

A4 1 Relativistic view of Alice in Wonderland

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Abstract

This paper investigates whether the temporal discrepancy Alice experiences in *Wonderland* (2010 film) relative to the real world could be explained by special or general relativity. Special relativity requires Wonderland to be moving at approximately the speed of light, an implausible cinematic scenario unless she is moving at a state of rest alongside everything around her. General relativity calculates a planet with either a lethal surface gravity ($\approx 7 \times 10^9 \text{ m s}^{-2}$) or a radius ($\approx 9 \times 10^{-3} \text{ m}$) approaching its Schwarzschild radius (a black hole). Our analysis concludes that the observed time dilation in the film is incompatible with the principles of special or general relativity under realistic conditions.

Introduction

The story of Alice in Wonderland is authored by Lewis Carroll in his 1865 children's novel [1] and adapted into a 2010 film by Tim Burton, follows a young girl named Alice who falls into a fantastical world. A key point of debate regarding Alice's experience is the discrepancy in the passage of time between Wonderland and the real world. In the 2010 film, while not explicitly stated, Alice's adventure in Wonderland is approximated to have lasted three days compared to approximately one hour in the real world [2].

Theory

Albert Einstein's Theory of Special Relativity says that the laws of physics are invariant for all non-accelerating observers and that the speed of light remains constant. As the speed of light is constant at approximately $3 \times 10^8 \text{ m s}^{-1}$, a moving observer would experience time at a slower rate compared to a stationary observer [3]. Special relativity describes the time dilation depen-

dent on the relative velocities of two inertial observers, as shown in Equation (1):

$$\Delta t = \frac{\Delta t_0}{\sqrt{1 - \left(\frac{v^2}{c^2}\right)}} = \gamma \Delta t_0 \quad (1)$$

The terms in Equation (1) are Δt , which is the time elapsed from the stationary observer; Δt_0 is the proper time (time elapsed in the moving observer's frame); v is the relative velocity between the observers; c is the speed of light in a vacuum; and γ is the Lorentz Factor [3].

Einstein's General Theory of Relativity explains gravity as a fundamental property of spacetime and how the curvature of this spacetime describes how objects move through it. The implication of General Relativity on how time passes at different rates is due to the strength of the gravitational field. Time is experienced at a slower rate in a lower gravitational potential compared to that observed by an observer further away from the mass. The gravitational-

time dilation is described by Equation (2):

$$\Delta\tau = \Delta t \sqrt{1 - \left(\frac{2GM}{rc^2}\right)} \quad (2)$$

The terms in Equation (2) are $\Delta\tau$ being the proper time (which is the time elapsed at an observer at distance r), Δt is the coordinate time (which is the time of an observer at an infinite distance away), G is the gravitational constant of $\approx 7 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$, r is the distance from the central mass, and c is the speed of light in a vacuum [4].

Calculations

Using Einstein's theories of Special and General Relativity, we calculate the conditions in *Wonderland* compared to the real world that enable Alice to experience the supposed time dilation.

Special Relativity Analysis

With regard to special relativity, we use the time dilation equation (1) to calculate the relative velocity (v) of Wonderland. Given that the time in Wonderland (Δt) is 3 days (72 hours) and the time in the real world (Δt_0) is 1 hour which gives a velocity of $\approx 3 \times 10^8 \text{ m s}^{-1}$. The calculated value is extremely close to the speed of light. This velocity represents the speed Wonderland must move through space relative to the real world.

General Relativity Analysis

For General Relativity, we use the gravitational time dilation Equation (2) to find the unknown mass (M) and radius (r) of Wonderland's world.

Case 1: Finding Wonderland's Mass -

Assuming the radius of the planet is the same as Earth, $r = 6 \times 10^6 \text{ m}$ [3], and $G \approx 7 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ which gives a mass of $\approx 4 \times 10^{33} \text{ kg}$. This calculated value is $\approx 2 \times 10^3$ times the mass of the Sun (M_\odot). The resultant acceleration due to gravity on its surface would be $g \approx 7 \times 10^9 \text{ m s}^{-2}$, compared to Earth's $g \approx 10 \text{ m s}^{-2}$.

Case 2: Finding Wonderland's Radius -

Alternatively, using the mass of Earth, $M \approx 6 \times 10^{24} \text{ kg}$ [3], the calculated radius of Wonderland would be $r \approx 9 \times 10^{-3} \text{ m}$. We compare this value to the Schwarzschild radius (r_s) calculated using Equation (3):

$$r_s = \frac{2GM}{c^2} \quad (3)$$

For a world with Earth's mass and the required time dilation, r is $\approx 9 \times 10^{-3} \text{ m}$, which is extremely close to its Schwarzschild radius, implying the world is nearly a black hole [3].

Conclusion

This paper aims to explain the difference in time experienced in Alice's Wonderland compared to the real world, drawing on an understanding of Einstein's special and general relativity.

In terms of special relativity, based on the assumption that the physics of the universe is the same as that of our world, we calculated the relative velocity of Wonderland to be $\approx 3 \times 10^8 \text{ m s}^{-1}$. This value is very close to the speed of light. As long as Alice is moving alongside everything else in Wonderland, then she would be in a state of rest relative to everything around her.

With regards to general relativity, the parameters of Wonderland are the same as Earth's, with the exception of the time experienced. The variables that could be affected are the mass that was calculated to be $4 \times 10^{33} \text{ kg}$ resulting in a gravitational acceleration of $7 \times 10^9 \text{ m s}^{-2}$ in which Alice would not survive. If the changing variable is the radius of Wonderland, then the planet would be $9 \times 10^{-3} \text{ m}$ which is extremely close to being a blackhole. We can conclude that the general relativistic predictions cannot explain Alice's experience in Wonderland.

References

- [1] Royal Collection Trust, "Alice's Adventures in Wonderland". Available at: <https://www.rct.uk/resources/alices-adventures-in-wonderland> [Accessed 30 September 2025].

- [2] Contributors to Alice in Wonderland Wiki, “Alice in Wonderland (2010),”. Available at: [https://aliceinwonderland.fandom.com/wiki/Alice_in_Wonderland_\(2010\)](https://aliceinwonderland.fandom.com/wiki/Alice_in_Wonderland_(2010)) [Accessed 30 September 2025].
- [3] P. A. Tipler and G. Mosca, in W. H. Freeman and Company, New York: Susan Finnemore Brennan (2008).
- [4] D. K. Dhiman, A study of redundancy of time dilation in theory of relativity, Indian J. Sci. Tech. 10(43), 1–19 (2017). doi:10.17485/ijst/2017/v10i43/109171.