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A4_8 Supercooling and Superspeeds - with Dio Brando

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Abstract

In the anime series, JoJo's Bizarre Adventure, Dio possesses a number of powers. One of these powers is the ability to freeze the blood and the hence body of an opponent. The other is the ability to stop time for everyone besides himself for up to 9 seconds. In this paper, we look at these two powers, and analyse the practicalities of using them. In order to freeze his opponent, we find he would need $6.07 \times 10^7 J$ of energy to cast the ability. Additionally, if he were to effectively freeze time, he would have to move at a speed of very near light speed, making his relativistic mass approximately 96,300 kg.

Introduction

Jojo's Bizarre Adventure focuses on different characters and shows how they each use their unique powers to their advantage in various duels throughout the series. This paper looks into one of the antagonists named Dio Brando, and the practicality of two of the powers he possesses.

The first ability we look at is his "Vaporization Freezing Technique", where he is able to freeze blood in an opponent's body. The other we look at is "The World", the ability to pause time for up to 9 seconds affecting any opponents around him who also do not possess this power. This leaves himself unaffected and free to move.

Theory

Vaporization Freezing Technique - Dio's first power involves him freezing the blood and hence body of his opponents in order to defeat and subsequently shatter them. We use the heat energy for specific heat capacity and latent heat of fusion in water to approximate how much energy this would require.

The heat energy for specific heat capacity is given by,

$$Q = mC\Delta T, \quad (1)$$

where Q is the heat energy, m is the mass of the opponent's body, C is the specific heat capacity, and ΔT is the change in temperature due to the heat transfer.

The heat energy for latent heat of fusion must also be known, and is given by,

$$Q = mL, \quad (2)$$

where L is the latent heat of fusion. The combined energy of both of these equations gives the total energy needed to freeze his opponent.

"The World" - Dio's second power allows him to pause time for his opponents around him for up to 9 seconds, leaving himself unaffected. We find how fast he would have to move to theoretically achieve this using time dilation equation rearranged for velocity. This is given by,

$$v = \sqrt{c^2 - \frac{c^2 \Delta t^2}{\Delta t'^2}}, \quad (3)$$

where v is Dio's velocity, c is the speed of light, Δt is time in the rest reference frame (i.e. what his opponents experience), and $\Delta t'$ is the time in the moving reference frame (i.e. what Dio experiences). Dio's increased mass due to this speed can then be found using the relativistic mass equation,

$$m_{rel} = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}, \quad (4)$$

where m_0 is his original mass.

Results

Vaporization Freezing Technique - First, the energy to freeze Dio's opponents is found. We assume the opponent's body is made entirely of water as opposed to a mix of blood and human tissue. We also assume the body is not producing any energy internally.

His opponents are typically overtly muscular, so we use the mass of a famous body builder, Arnold Schwarzenegger, 107 kg [1]. The specific heat capacity of water is $4190 \text{ J kg}^{-1} \text{ K}^{-1}$ [2], and the difference in temperature from average body heat [3] to the freezing point of water (0°C) is $\Delta T = 37.5^\circ \text{K}$. Using Eq.(1) gives a heat energy of $1.70 \times 10^7 \text{ J}$. Next, using Eq.(2), with a latent heat of fusion for water of $334 \times 10^3 \text{ J kg}^{-1}$ [2], gives a heat energy of $3.57 \times 10^7 \text{ J}$. These two energies can be combined to give a total energy cost of $6.07 \times 10^7 \text{ J}$.

"The World" - For his ability "The World", the velocity Dio is travelling at can be found using Eq.(3), where $\Delta t'$ is 9 seconds [5], and Δt is 0.01 seconds for near-instant transportation. This gives a velocity of $2.9979227 \times 10^8 \text{ ms}^{-1}$, or $99.9999404c$. It is given to this many significant figures as v is incredibly sensitive at high values and c is known to a precise value.

Substituting this value for v into Eq.(4) and using a mass of 107 kg [1] finds his relativistic mass at these speeds, which is approximately 96,300 kg.

Conclusion

This paper makes some assumptions, namely in the "Vaporization Freezing Technique" ability. This is done due to no reliable documentation for a latent heat of fusion value for human tissue and blood being known. Further, as a body internally produces heat, the energy requirements would be increased. We feel like assuming a body made entirely of water is a reasonable substitute due to most of the human body being water.

It is calculated that the energy to freeze an entire person would require a large energy cost, and it is found to be comparable to the energy content of around 1.5 kg of petrol [6].

It is also calculated that a velocity of very near the speed of light would be required for Dio's "The World" ability. It would be unrealistic for a real person to reach these speeds, therefore the power would not work outside of fictional scenarios.

References

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