# THE EXISTENCE OF SUPERLUMINAL PARTICLES IS CONSISTENT WITH THE KINEMATICS OF EINSTEIN'S SPECIAL THEORY OF RELATIVITY

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Within an axiomatic framework of kinematics, we prove that the existence of faster than light (FTL) particles is logically independent of Einstein's special theory of relativity. Consequently, it is consistent with the kinematics of special relativity that there might be faster than light particles.

**Keywords:** special relativity, superluminal motion, tachyons, axiomatic method, first-order logic.

## 1. Introduction

From time to time short-lived experimental results appear that suggest the existence of FTL objects. Recently, the OPERA experiment, see [11], raised the interest in the possibility of FTL particles. The trouble is that if there are FTL particles, then several branches of the tree that grew out of relativity theory die out, e.g. the ones that directly assume the nonexistence of superluminal objects. The Weinberg–Salam theory is a concrete example for a theory which has to be modified if someone discovers FTL particles, see Mészáros [26, 27].

The OPERA result has turned out to be erroneous, but the possibility will always be there that one day an experiment will prove the existence of FTL particles. Therefore, the question

*Which parts of tree sprung out of relativity theory would survive the discovery of FTL particles?*

remains interesting and relevant for further investigation. In this paper, we axiomatically show that the roots of the metaphorical tree surely endure any experiment proving the existence of FTL objects since their existence is completely consistent with the kinematics of special relativity.

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The investigation of superluminal motion in relativity theory goes back (at least) to Tolman, see [38, p. 54–55].[2] After showing that faster than light (FTL) particles travel back in time according to some observers,[3] Tolman writes: "Such a condition of affairs might not be a logical impossibility; nevertheless its extraordinary nature might incline us to believe that no causal impulse can travel with a velocity greater than that of light." It is interesting to note that Tolman has not claimed that relativity theory implies the impossibility of the existence of superluminal particles; he just claims that, if they exists, they have some "extraordinary" properties.

In 1962 Bilaniuk, Deshpande and Sudarshan, in their pioneering article, introduce a reinterpretation principle suggesting that superluminal particles are consistent with relativity theory [8]. Since then a great many works dealing with superluminal motion have appeared in the literature. The extensive survey of Recami reviews the papers dealing with superluminal motion before 1986 [30]. For more recent papers concerning FTL motion, see e.g. Arntzenius [7], Chashchina-Silagadze [10], Geroch [17], Jentschura [18], Jentschura–Wundt [19], Nikolić [29], Matolcsi–Rodrigues [25], Mittelstaedt [28], Recami [31, 32, 34], Selleri [35], Recami–Fontana–Garavaglia [33], Weinstein [39], Zamboni-Rached–Recami–Besieris [40] and references therein.

These papers contain various nonaxiomatic theories of FTL particles compatible with relativity. However, the only framework where the question of consistence can properly be investigated is the axiomatic framework of mathematical logic. Therefore, in this paper, we take one step further and investigate the consistency question of FTL particles within mathematical logic.

Based on Einstein's original postulates, we formalize the kinematics of special relativity within an axiomatic framework; and we prove that axiom system SR (see p. 140) capturing the kinematics of Einstein's special relativity does not contradicts the existence of FTL particles.

The fact that the axioms of relativistic kinematics do not contradict the existence of FTL particles is interesting by itself. However, it leaves the question open whether the axioms of relativistic dynamics contradict superluminal motion of particles or not. In a forthcoming paper, we will show, with the axiomatic rigor of this paper, that even relativistic particle dynamics is consistent with the existence of FTL particles, see [24], as it is already suggested by the literature.

As general relativity is more general than special relativity, every model (solution) of the axioms of special relativity is also a model of the axioms of general relativity.[4] Consequently, if special relativity has a model allowing FTL particles, then general relativity also has such a model. Therefore, our result implies that the existence of superluminal particles is consistent with general relativity.

We show that the statement "there can be faster than light particles" is logically independent of the kinematics of special relativity. This means that we can add

[2]A detailed history of the tachyon concept tracing back even to pre-relativistic times can be found in [15].

[3]This observation is the basis of several causal paradoxes (i.e. seemingly contradictory statements) concerning FTL particles.

[4]For an axiom system of general relativity explicitly reflecting this fact, see [5].