Reconciling the Concept of Cosmic Time with Special Relativity

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Abstract

This note explores a simple way to combine the idea of cosmic time with special relativity. A universal cosmic time is assumed to tick uniformly across the universe. Local time for each observer is then related to this cosmic time through the standard time dilation factor. This gives a consistent framework where both absolute and relative aspects of time coexist.

1 Introduction

Einstein's special relativity removed absolute time. Each observer measures their own proper time, with no universal clock. On the other hand, cosmology often uses a "cosmic time," defined by the large-scale expansion of the universe. This paper suggests that both views can be joined in a simple way.

2 Framework

In special relativity, the relation between coordinate time t and proper time τ is

$$d\tau = dt\sqrt{1 - \frac{v^2}{c^2}}.$$

Step 1: Define cosmic time. We introduce a universal baseline called cosmic time, denoted by t_c. It is defined as the proper time of an observer at rest in the cosmic frame. By definition,

$$dt_c = d\tau \quad \text{when } v = 0.$$

Step 2: Insert cosmic time. Replacing dt with dt_c gives

$$d\tau = dt_c\sqrt{1 - \frac{v^2}{c^2}}.$$

Step 3: Interpret the result.

- If $v = 0$, then $d\tau = dt_c$, so proper time equals cosmic time.
- If $v > 0$, then $d\tau < dt_c$, so proper time runs slower than cosmic time.

Thus, time dilation is now measured against a universal baseline t_c, rather than being purely relative between observers.

3 Examples

3.1 Stationary observer.

Let us consider an observer at rest, with its $v = 0$ and $dt_c = 10$ s,

$$d\tau = 10\,\text{s}.$$

3.2 Moving observer.

For a moving observer, assume $v = 0.8c$ and $dt_c = 10$ s,

$$d\tau = 10\sqrt{1 - 0.64} = 6\,\text{s}.$$

4 Twin Paradox Resolution

In the standard twin paradox, one twin remains on Earth while the other travels at high speed and then returns. In special relativity this creates an apparent symmetry: each twin could argue that the other is moving. By introducing cosmic time t_c as the universal baseline, the situation becomes clear.

Step 1: Cosmic time passes equally for both. Suppose 100 cosmic years pass according to the universal clock.

Step 2: Proper time for the stay-at-home twin. For Twin A, who is at rest ($v = 0$),

$$\tau_A = \int dt_c = 100 \text{ years.}$$

Step 3: Proper time for the traveling twin. For Twin B, who moves at $v = 0.6c$,

$$\tau_B = \int dt_c \sqrt{1 - \frac{v^2}{c^2}}.$$

With $dt_c = 100$ years,

$$\tau_B = 100\sqrt{1 - 0.36} = 100 \times 0.8 = 80 \text{ years.}$$

Step 4: Interpret the result.

- Both twins agree that 100 cosmic years have passed.
- Twin A experiences all 100 years as proper time.
- Twin B experiences only 80 years of proper time.

Thus, the paradox disappears: the difference is explained directly by comparing each twin's proper time against the same cosmic baseline.

5 Discussion

This framework keeps the tested predictions of special relativity but anchors them to cosmic time. It removes the symmetry issue in the twin paradox by defining a preferred cosmic frame. The idea may also connect relativity with cosmology more directly, since the universe already has a natural time scale through cosmic expansion. Further work could explore whether cosmic time aligns with FLRW cosmic time.

6 Conclusion and Implications

The model shows that cosmic time can coexist with special relativity in a simple way. Time dilation remains valid, but now has a clear baseline. The twin paradox is resolved directly. If such a cosmic clock exists, it could link relativity and cosmology more tightly, and provide a new way of thinking about absolute and relative time together.

Implications

- **Resolution of paradoxes:** Provides a straightforward solution to the twin paradox by introducing a universal reference clock.
- **Cosmological unification:** Suggests a deeper connection between local relativistic effects and the large-scale structure of the universe.
- **New definitions of time:** Encourages a re-examination of time as both relative (observer-dependent) and absolute (cosmic baseline).
- **Experimental guidance:** Opens the possibility of designing tests to measure or detect a cosmic reference frame.
- **Philosophical impact:** Revives the debate on whether time is fundamentally absolute or relative, with a modern framework.

AI Statement

This draft was prepared with the assistance of an AI writing tool (OpenAI's ChatGPT), used for formatting and clarity. All ideas and results belong to the author.

References

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