LORENTZ INVARIANCE VIOLATION

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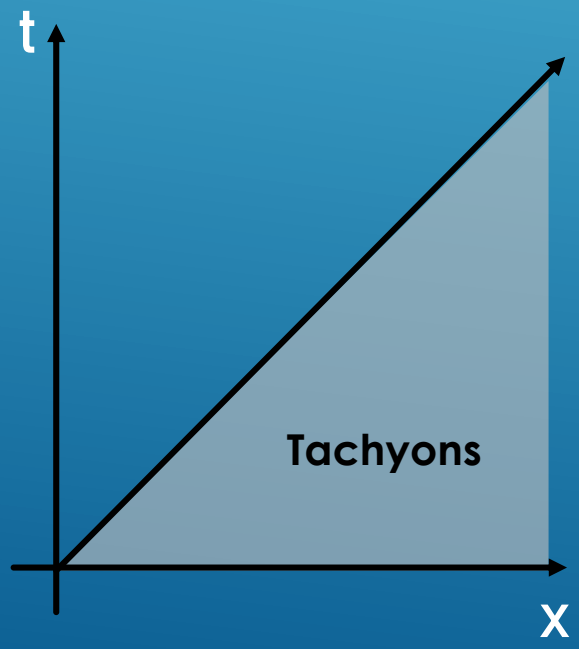
WHERE ARE THE NEUTRINOS?

- It is believed that UHE cosmogenic neutrinos (10^{17} eV and above) are produced in astrophysical processes such as the GZK effect, in which UHECRs interact with the CMB
- These particles will afford us the chance to test relativity at energies higher than ever before
- However, we have yet to observe UHE neutrinos!

LORENTZ INVARIANCE VIOLATION (LIV)

- One possible reason for this absence is that the neutrinos may be violating Lorentz Invariance (principles of relativity should hold)
- Violation has not been previously observed; however, even small violations will greatly reduce UHE neutrino flux
- Why test it? Reconcile GR with quantum

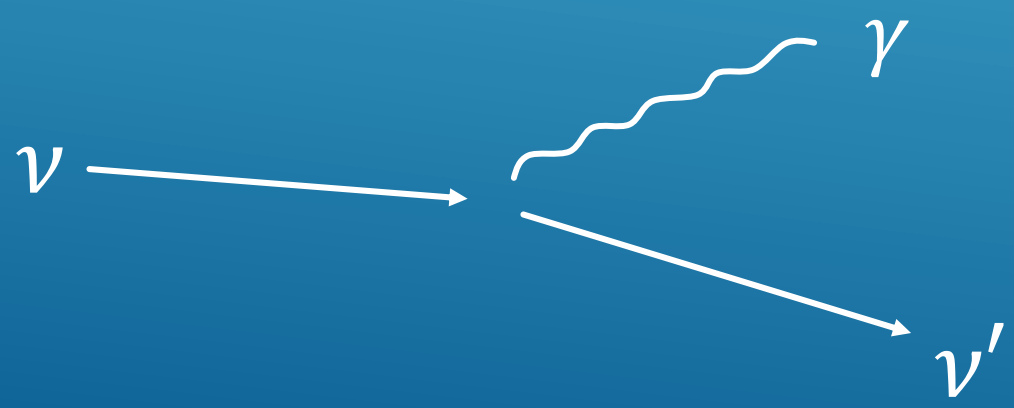
SUPERLUMINAL BEHAVIOR



- Coleman and Glashow have calculated that the maximum attainable velocity for a particle depends on the particle, and the velocity may exceed c
- If neutrinos exhibit non-tachyonic superluminal behavior, this would violate relativity
- Tachyons are particles that permanently travel faster than c (they live in the shaded area at left)
- Non-tachyonic superluminal neutrinos would be accelerated above c then slow back down

IS THIS LIV?

- If neutrinos were to travel above c, they would need to somehow lose energy to return to velocities below c
- Energy loss might be possible if the neutrino were to decay into other particles, or radiate photons

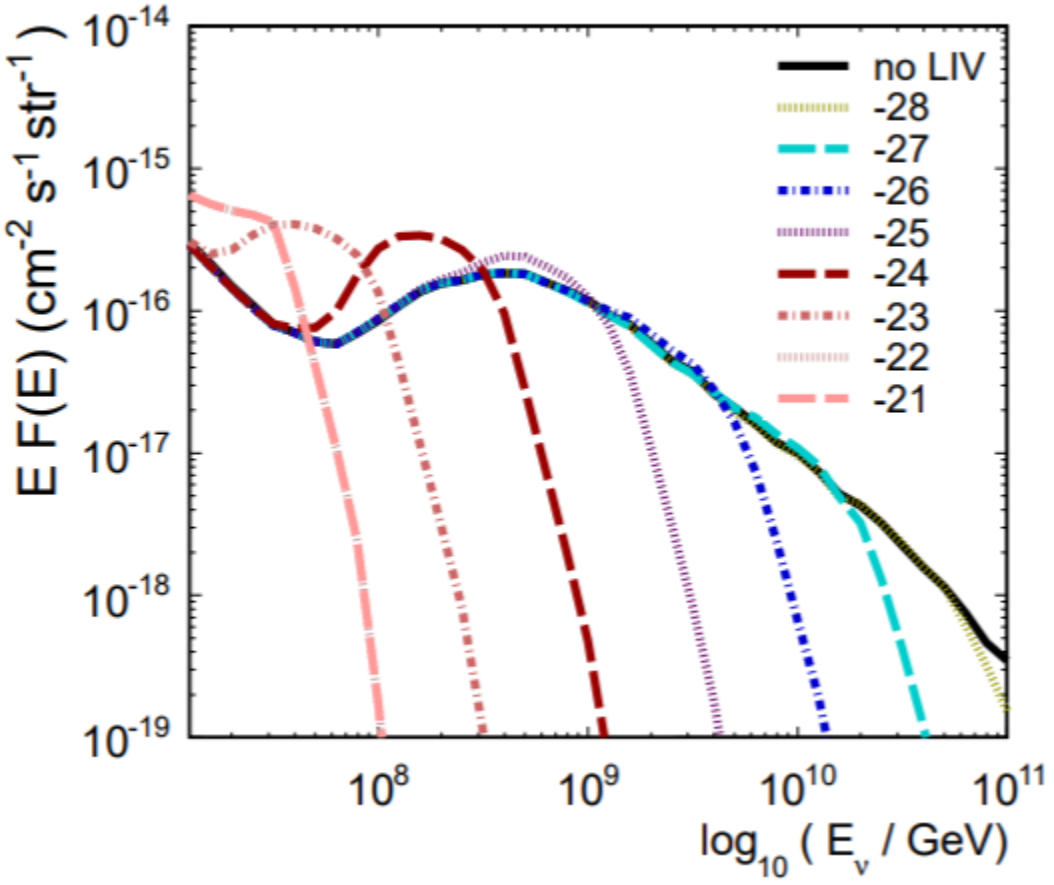


SUPERLUMINAL NEUTRINOS ARE RULE BREAKERS

- However, neutrinos have mass, so we can view interactions in their frame
- If we move to a frame where the neutrino is initially at rest, then photon emission appears as a system with no kinetic energy that gains kinetic energy without any change in the rest mass energy
- Similarly, a stationary neutrino cannot decay into other particles (such as an electron-positron pair) because it has a very small rest mass

EFFECTS

- If neutrinos do indeed violate relativity through superluminal behavior, we expect to see a pileup of lower-energy neutrinos, and a sharper cutoff on higher-energy ones



CONCLUSION

- We haven’t seen UHE neutrinos yet!
- A possible explanation is that SR might be violated

SOURCES

- Gorham, P.W.; et al. Implications of ultrahigh energy neutrino flux constraints for Lorentz-invariance violating cosmogenic neutrinos,arXiv:1207.6425
- F. W. Stecker, Testing Lorentz symmetry using high energy astrophysics observations, arXiv:1708.05672
- Coleman, S.R.; Glashow, S.L. High-energy tests of Lorentz invariance, arXiv:hep-ph/9812418