

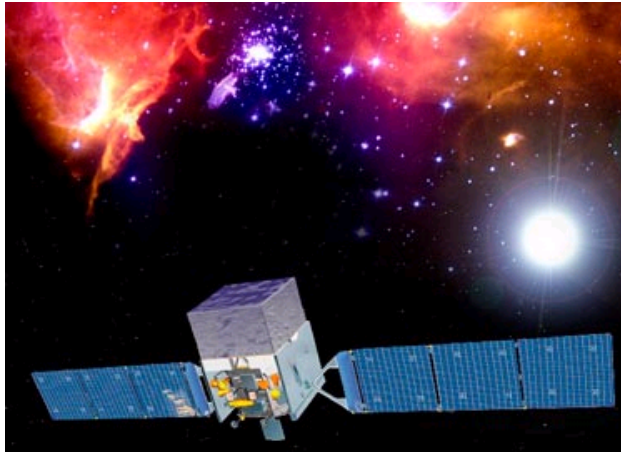
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Special relativity passes key test

Oct 28, 2009 [20 comments](#)

NASA's Fermi Gamma-ray Space Telescope, launched in 2008

Scientists studying radiation from a distant gamma-ray burst have found that the speed of light does not vary with wavelength down to distance scales below that of the Planck length. They say that this disfavors certain theories of quantum gravity that postulate the violation of Lorentz invariance.

Lorentz invariance stipulates that the laws of physics are the same for all observers, regardless of where they are in the universe. Einstein used this principle as a postulate of special relativity, assuming that the speed of light in a vacuum does not depend on who is measuring it, so long as that person is in an inertial frame of reference.

Unifying the cosmic with the quantum

In over 100 years Lorentz invariance has never been found wanting. However, physicists continue to subject it to ever more stringent tests, including modern-day versions of the famous Michelson–Morley interferometry experiment. This dedication to precision stems primarily from physicists' desire to unite quantum mechanics with general relativity, given that some theories of quantum gravity – including string theory and loop quantum gravity – imply that Lorentz invariance might be broken. In particular, these theories allow for the possibility that the invariance does not hold near the minuscule Planck length – about 10^{-33} cm – since at this scale quantum effects are expected to strongly affect the nature of space–time.

It is not possible to test physics at the Planck length directly because this length corresponds to an energy of around 10^{19} gigaelectronvolts – way beyond the reach of particle accelerators (the most powerful of which, CERN's Large Hadron Collider, will generate collision energies of around 10^4 gigaelectronvolts). However, this latest research, carried out by a collaboration of physicists under the leadership of Jonathan Granot of the University of Hertfordshire in the UK, has provided an indirect test of Lorentz invariance at the Planck scale.

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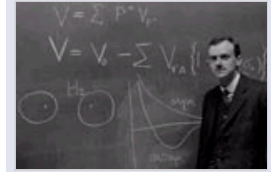
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Granot and colleagues studied the radiation from a gamma-ray burst – associated with a highly energetic explosion in a distant galaxy – that was spotted by NASA's Fermi Gamma-ray Space Telescope on 10 May this year. They analysed the radiation at different wavelengths to see whether there were any signs that photons with different energies arrived at Fermi's detectors at different times. Such a spreading of arrival times would indicate that Lorentz invariance had indeed been violated; in other words that the speed of light in a vacuum depends on the energy of that light and is not a universal constant. Any energy dependence would be minuscule but could still result in a measurable difference in photon arrival times due to the billions of light years that separate gamma-ray bursts from us.

The Fermi team used two relatively independent data analyses to conclude that Lorentz invariance had not been violated. One was the detection of a high-energy photon less than a second after the start of the burst, and the second was the existence of characteristic sharp peaks within the evolution of the burst rather than the smearing of its output that would be expected if there were a distribution in photon speeds. The researchers arrived at the same null result when studying the radiation from a gamma-ray burst detected in September last year, but could only reach about one-tenth of the Planck energy. Crucially, the shorter duration and much finer time structure of the more recent gamma-ray burst takes this null result to at least 1.2 times the Planck energy.

Constraining quantum-gravity

According to Granot, these results "strongly disfavour" quantum-gravity theories in which the speed of light varies linearly with photon energy, which might include some variations of string theory or loop quantum gravity. "I would not use the term 'rule out'," he says, "as most models do not have exact predictions for the energy scale associated with this violation of Lorentz invariance. However, our observational requirement that such an energy scale would be well above the Planck energy makes such models unnatural."

Granot says that far more precise measurements would be needed to probe the Planck scale for theories that postulate a quadratic or higher-order dependence of light speed on photon energy. He also points out that his group's approach probes just one of a number of possible effects of Lorentz invariance violation, and that extremely precise constraints on this violation have been obtained by studying the possible dependence of light speed on photon polarization from X-rays emitted by the Crab nebula. But he adds that his group's new limit is the most precise for simple energy dependence.

Giovanni Amelino-Camelia of the University of Rome La Sapienza believes that the latest work points to the coming of age of the field of quantum gravity phenomenology, with physicists finally able to submit theories of quantum gravity to some kind of experimental test. "Nature, with its uniquely clever ways, might have figured out how to quantize space–time without affecting relativity. But even a slim chance of being on the verge of a new revolution is truly exciting," he says.

About the author

Edwin Cartlidge is a science writer based in Rome

20 comments

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1

usman

Oct 29, 2009 6:28 AM
Islamabad, Pakistan

This is bad news for loop quantum gravity!

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2

gadzirayi

Oct 29, 2009 1:33 PM
Potchefstroom, South Africa

Good News

Quote:

Originally posted by usman

This is bad news for loop quantum gravity!

And good news for they that seek nothing but the truth. I think scientist must emulate Einstein, that if their ideas are short down, they must be able wake-up the following day and pursue a new idea rather than defending the indefinably. This the spirit ...

I am very suspicious of theories that years to take-off the ground, like string theory etc. A true scientific theory that will tie gravitation and quantum physics will come in a single paper by a single author. The history of unification point in this direction. Unifications occur in a single mind and not in a set of different minds.

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3

Ragtime

Oct 30, 2009 2:51 AM
Prague, Czech Republic

Quote:

*Originally posted by **usman***
This is bad news for loop quantum gravity!

At first, this (zero) result has nothing to do with LQG in its present state of development, at second, it can be evidence of photon clustering, which seemingly violates Lorentz symmetry - but in fact it still supports it due the presence of microwave background field. tinyurl.com...yk239q7

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4

petehahn

Oct 30, 2009 4:11 AM
Sherwood Park, Canada

Quote:

*Originally posted by **gadzirayi***
Quote:
*Originally posted by **usman***
This is bad news for loop quantum gravity!

And good news for they that seek nothing but the truth. I think scientist must emulate Einstein, that if their ideas are short down, they must be able wake-up the following day and pursue a new idea rather than defending the indefinably. This the spirit ...

I am very suspicious of theories that years to take-off the ground, like string theory etc. A true scientific theory that will tie gravitation and quantum physics will come in a single paper by a single author. The history of unification point in this direction. Unifications occur in a single mind and not in a set of different minds.

And that single mind won't come from the mainstream physics community.

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5

gadzirayi

Oct 30, 2009 6:42 AM
Potchefstroom, South Africa

Unificaton

Quote:

*Originally posted by **petehahn***
And that single mind won't come from the mainstream physics community

You are right, that unification will take place outside of the mainstream and that mind will have to be strong for that whole mainstream will pounce heavily on this mind. But ... when the truth is before you, you ain't got not choice but accept it.

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6

srp

Oct 30, 2009 4:28 PM
Quebec, Canada

Quote:

You are right, that unification will take place outside of the mainstream and that mind will have to be strong for that whole mainstream will pounce heavily on this mind. But ... when the truth is before you, you ain't got not choice but accept it.

Methink you are overly optimistic with your second sentence.

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7

Ragtime

Oct 30, 2009 9:16 PM
Prague, Czech Republic

Quote:

*Originally posted by **gadzirayi***
.. when the truth is before you, you ain't got not choice but accept it...

There are many observational perspectives and their corresponding truths as well. If you realize it, you get the truth. This doesn't mean opportunism - just the fact, every truth is logically connected with its perspective of vision. Get the connections - and stay tolerant.

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8

sushnil

Where is the causal explanation?

We must note that special relativity does not establish the Lorentz symmetry; it only establishes the Lorentz symmetry in inertial frames, which means laws of physics may not be same for all observers. It is possible that laws of physics may not be same for all the observers but laws of nature are same for all the observers. It is this symmetry of laws of physics that needs to be established.

As far as special relativity is concerned, it makes two contradictory proposals, $x=ct=x'=ct'$, which is possible only if length and time contract proportionally i.e. time must run faster when length contracts and then it contradicts itself and suggests that time runs slower when length contracts.

Special relativity wrongly assumes that we can treat perceived reality at par with quasi reality. It is the motion, not the appearance of the motion that causes a change in the properties of an entity. However, since einstein does not provide causal explanation for Lorentz transformations, therefore, it is at best an observation. A theory must provide causal explanation for its proposals.

Coming back to $x=ct=x'=ct'$, we find that x is not equal to x' and t is not equal to t' , therefore, symmetry is established only by proving that all measurements change proportionally and this observation is valid for all frames of reference whether inertial or inertial. When we move from one frame of reference to another, measurements change proportionally and that must mean that time must run faster when length contracts.

Eclipse paradox shows that information can be communicated instantly. If you believe otherwise then you may very well win \$10000/-.

Sunil Thakur, www.norlabs.org

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9

alanmcintyre
Oct 31, 2009 8:51 PM
Norfolk, United States

Quote:

Originally posted by sushnil
A theory must provide causal explanation for its proposals.

I'm not a physicist, but I've never heard this requirement for hypotheses or theories. I'm also not an expert in logic or rhetoric, but it seems to me that a strict application of this "rule" would require any proposed hypothesis to explain all physical phenomena at arbitrarily fine levels of detail below the hypothesis itself. Would you say that Newton's theory of gravity is "wrong" because he just decribed the effect of gravity, and not the underlying mechanism of how gravity produces a $M_1 * M_2 / r^2$ force between two particles?

Quote:

Originally posted by sushnil
Eclipse paradox shows that information can be communicated instantly.

That's fascinating; can you propose an experiment that demonstrates instantaneous communication? The people that make communications satellites and space probes would certainly be glad to have FTL communication methods, and if you could build such a thing I'm sure they'd be glad to make use of it regardless of what the physics community thinks.

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10

Ragtime
Oct 31, 2009 9:09 PM
Prague, Czech Republic

Quote:

Originally posted by alanmcintyre
can you propose an experiment that demonstrates instantaneous communication?

Eclipse paradox is described here

www.norlabs.org...paradox.pdf

But I don't see any place for interpretation by instantaneous communication here. Of course every theory contains postulates, which are axioms considered true ad-hoc. If it wouldn't, then every theory would become self-referencing tautology.

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11

sushnil
Nov 1, 2009 1:31 PM
INDORE,, India

Instantaneous communication

Quote:

Originally posted by Ragtime
Quote:
Originally posted by alanmcintyre
can you propose an experiment that demonstrates instantaneous communication?

Eclipse paradox is described here

www.norlabs.org...paradox.pdf

But I don't see any place for interpretation by instantaneous communication here. Of course every

theory contains postulates, which are axioms considered true ad-hoc. If it wouldn't, then every theory would become self-referencing tautology.

A theory needs an experiment only it does not base its observations on the study of nature. Physics is about explaining what we observe in nature. However, I have proposed an experiment at the end of this post.

Total solar eclipse can occur only and only if we 'see' the sun and the moon at the place they actually are. Theoretically, it means that if two events were to take place at the sun and the moon simultaneously then we can see these events instantly and simultaneously.

Even gravitational force is communicated instantly. Distance of saturn is 8.8AU, which means any change in the position of saturn shall have an effect on the position of earth only after over an hour. Does any our gravitational theories account for this time delay? Visitors may recall that sometime back, there was a claim that even gravitational waves travel at speed of light (The news was reported in the Physicsworld).

Now, the experiment...

We need a hi-speed camera, a torch, and a mirror.

Torch shall be so placed that its image is formed in a mirror.

The distance of the light source of the mirror depends on the fastest shutter speed of the camera e.g. if the fastest shutter speed of the camera is 5 nanoseconds then the distance between light source and the mirror has to be over 1.5 meters (Light travels about 1.5 meters in 5 ns).

Torch and mirror shall be in the field of view of the mirror.

If instantaneous communication is possible then we shall see that light bulb illuminates in the mirror as soon it lights up in the torch.

It is a simple experiment provided we have a hi-speed camera. unfortunately, I do not have access to such a fast camera.

However, as mentioned earlier, the theory is proved from our observations in nature. My articles titled, 'Human eye can instantaneously detect action at a distance' explains the point elaborately.

As we know, the data collected in the CERN experiment will take years to be evaluated but one of the first evidence from this experiment will be of my prediction that particles in LHC will decay faster than particles decay in any other accelerator.

I have not just made observations like 'Motion results in length contraction'. I have provided causal explanation for every single observation.

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12

sushnil

Nov 1, 2009 2:46 PM
INDORE,, India

Quote:

Originally posted by alanmcintyre

Quote:

Originally posted by sushnil

A theory must provide causal explanation for its proposals.

I'm not a physicist, but I've never heard this requirement for hypotheses or theories. I'm also not an expert in logic or rhetoric, but it seems to me that a strict application of this "rule" would require any proposed hypothesis to explain all physical phenomena at arbitrarily fine levels of detail below the hypothesis itself. Would you say that Newton's theory of gravity is "wrong" because he just described the effect of gravity, and not the underlying mechanism of how gravity produces a $M_1 * M_2 / r^2$ force between two particles?

The sooner physics realizes that it cannot answer all questions that our observations throw at us, the better it will be for all of us. We cannot have causal explanation for the first law of thermodynamics because it explains the way things really are.

However, at times, we accept or conclude too soon that this is the way things are and hence we cannot have a causal explanation for an observed phenomenon. Before Newton pointed out that objects attract each other; people probably believed that objects fall toward the earth because this is the way things really are. Newton showed that this is not the way things really are!!! Newton's universal law of gravitation is not valid but it still marks a linear development in physics. A very major development because it changed the way we looked at the things.

However, Newton himself admitted that his universal law of gravitation is only an observation as he cannot explain why objects attract each other.

An observation may be right and based on the observation, we may draw some conclusions and use this knowledge but a theory of science must give causal explanation.

Please read my article, 'The X-force - Physics of Gravitational force'.

Einstein at least provides causal explanation in general relativity. It may not be completely right but it at least gives us something that we can examine logically and scientifically.

We have to keep on asking every possible 'why' and if can do that then we reach a stage where we find that a phenomenon is not the effect but just 'is' e.g., in case of first law of thermodynamics, we cannot have causal explanation because we cannot establish any cause-effect relationship. It is a phenomenon that stands alone; we can just know that energy cannot be created or destroyed but cannot explain why.

Science is not a matter of convenience, nor it is a matter of imagination. Theories of science shall not be decided by toss of coin either.

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13

Frank Peeters

Nov 3, 2009 3:09 PM

Quote:

Originally posted by sushnil

If instantaneous communication is possible then we shall see that light bulb illuminates in the mirror as soon it lights up in the torch.

It is a simple experiment provided we have a hi-speed camera. unfortunately, I do not have access to such a fast camera.

A similar experiment, albeit slightly more complex in set-up, was performed by Fizeau and Foucault at a time when cameras just emerged: en.wikipedia.org...93Foucault_apparatus

The experiment resulted in a rather accurate measure of the speed of light, but certainly not an infinite one as your statement suggests.

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14

alanmcintyre

Oct 31, 2009 8:56 PM
Norfolk, United States

Typo in fourth paragraph?

"CERN's Large Hadron Collider, will generate collision energies of around 104 gigaelectronvolts" -- shouldn't that be 10⁴?

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15

haijhun_wanng

Nov 1, 2009 1:04 AM
Changchun, China

The case Lorentz voilation may exist

I've repeated that the voilation of Lorentz symmetry should/might exist while weak interaction works, but the voilation must have nothing to do with the electromagnetism, the photon, there it strictly holds.

On the other hand, it has nothing to do with the named quantum gravity, as string theory, the quantum gravity has no any physics presented for us, maybe just a kind of branch of mathematics.

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16

sushnil

Nov 1, 2009 1:35 PM
INDORE,, India

Quote:

Originally posted by haijhun_wanng

I've repeated that the voilation of Lorentz symmetry should/might exist while weak interaction works, but the voilation must have nothing to do with the electromagnetism, the photon, there it strictly holds.

On the other hand, it has nothing to do with the named quantum gravity, as string theory, the quantum gravity has no any physics presented for us, maybe just a kind of branch of mathematics.

Violation of Lorentz symmetry is not possible.....Principle of Relativity (it is more a principle of absoluteness as it assumes absoluteness of laws of physics) must hold in all conditions, in all frames of reference, and at all times.

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17

Ragtime

Nov 3, 2009 1:21 AM
Prague, Czech Republic

Quote:

Originally posted by sushnil

Violation of Lorentz symmetry is not possible.

It's not possible in three dimensions only. Whenever observational perspective becomes highdimensional, Lorentz symmetry gets violated, which is nothing else, then the consequence of Lorentz symmetry in higher dimensions. If Lorentz symmetry violation of higher dimensions wouldn't be possible, our Universe would be perfectly transparent and empty. If light wouldn't change its speed, it even couldn't undergo dispersion and diffraction. Thinking of contemporary people is still very primitive in this point.

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18

sushnilNov 3, 2009 7:46 AM
INDORE,, India

Quote:

*Originally posted by **Ragtime***

Quote:

*Originally posted by **sushnil***

Violation of Lorentz symmetry is not possible.

It's not possible in three dimensions only. Quote:

Believing in extra dimensions is like believing that God moved his magic wand and universe was created. Both the proposals cannot be scientifically examined. Universe may have 111, not just 11 dimensions, but we can perceive, comprehend and explain only a three-dimensional universe. Even our mathematics is designed to explain only a three-dimensional universe and therefore, the moment we perceive extra dimensions, we end up creating chaos.

Quote:

*Originally posted by **Ragtime***

If Lorentz symmetry violation of higher dimensions wouldn't be possible, our Universe would be perfectly transparent and empty. If light wouldn't change its speed, it even couldn't undergo dispersion and diffraction. Thinking of contemporary people is still very primitive in this point.

Lorentz symmetry does not demand that speed of light remains same in all mediums; Lorentz symmetry only demands that measured speed of light remains same in all mediums and that is possible if length and time contract proportionally. The moment we make one of these measurements in one frame of reference and the other measurement in another frame of reference; we encounter relativity i.e we find that speed of light varies with a change in medium. This is because both measurements do not change proportionally.

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19

RagtimeNov 3, 2009 6:05 PM
Prague, Czech Republic

Quote:

*Originally posted by **sushnil***

Believing in extra dimensions is like believing that God moved his magic wand and universe was created.

You just cannot realize, what you can see. For example, in Lorentz symmetry all forces in 3D space should undergo inverse square law. Only Coulomb and gravitational forces are following it, though. The rest are forces in extradimensions - and these forces are all perfectly real.

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20

haijhun_wanngNov 4, 2009 9:27 AM
Changchun, China

Quote:

*Originally posted by **sushnil***

Violation of Lorentz symmetry is not possible.....

You should note that this kind of tests are just based on the examination of photon properties, which just like we make a scale based on a body then at once evaluate this body using the very scale. Can that body undergo any change?

Can you (observer) become one of the microscope weak-interacting particles to test the Lorentz invariance? However, we do be able to test the photon properties by design macroscope devices. Did you realize that?

So, this kind of test make no sense.

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