Journal of Interdisciplinary Science Topics

Knocking Dr Doom Off His Feet – The Energy and Force Behind the Silver Surfer's Attack

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19/03/2015

Abstract
The 2007 film "*Fantastic 4: Rise of the Silver Surfer*" introduced Marvels Silver Surfer character to the big screen for the very first time. The Surfer is a metallic skinned humanoid from a distant alien race who is able to summon large amounts of energy from his silver surf board. This energy is the source of his power and allows him to not only travel through space but also to attack his enemies. In the film, the Surfer uses this energy to produce a shock wave that is able to knock Dr Doom, an enemy of the Fantastic Four, clean of his feet and backwards into a wall of ice. This paper uses simple mechanics and assumptions to show that this shock wave would need to have a minimum of 3.22kJ of energy and 214.5N of force to knock Dr Doom back a distance of 30m over a period of 4 seconds.

Introduction

The Fantastic Four [1] are a fictional superhero team published in stories by the infamous Marvel Comics since 1961. The team consists of Mr Fantastic (Reed Richards), The Invisible Woman (Sue Storm), The Human Torch (Johnny Storm) and The Thing (Ben Grimm). After gaining their superpowers from exposure to cosmic rays whilst on a space mission, they now fight together, using their powers for good fighting against notable villains such as Dr Doom, Mole Man, Klaw and Galactus [1].

In the 2007 film adaptation, *Fantastic 4: Rise of The Silver Surfer* (see figure 1), the team takes on the Silver Surfer, a humanoid with metallic skin who is able to travel through space on his spacecraft shaped like a surfboard. The film shows the arrival of the Surfer to Earth and how his arrival coincides the formation of large craters all over the planet's surface. The army soon contacts Dr Richards with regards to the Surfer, and the team are eventually tasked with taking him down. Unbeknown to the team, the Surfer is being coursed into attacking the Earth by the films true villain, Galactus, a cosmic being who feeds off the energy of living planets [2].

During the film, a confrontation between Dr Doom and the Surfer takes place. Dr Doom, the main antagonist from 2005's "Fantastic 4" and is defeated by the team at the end of this first film [3].

Figure 1 – The Fantastic Four and the Silver Surfer as they appear in the movie adaptations [4].

Throughout the film, Dr Doom develops an organic metallic exterior, which replaces his skin and allows him to produce bolts of electricity. Following the defeat, Dr Doom is trapped in a metal encasement and released during the sequel due to the cosmic

energy from the Surfer. Following Dr Doom's release, the pair meet at Russell Glacier and Doom attempts to convince the Surfer to work alongside him. With negotiations failing, Dr Doom attacks the Surfer, who then returns fire with a shock wave that knocks doom off his feet and blasts him back into a wall of ice. The cosmic energy from the blast is able to heal Dr Doom's body from the scars obtained from his metal casing and it is later revealed that Dr Doom recorded the whole encounter. Dr Doom shows this footage to General Hagar and the Fantastic Four where he and Richards quickly realize that the Surfer draws his power from his board. Therefore to make the Surfer powerless, they would have to separate the board from its master [2].

This paper uses simple mechanics and assumptions to calculate the minimum amount of energy and force that the Silver Surfer would need to generate from his board in order to produce the resulting shock wave that was able to knock Dr Doom clean off his feet.

Calculating Dr Doom's Mass
Before calculating the energy or the force of the shockwave, a calculation for Dr Doom's total mass is required. This was done by assuming that the actor who plays Dr Doom, Julian McMahon, weighed the same as Dr Doom without his metal skin. In order to consider the metal, it was assumed that the metal layer acted as a second skin and therefore had a similar surface area and thickness to human skin. Since the surface area of human skin is approximately $2m^2$ and the average thickness is about 2 mm, these values were used to calculate the volume of Dr Doom's metal skin [5]:

$$Volume = Surface\ area \times Thickness$$
$$V = 2 \times (2 \times 10^{-3}) = 4 \times 10^{-3} m^3$$

It was also assumed that the metal layer was made of steel and therefore, using the density of steel allowed the metal layers mass to be calculated [6]:

$$Mass = Density \times Volume$$
$$m = 7850 \times 4 \times 10^{-3} = 31.4\ kg$$

Adding this to Julian McMahon's mass of 83 kg gave a value from Dr Doom's total mass of 114.4 kg [7].

Modelling the Shockwave
Using Dr Doom's calculated total mass; the shock wave that is produced by the Silver Surfer could then be modelled. To do this, it was assumed that the shockwave knocked Dr Doom clean off his feet and sent him back into the wall of ice with his path of travel being a straight line back into the wall of ice. To simplify the model, it is assumed that there is no air resistance, and the effect of the snow as Dr Doom travels through it hitting the back wall of ice is ignored. Since the distance and time period of Dr Doom's travel were unknown, they were taken to be 30 m and 4 s respectively. This is based on observations from the scene in the film. Using these values Dr Doom's final speed when he hit the wall could be calculated to be:

$$Speed = Distance/Time$$
$$v = 30/4 = 7.5\ ms^{-1}$$

Using the equations of motion, Dr Doom's acceleration could then be calculated by taking his initial velocity as 0 ms⁻¹, his final velocity as 7.5 ms⁻¹ and his travel time as 4 s [8].

$$v = u + at$$
$$a = (v - u)/t$$
$$a = (7.5 - 0)/4 = 1.875\ ms^{-2}$$

Using his mass with this acceleration, the force required in order to send Dr Doom back by this distance can be calculated as follows:

$$F = ma = 114.4 \times 1.875 = 214.5\ N$$

And using Dr Doom's final velocity, his kinetic energy at the point of impact can be calculated to be:

$$KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 114.4 \times 7.5^2 = 3.22\ kJ$$

Conclusions
In order to model the Silver Surfer's attack, it was assumed that the shock wave used was able to knock Dr Doom back a distance of 30 m over a period of 4 s. Assuming that the minimum force required to knock him back this distance was the same as the minimum force of the shock wave, and that there was a complete energy transfer from the wave to Dr Doom, the model shows that the Surfer would have to summon a minimum of 3.22 kJ in

order to produce a shock wave with a magnitude of force of 214.5 N.

These calculations show the bare minimum energy and force required for the Silver Surfer to accomplish this attack and confirms that he is indeed able to summon large amounts of energy from his board. This is expected when considering that he uses it to defend himself against his enemies and also to travel across the galaxy.

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