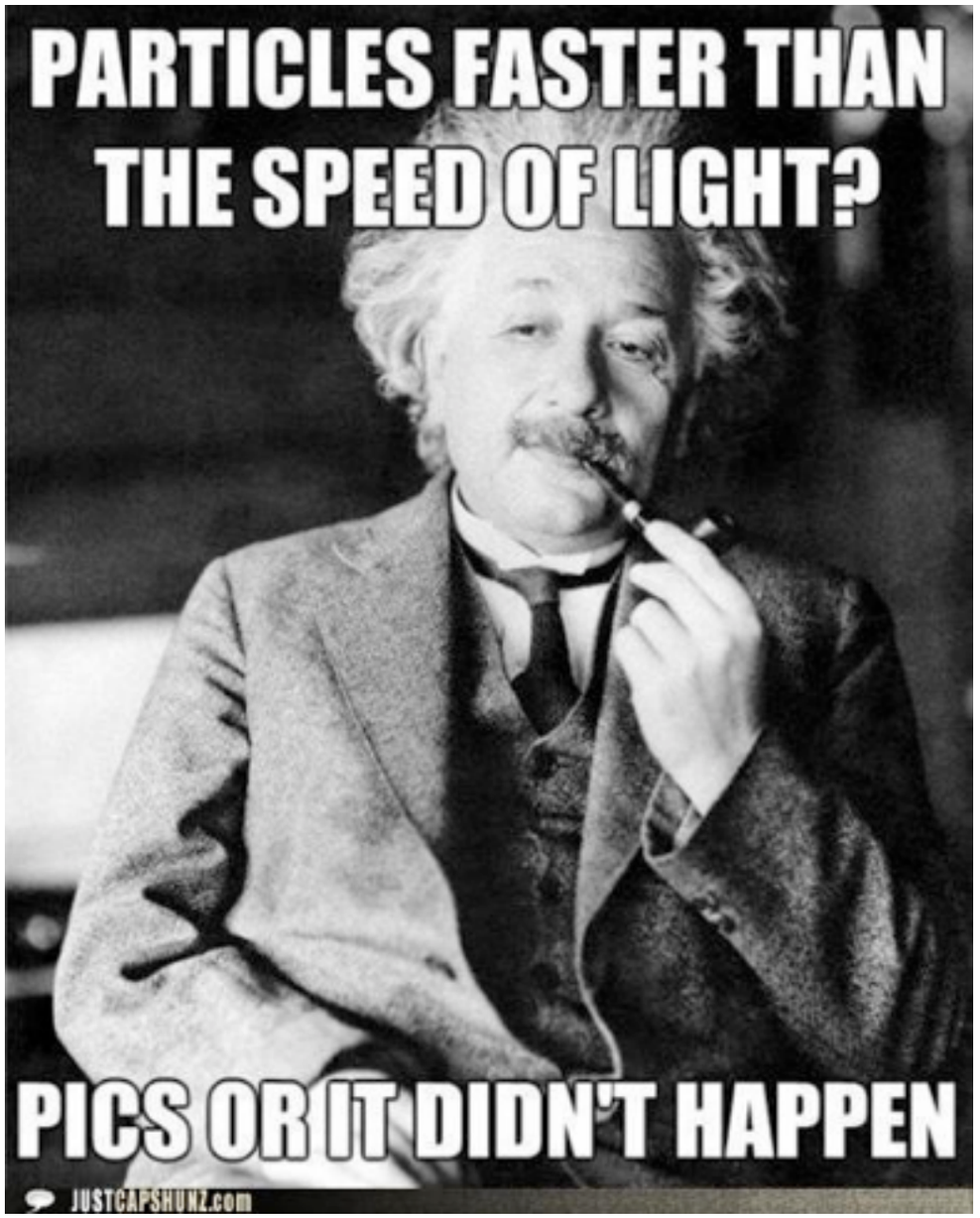
Consequences of the OPERA result



Consequences of the OPERA result

The Minister and the Neutrino

Statement by the Minister Mariastella Gelmini (Rome, 23 sep 2011)

"The CERN and National Institute for Nuclear Physics discovery is a scientific event of fundamental importance."

"I extend my approval and my sincerest congratulations to the authors of a historical experiment. I am deeply grateful to all the Italian researchers who contributed to this event that will change the face of modern physics.

Exceeding the speed of light is an epochal victory for scientific research around the world.

Italy has contributed to the construction of the tunnel between CERN and Gran Sasso Laboratories, through which the experiment took place, with a sum now estimated at around 45 million euros.

In addition, today Italy supports the CERN with absolute conviction, with a contribution of more than 80 million euros per year and the events we are experiencing are confirming that it is a good and far-sighted choice".

(http://www.istruzione.it/web/ministero/cs230911)

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What happens if the OPERA result is correct?

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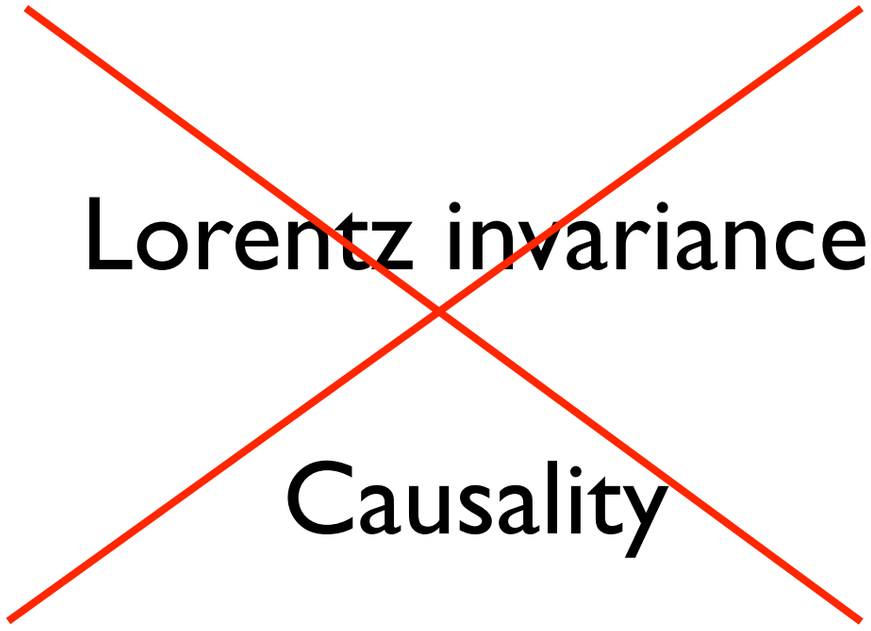


Lorentz invariance:

Speed of light is the same in all inertial frames

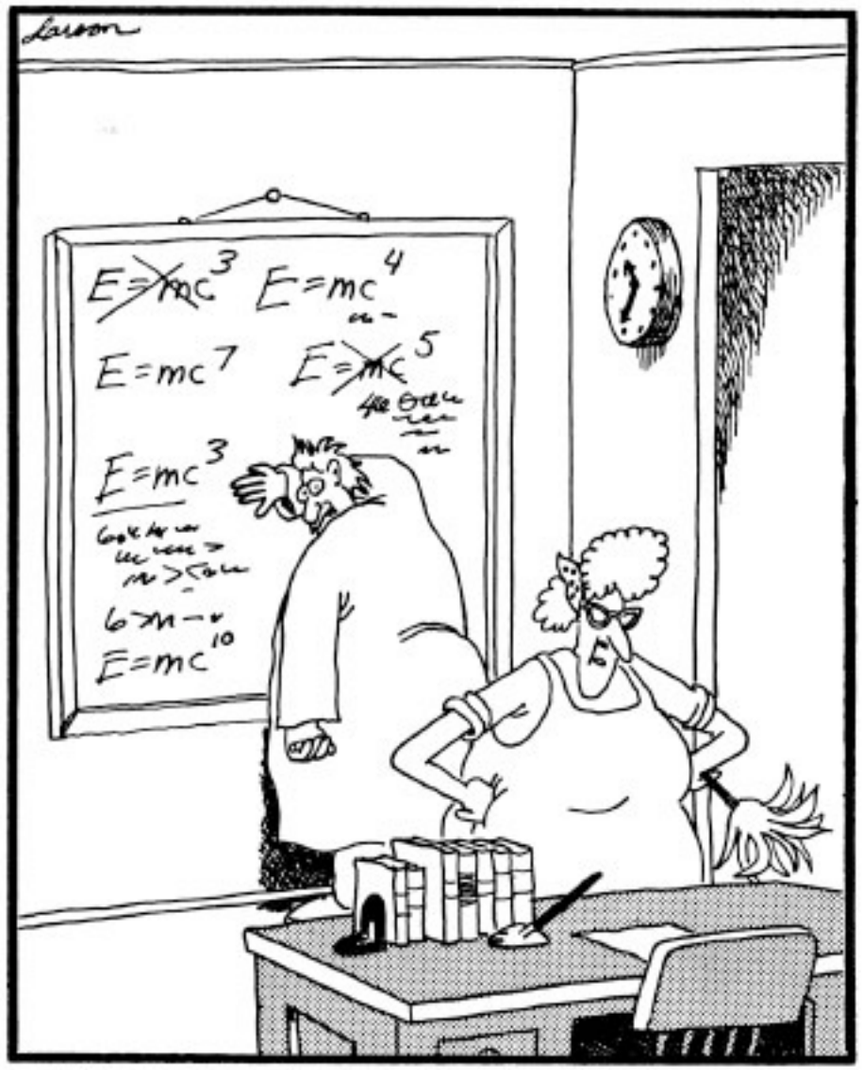
Laws of physics are the same in all inertial frames

Implication

c is the maximum speed in nature!!!

Atomic clocks,
telecommunications
satellites, computers, GPS,
astronomy, nuclear power....

These obviously work!!!



"*Now* that desk looks better. Everything's squared away, yessir, squaaaaaared away."

Causality

Causality is the relationship between an event (the cause) and second event (the effect), where the second event is understood as a consequence of the first... (Wikipedia et al.)

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The facts...

The most striking result of the OPERA experiment is the energy independence of the neutrino speed

$$13.9\,\mathrm{GeV}: \frac{\mathrm{v}-\mathrm{c}}{\mathrm{c}} = (2.16 \pm 0.76 \pm 0.30) \times 10^{-5}$$

$$42.9\,\mathrm{GeV}: \frac{\mathrm{v}-\mathrm{c}}{\mathrm{c}} = (2.74 \pm 0.74 \pm 0.30) \times 10^{-5}$$

$$3\,\mathrm{GeV}: \frac{\mathrm{v}-\mathrm{c}}{\mathrm{c}} = (5.1 \pm 2.9) \times 10^{-5}\,(\mathrm{MINOS})$$

but...

$$10\,\mathrm{MeV}: \frac{\mathrm{v}-\mathrm{c}}{\mathrm{c}} \leq 2 \times 10^{-9}\,(\mathrm{SN1987A})$$

In "ordinary" tachyonic theories, Lorentz invariance brakes down in Planck scales & tachyons have negative masses

$$\nu_{\geq c} \rightarrow \nu_{\leq c} + e^+ e^-$$

lower energy neutrinos should also have >c velocities!!!

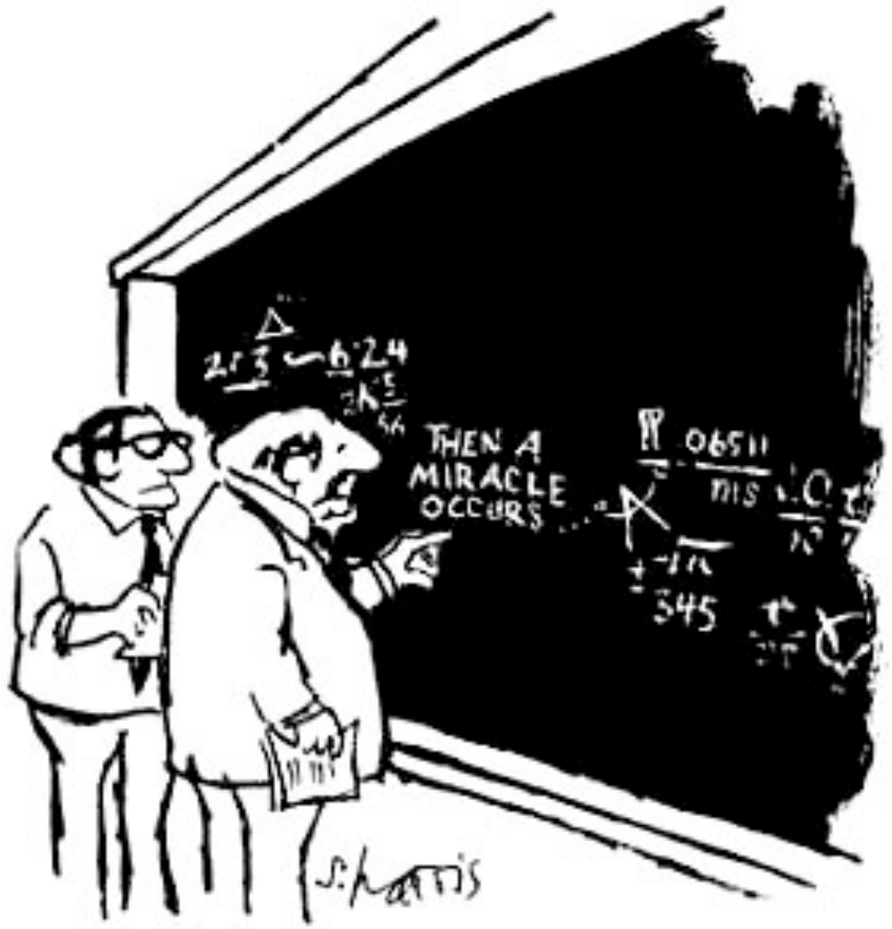
high energy neutrinos should decay fast

upper limit for OPERA baseline: ~12.5 GeV

"...Thus we refute the superluminal interpretation of the OPERA results..."

Andrew G. Cohen & Sheldon L. Glashow (arXiv:1109.6562 29-Sep)

Speculations...



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

Can apparent superluminal neutrino speeds be explained as a quantum weak measurement?

M V Berry[1], N Brunner[1], S Popescu[1] & P Shukla[2]

[1]H H Wills Physics Laboratory, Tyndall Avenue, Bristol BS8 1TL, UK

[2] Department of Physics, Indian Institute of Technology, Kharagpur, India

Abstract

Probably not.

Paper I

Giacomo Cacciapaglia, Aldo Deandrea, Luca Panizzi (arXiv:1109.4980 23-Sep)

Abstract

Precise tests of Lorentz invariance in neutrinos can be performed using long baseline experiments such as MINOS and OPERA or neutrinos from astrophysical sources. The MINOS collaboration reported a measurement of the muonic neutrino velocities that hints to super-luminal propagation, very recently confirmed at 6σ by OPERA. We consider a general parametrisation which goes beyond the usual linear or quadratic violation considered in quantum-gravitational models. We also propose a toy model showing why Lorentz violation can be specific to the neutrino sector and give rise to a generic energy behaviour E^α, where α is not necessarily an integer number. Supernova bounds and the preferred MINOS and OPERA regions show a tension, due to the absence of shape distortion in the neutrino bunch in the far detector of MINOS. The energy independence of the effect has also been pointed out by the OPERA results.

Explain the data using a step function ~ 1 GeV

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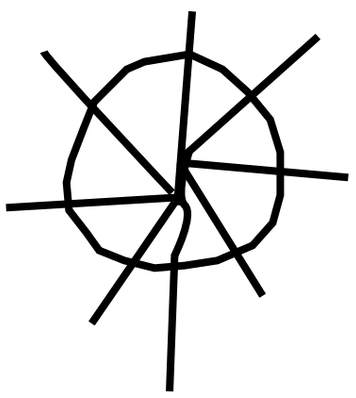
Explain the data using a step function ~ 1 GeV

Paper II

Scalar field coupled to matter, originating from the earth

Φ(r)



- Breakdown of Lorenz invariance
- v-c/c depends on the baseline

but....

such a strong field would show up in satellite experiments (e.g. Cassini)

Paper III

Jean Alexandre, John Ellis and Nick E. Mavromatos (arXiv:1109.6296 28-Sep)

- Look at how strong the Ev dependence should be in order to satisfy data

- New gauge-field theory with a new fermion-U(1) coupling

Implications

- Superluminal speeds arise naturally due to background Bv gauge field

- Light-cone seen by neutrinos is different (no causality problem)

- Particles acquire their masses dynamically... No need for a Higgs boson!