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A relativistic Newtonian mechanics predict with precision the results of recent neutrino-velocity experiments

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ABSTRACT

The research on quasi-luminal neutrinos has sparked several experimental studies for testing the "speed of light limit" hypothesis. Until today, the overall evidence favors the "null" hypothesis, stating that there is no significant difference between the observed velocities of light and neutrinos. Despite numerous theoretical models proposed to explain the neutrinos behavior, no attempt has been undertaken to predict the experimentally produced $(v\text{-}c)/c$ results. This paper presents a simple novel extension of Newton's mechanics to the domain of relativistic velocities. For a typical neutrino-velocity experiment, the proposed model is utilized to derive a general expression for $(v\text{-}c)/c$. Comparison of the model's prediction with results of six neutrino-velocity experiments, conducted by five collaborations, reveals that the model predicts all the reported results with striking accuracy. Because in the proposed model, the direction of the neutrino flight matters, the model's impressive success in accounting for all the tested data, indicates a complete collapse of the Lorentz symmetry principle in situation involving quasi-luminal particles, moving in two opposite directions. This conclusion is support by previous findings, showing that an *identical* Sagnac effect to the one documented for radial motion, occurs also in linear motion.

Keywords

Neutrino velocity, OPERA, MINOS, ICARUS, LVD, Borexino, Sagnac effect.

Academic Discipline And Sub-Disciplines

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1. INTRODUCTION

In 2011 the OPERA collaboration at CERN announced that neutrinos have travelled faster than light [1]. The reported anticipation time was 60.7 ±6.9 (stat.)± 7.4 (sys.) ns and the relative neutrino velocity was $(v\text{-}c)/c$ = (5.1 ±2.9) $\times 10^{-5}$. The excitement that swept physicists and laymen concerning the possibility that a new era is "knocking on physics doors", waned a few months later, after OPERA reported the discovery of hardware malfunctions in the GPS system, which resulted in a critical measurement error. After accounting for the error, the anticipation time was only 2.7 $\times 10^{-6}$ ns, with corresponding $(v\text{-}c)/c$ = 2.67 x 10^{-6} [2]. Since then, the "null" result has been replicated by OPERA and by several collaborations, including ICARUS, LVD and Borexino [3-6]. The only "faster than light" result, which I am aware of, was reported in 2007 by MINOS collaboration [7], who reported an early anticipation time of 126 ± 32 (stat.) ± 64 (sys.) ns (C.L. = 68%), with corresponding $(v\text{-}c)/c$ = 5.1±2.9 (stat.+sys.)$\times 10^{-5}$. However, the high statistical and system errors, reported by MINOS, impede the validity of the above quoted result. Notably, despite the vast body of theoretical research on the topic [e.g., 8-15], no attempt has been undertaken to produce a point prediction of the $(v\text{-}c)/c$ results reported by OPERA, and by other collaborations, who replicated the "null" result.

In the present paper I demonstrate that a simple relativistic extension of Newtonian mechanics, predicts with precision, the results reported by OPERA, MINOS, ICARUS, LVD and Borexino collaborations. The following section gives a brief account of the proposed model. Section 3 details the derivation of the model's $(v\text{-}c)/c$ term, for a typical neutrino velocity experiment, and contrasts the theoretical prediction with the findings of six neutrino velocity experiments. Section 4 summarizes and concludes.

2. A NEWTONIAN RELATIVISTIC MODEL

The proposed model is a relativistic extension to Newtonian mechanics, termed Newtonian relativity. The model makes no assumptions, except the well accepted principle that time is relativistic and not absolute. Aside of being a result of Einstein's Special Relativity [16], the relativism of time has been confirmed by numerous experiments (see e.g., 17-19) and is currently considered a well-established scientific fact. Corrections for relative effects in time are also standard procedures in crucial navigation technologies (e.g., 20-21). To derive the term for the relativistic time, consider two observers who synchronize their watches just before one of them starts to move in $+x$ direction with constant velocity v. Assume that a certain event started exactly at the time of departure ($t=t'=0$). Suppose the event ended when the moving frame was at distance $x = d$ (in the rest frame of the "staying" observer). If the "moving" observer sends a signal to indicate the termination of the event, the signal will arrive at the "staying" observer after time dilation of $\Delta t = \frac{d}{c}$, where c is the velocity of the wave signal relative to "staying" observer. Thus we can write:

$$t = t' + \Delta t = t' + \frac{d}{c} \quad \text{...... (1)}$$

But $d = v\,t$, where v is the velocity of the "moving" frame relative to the "stationary" frame. Substitution the value of d in Eq. 1 yields:

$$t = t' + \frac{v\,t}{c} = t' + \beta t \quad \text{...... (2)}$$

Where $\beta = \frac{v}{c}$.

Or:

$$\frac{t}{t'} = \frac{1}{1-\beta} \quad \text{...... (3)}$$

Note that eq. (3) is similar to the Doppler formula, except that the Doppler Effect describes frequency shifts of waves propagating from a departing or approaching wave source, whereas the result above describes the time "shifts" of moving bodies. For two frames that depart from each other $\beta > 0$, and thus $1/(1-\beta)$ is larger than one, implying a *time dilation* (comparable to redshift), whereas for two frames which approach each other, $\beta < 0$, and thus $1/(1-\beta)$ is smaller than one, implying a *time contraction* (comparable to blue-shift).

3. PREDICTION OF $(v\text{-}c)/c$ FOR A TYPICAL NEUTRINO-VELOCITY EXPERIMENT

In a typical neutrino-velocity experiment, neutrinos travel a distance $d \approx 730$ km in matter, with one of the highest relativistic γ factors ever artificially produced, allowing the emergence of significant relativistic effects. A typical neutrino velocity experiment includes *three* frames: The neutrino frame F, the source frame F', and the detector frame F'' . F is *departing* from F' with velocity v and *approaching* F'' with velocity $-v$. F' and F'' are at rest relative to each other. Using Eq. 3 we can write:

$$\Delta t_S = \frac{\Delta t}{1-\frac{v}{c}} \quad \text{...... (4)}$$

And:

$$\Delta t_D = \frac{\Delta t}{1-\frac{-v}{c}} = \frac{\Delta t}{1+\frac{v}{c}} \quad \text{...... (5)}$$

Where , v is the neutrino velocity, c is the velocity of light. Δt, Δt_S, and Δt_D are the times, as measured in frames F (neutrino rest-frame), F' (source), and F'' (detector), respectively.

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The neutrino time of flight *to* tof_v is equal to difference between the times as measured in the detector and the source, or:

$$tof_v = \frac{d}{v} = \frac{\Delta t}{1+\frac{v}{c}} - \frac{\Delta t}{1-\frac{v}{c}} = - \frac{2\frac{v}{c}}{1-(\frac{v}{c})^2} \quad \text{.... (6)}$$

Where *d* is the distance of travel. For an *early* neutrino arrival time, ***δt***, with respect to the velocity of light, we can write:

$$\frac{d}{c} - \delta t = tof_v = - \frac{2\frac{v}{c}}{1-(\frac{v}{c})^2}\frac{d}{v} \quad \text{..... (7)}$$

Solving for $\frac{v}{c}$ yields:

$$\frac{v}{c} = \left(\frac{2}{1-\frac{c\,\delta t}{d}} - 1\right)^{\frac{1}{2}} \quad \text{.... (8)}$$

Or:

$$\frac{v-c}{c} = \sqrt[2]{\frac{2}{1-\frac{c\,\delta t}{d}} - 1} - 1 \quad \text{.... (9)}$$

For the OPERA *corrected* result [2], *d* = 730.085 km and δt = (6.5 ± 7.4 (stat.) $\pm^{+9.2}_{-6.8}\ (sys.)$) ns. Substituting in Eq. 10, we get:

$$\frac{v-c}{c} = \left(\frac{2}{1-\frac{299792.458\ x\ 6.5\ x\ 10^{-9}}{730.085}} - 1\right)^{\frac{1}{2}} - 1 \approx -2.67 \text{ x } 10^{-6} \quad \text{.... (10)}$$

Which is almost identical to the reported result of (*v*-*c*)/*c* = (2.7 ± 3.1 $(stat.)\ \pm^{+3.8}_{-2.8}$ (sys.))×10^{-6}. Applying Eq. 9 to five others experiments, conducted by MINOS, OPERA, ICARUS, LVD, and Borixeno collaborations, yields the results summarized in Table 1. As shown in the table, the mode yields precise predictions for ***all*** the tested experiments.

Table 1

Predictions of Newtonian Relativity

Experiment	**Experimental** $\frac{v-c}{c}$	**Predicted** $\frac{v-c}{c}$
MINOS 2007 [7]	(5.1±2.9))(stat) ×10^{-5}	5.14 10^{-5}
OPERA 2012 (corrected result) [2]	(2.7 ± 3.1 (stat.) + $^{+3.8}_{-2.8}$ (sys.)) ×10^{-6}	2.67 x 10^{-6}
OPERA 2013 [3]	(- 0.7 ± 0.5 (stat.) +$^{+2.5}_{-1.5}$ (sys.)) ×10^{-6}	- 0.66 x 10^{-6}
ICARUS 2012 [4]	(0.4 ± 2.8(stat.) ± 9.8 (sys.)) ×10^{-7}	0.41 x 10^{-7}
LVD [5]	(1.2 ± 2.5(stat.) ± 13.2 (sys.)) ×10^{-7}	1.23 x 10^{-7}
Borexino [6]	(3.3 ± 2.9(stat.) ± 11.9 (sys.)) ×10^{-7}	3.28 x 10^{-7}

4. CONCLUDING REMARKS

The present paper demonstrates that a simple, straightforward extension of Newton's mechanics, to the domain of relativistic velocities, is successful in producing strikingly accurate predictions of six experimental (*v*-*c*)/*c* results, reported by five collaborations. Because in the proposed model the direction of the neutrino flight, i.e., of *v*, matters, the model's impressive success in accounting for all the tested data, indicates a complete collapse of the Lorentz symmetry principle in situation involving quasi-luminal particles, moving in two opposite directions. This conclusion is support by the present analysis and by previous findings of well-designed experiments [22-24, see also 25, 26] demonstrating that an *identical* Sagnac effect to the one documented for radial motion, occurs also in linear motion.

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