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A2 5 Shrinking Suspicions: Why Mario Kart's Shock Isn't So Shocking

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Abstract

In this paper, we look to investigate if the shrinking seen in *Mario Kart Wii* using the shock item is feasible. We find that the required energy to overcome the Coulomb repulsion force is within the range of 0.2 to 7×10^{12} J, which is three orders of magnitude greater than the energy of an average lightning bolt. Therefore, we conclude that this is not a feasible method to shrink the characters in the game, suggesting that alternative mechanisms must be responsible for the observed phenomenon.

Introduction

Mario Kart Wii is a Go-Kart racing game that differs from other racing games by providing players with item boxes that offer a variety of tools to help them catch up with leading racers. Among the most powerful items is the shock. When used, this item causes all other players to shrink and move at a reduced speed, providing the user with a competitive advantage. We have chosen to investigate this scenario to estimate the energy necessary to compress atomic spacing to achieve the shrinkage depicted in the game, assuming mass and number of atoms remains constant.

Theory and Results

To reduce the atomic spacing between atoms we have assumed a simplified model, where the main force to overcome is the Coulomb repulsion force between the two charged nuclei. This force is given by:

$$F = \frac{q_1 \cdot q_2}{4\pi\varepsilon_0 r^2} \tag{1}$$

where q_1 and q_2 are the charges of the nuclei, ε_0 is the permittivity of free space and r is the separation between nuclei. As such, to find the energy required to reduce the spacing we calculate the change in potential energy:

$$\Delta U = -\int_{r_1}^{r_2} F dr = \frac{q_1 \cdot q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_2} - \frac{1}{r_1}\right) \tag{2}$$

where r_1 is the the original spacing and r_2 is the shrunk atomic spacing.

In our simplified model, we have two separate contractions to consider: the kart and the character, whose energies will be summed together to find the total energy. For simplicity, we have assumed each to be made up of a single element. Each kart is the character's respective standard kart, composed of iron, while the characters are assumed to be made of carbon. This is because most Go-Karts are constructed with a steel composite, which primarily contains iron, while all characters in the game are carbon-based life forms. Iron has a atomic mass of 55.9 u and a nuclear charge of $26e$ where e is the charge of an electron. Carbon has an atomic mass of 12.011 u and a nuclear charge of $6e$. The standard medium kart dimensions were modelled after a typical Go-Kart [1] and subsequently scaled up, while each character's volume was found using pixel measurement (where Mario was a reference height [2]). Due to limited data, each character's mass was estimated based on assumptions about BMI, bone mass percentage, and comparisons to analogous animals.

The number of atoms per character/kart was found by dividing their mass by the mass of their respective element. Dividing the volume by the number of atoms provided the volume per atom. Assuming a cubic arrangement, the atomic spacing r_1 was determined as the cube root of this value. Experimentally we found that the karts and characters shrink by a factor of 2.5, which was used to find the shrunk atomic spacing, r_2. The calculated values for the kart and character were then substituted into Equation 2 and multiplied by the number of atoms, and summed to find total energy required to reduce the atomic spacing. These results are displayed below in Figure 1. Note: both Bowser and King Boo were removed from the data set. This is due to Bowser having a mass of 9611 kg [3] which is incompatible with the scaled Standard Large Kart mass of 141.6 kg. King Boo was removed due to his unknown atomic make-up.

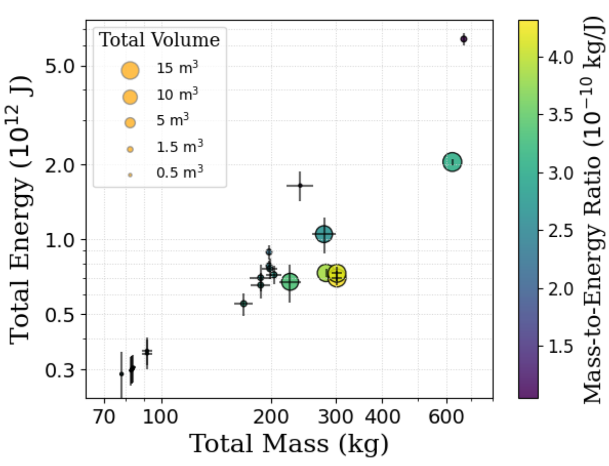

Figure 1: Mass-Energy plot for all characters in *Mario Kart Wii* excluding Bowser and King Boo, illustrating the energy required for atomic compression. The colours correspond to efficiency of shrinking effect with dark purple being least efficient. The energy required to shrink spans $(0.2 - 7) \times 10^{12}$ J.

Discussion

We have calculated that the energy required to overcome the Coulomb repulsion force is within the range of $(0.2 - 7) \times 10^{12}$ J as seen in Figure 1. In the game, the shock appears as a bolt of lightning that impacts and subsequently shrinks both the character and their kart, as such to investigate whether or not this result is feasible we need to find the energy released from a single bolt of lightning. Approximately the average amount of energy per lightning bolt is 1×10^9 J [4], this value is three orders of magnitude out. As such, it seems that the energy imparted by lightning is not a high enough value to overcome the Coulomb repulsion force.

It is important to note that these results likely represent an underestimate due to this simplified model not accounting for electrons or the effect of atoms beyond their nearest-neighbour. Inclusion of these factors would increase the repulsion force and consequently the required energy, further supporting the conclusion that this mechanism is implausible.

Conclusion

The shrinking of the inter-atomic spacing for characters shocked in *Mario Kart Wii* is estimated to be within the range $(0.2 - 7) \times 10^{12}$ J of energy. This value is 3 orders of magnitude higher than the average energy in a bolt of lightning. This indicates that an alternative mechanism is likely responsible for the shrinkage observed in the game.

References

[1] `https://gokartsgo.com.au/hunter-valley/the-karts/` [Accessed Oct. 18, 2024].

[2] `https://super-mario-luigi-bros.fandom.com/wiki/Height_and_Weight_Guide` [Accessed 6 Oct. 2024].

[3] `https://www.youtube.com/watch?v=aowqPQ0bybw` [Accessed 6 Oct. 2024].

[4] `https://tinyurl.com/35yb9ppk` [Accessed 8 Nov. 2024].