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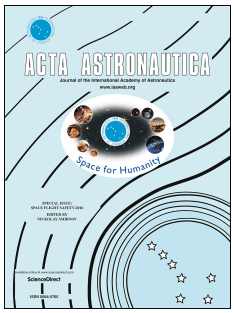

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Limits and Signatures of Relativistic Spaceflight

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While special relativity imposes an absolute speed limit at the speed of light, our Universe is not empty Minkowski spacetime. The constituents that fill the interstellar/intergalactic vacuum, including the cosmic microwave background photons, impose a lower speed limit on any object travelling at relativistic velocities. Scattering of cosmic microwave phtotons from an ultra-relativistic object may create radiation with a characteristic signature allowing the detection of such objects at large distances.

Keywords: Relativity, Interstellar Travel, Cosmic Microwave Background Radiation

Nomenclature of symbols: c: speed of light; $\gamma = 1/\sqrt{1 - v^2/c^2}$: Lorentz factor for velocity v; m_e: Electron rest mass; $\hbar$: Reduced Planck's constant; $\vec{k}$: Three-dimensional wave number; T: Absolute temperature

Introduction

At a fixed speed v, the distance travelled by a spacecraft within a given (proper) time τ scales as $\gamma v\tau = (v/c)\gamma c\tau$, which for relativistic speeds approximately equals $\gamma c\tau$, where $\gamma = (1 - v^2/c^2)^{-1/2}$. For a journey that has a proper time $\tau = 50$ years at a speed $v/c = 0.64$, the distance travelled is 41.6 lightyears. Considering that the distance to the center of our galaxy is 30,000 lightyears, we will not get very far away from home unless we can go much faster. Travelling at a speed close to that of light, the range is directly proportional to γ (see Fig. 1 below), and to cover a large distance in a human lifetime requires $\gamma \gg 1$. We will show why we choose $v = .64\,c$ for travelling in the local galactic neighborhood, and discuss issues associated with extreme velocities. This paper is not about how to obtain relativistic velocities, but about what happens once they are technologically attainable.

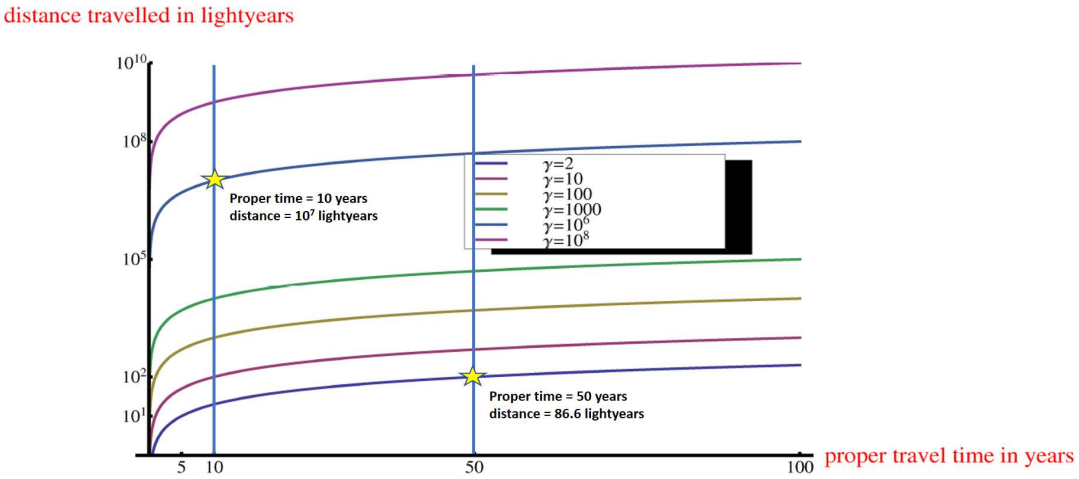

FIG. 1: Distance travelled in a given rest frame as a function of proper time elapsed for the traveler, for different travel velocities (shown are the corresponding Lorentz factors γ).

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