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Conquering Time

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Abstract
As the human population continues to expand, we continue to use up Earth's resources. While some choose to focus on ways of improving and engineering new systems to slow down this effect, others look to the stars, not for answers, but for a fresh start. No planet within our solar system is capable of hosting human life unsupported. Instead, we must look further. However, in our quest to colonise a new planet, we will not just be exploring space but also travelling through time. This paper aims to explore how futuristic travel to Kepler-442b, a distant exoplanet, will have consequences in the time perceived for someone onboard this mission.

Keywords: *Physics; Astrophysics; Relativity; Exoplanets; Kepler-442b*

Introduction
Science fiction literature and films frequently depict a future in which human activity renders Earth uninhabitable, forcing humanity to seek a new home on another planet. There are many issues with this: financing, technology, finding a habitable planet, distance from Earth, and cosmic radiation. However, one aspect often overlooked is the physical and temporal toll experienced by the travellers as they fly through space in pursuit of a new home.

Finding a Habitable Exoplanet
As of 26th of February 2026, 6,128 exoplanets have been discovered [1]. Proxima Centauri b is the closest 'habitable' exoplanet, roughly 4.2 light-years (ly) away [2]. However, whilst it may be able to host alien life, it receives hundreds of times more radiation compared to Earth [2], making it impossible for humans to survive there. Of the 6,128 confirmed planets, it is predicted that only 10-20% would be habitable for humans [3]. A 2019 study narrowed the possibilities for exoplanets capable of hosting complex life to 13, with only 2 of these suitable for human habitation: Gliese 667Cc and Kepler-442b [4]. Whilst Gliese 667Cc is closer at only 22.2 ly away, Kepler-442b is often cited as the most habitable due to its more favourable conditions [5]. Therefore, Kepler-442b is the nearest potential exoplanet for human colonisation – only 1,194 ly away (1.129×10^{19} m) [6].

Travelling Through Space
The fastest known objects with mass are blazar jets, travelling at 99.9% the speed of light (0.999c) [7]. If a spacecraft were capable of achieving such velocities, the journey to Kepler-442b would still require roughly 1,200 years. By comparison, the fastest man-made object is NASA's Parker Solar Probe, travelling at roughly 190,000 ms^{-1} [8]. Using the relationship [9]:

$$v = \frac{x}{t}, \quad (Eq^n 1),$$

the time taken to reach Kepler-442b can be calculated as:

$$190{,}000 = \frac{1.129 \times 10^{19}}{t},$$
$$t = 5.94 \times 10^{14}\ s.$$

This yields a travel time of 5.94×10^{14} s (~1.87 million years) to reach Kepler-442b. Considering that this is 30 times longer than the existence of *Homo sapiens*, such travel time is clearly impractical with current technology. For the purposes of this paper, it will be assumed that a spacecraft could reach speeds near the speed of light, specifically 0.9c.

Travelling Through Time
Objects travelling at such speeds experience time differently from stationary observers. Einstein discovered that time behaves differently in different

frames of reference, thereby establishing the Theory of Special Relativity. This causes the phenomenon known as time dilation, where an object moving at high speeds experiences time more slowly than a stationary object [8]. Dilated time, t', can be expressed as [10]:

$$t' = \gamma t, \quad (Eq^n\ 2)$$

where t is the proper time and γ is the Lorentz factor, defined as [10]:

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}. \quad (Eq^n\ 3)$$

Here, v is the velocity of the object and c is the speed of light (3×10^8 ms^{-1}). The Lorentz factor quantifies the relativistic effects, such as time dilation and length contraction, as an object approaches the speed of light [10].

For these purposes, an observer on Earth is considered to be stationary. *Equation 1* calculates the time experienced from an observer on Earth's perspective.

$$t = \frac{1.129 \times 10^{19}}{0.9 \times 3 \times 10^8} \approx 1326\ years.$$

Substituting these values, it gives a travel time of approximately 1326 years to reach Kepler-442b. However, this would not be the case for an astronaut aboard this spacecraft. *Equation 2* calculates how they would experience proper time instead. Rearranging for t:

$$t = t' \times \sqrt{1-\frac{v^2}{c^2}},$$

$$t = 1326 \times \sqrt{1-\frac{0.9c^2}{c^2}} = 578\ years.$$

Thus, the astronaut would perceive that 578 years have passed. For every year that elapses on the spacecraft, 2.3 years pass on Earth. Whilst this may not seem like a significant difference, for a mission of this length, it has major consequences.

Consequently, once the spacecraft reaches Kepler-442b, an additional 748 years would have passed on Earth compared with the astronaut's experienced time. Furthermore, Kepler-442b has an estimated mass approximately 2.3 times that of Earth [6]. According to the Theory of General Relativity, gravitational fields also influence the flow of time [11]. The stronger gravitational field of Kepler-442b would therefore produce additional relativistic effects; however, this is a discussion better suited to another paper.

Time Dilation on the Journey

If the astronaut were to maintain contact throughout the journey, the messages between them and the Earth would also face a similar issue. Consider a scenario in which a mission controller on Earth sends a message to the spacecraft a hundred years after launch to commemorate the first century of travel. Currently, the spacecraft has travelled 90 ly. The signal must traverse the initial distance and the additional distance the spacecraft travels whilst the message is en route. The relative closing speed is calculated by [9]:

$$v_{closing} = v_{message} - v_{spacecraft} \quad (Eq^n 4)$$
$$v_{closing} = c - 0.9c = 0.1c$$

This indicates that the signal catches up to the ship at 0.1c. As a result, the message takes 900 years to catch up to the ship before the signal is finally received. Therefore, 1000 years after launch, the astronauts receive a message congratulating them on 100 years in space – perhaps it was best to congratulate them on a millennium instead.

From the astronaut's perspective, the elapsed time would differ due to relativistic effects. Using *Equation 2*:

$$t' = \frac{1000}{\sqrt{1-\frac{0.9c^2}{c^2}}} = 436\ years.$$

Regardless of the intended message, 100 or 1000 years, the message they receive would not correspond to their experienced duration of the journey.

Conclusion

Regardless of the scenario, scientists would constantly have to calculate how far the astronaut has travelled and the difference in the time experienced between both parties. This paper examined two potential issues, bringing to light temporal issues that may arise in future space travel in the search for another planet to colonise.

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