the ground to the thunder clouds above him. Thunder clouds, or cumulonimbus clouds, are at an altitude of approximately 1.98 km above the ground [5]. This is the vertical distance Thor will fly. As he has an initial linear velocity of 0 m s^{-1}, equation (3) is used.

$$s = \frac{1}{2}v_f t \qquad (3)$$

s is the vertical distance of 1.98 km and we found t to be 1.85 s. t was found by slowing a clip from *Thor: Ragnarok* [6] to a quarter speed, timing it with a stopwatch and then dividing that time by 4. This was done for a clip of Thor flying from the ground to the clouds. From equation (3), v_f is found to be 2140 m s^{-1}.

Using equation (2), the final momentum of Thor and Mjolnir p is 214,000 kg m s^{-1}.

To work out the initial mass of Mjolnir, the two momenta are equated, as momentum must be conserved.

$$m_i v_i r = pr \qquad (4)$$

$$m_i = \frac{p}{v_i} \qquad (5)$$

Hence, from equation (5), the mass of Mjolnir as it is being spun is 774 kg. This is equal in the change in mass needed of Mjolnir needed for Thor to fly from the ground to the thunder clouds.

Discussion

The biggest assumption made is that Mjolnir can control gravitons. This is beyond our current understanding of physics.

As Mjolnir loses its mass, momentum is conserved by increasing the velocity. The change in mass of Mjolnir would change depending on the distance and velocity that Thor was flying. Sometimes he is seen to travel much faster and so the change in mass would be greater than 774 kg.

Gravitons are hypothetical particles, and so the physics involving them is not fully known. If Mjolnir can use gravitons to manipulate its mass, this could explain why those not deemed worthy are unable to lift the hammer. Mjolnir may acquire so much mass that it is impossible for others to lift it. However, when Thor lifts Mjolnir, it may lose mass (although Thor is stronger than a human).

Conclusion

In order for Thor to fly from the ground to the thunderclouds above him by using momentum for Mjolnir, Mjolnir would need to initially have a mass of 774 kg. Whilst flying, the mass of Mjolnir decreases to 0 kg. This is done by Mjolnir using the hypothetical particles gravitons to manipulate its mass.

References

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