Is Special Relativity compatible with General Relativity?

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Abstract

Is special relativity theory applicable to the matter universe, as this theory was developed for places with no gravity or acceleration? Is Special Relativity compatible with General Relativity?

Yes, both theories are compatible but only in specific cases.

There is a difference between Special Relativity (SR) and General Relativity (GR). SR relates to speed and time. It was developed by Einstein in 1905 and was based on works done by Newton, Lorentz, Maxwell, Michelson-Morley, and others. GR was published by Einstein in 1915 to generalize SR, by including acceleration. According to the equivalence principle, acceleration and gravity are equivalent. As the matter universe is full of celestial bodies gravity exists everywhere.

SR has caused an ongoing debate on its validity. It gives strange and unexpected consequences such as length contraction, time dilation, twin paradox, etc.

It should be noted that Einstein had doubts about the validity of SR in presence of gravity. A quote from the collected papers of Albert Einstein Volume 7: The Berlin Years: Writings, 1918-1921

https://einsteinpapers.press.princeton.edu/vol7-trans/156?highlightText=%22spatially%20variable%22

"Second, this consequence shows that the law of the constancy of the speed of light no longer holds, according to the general theory of relativity, in spaces that have gravitational fields. As a simple geometric consideration shows, the curvature of light rays occurs only in spaces where the speed of light is spatially variable. **From this, it follows that the entire conceptual system of the theory of special relativity can claim rigorous validity only for those space-time domains where gravitational fields (under appropriately chosen coordinate systems) are absent. The theory of special relativity, therefore, applies only to a limiting case that is nowhere precisely realized in the real world**. Nevertheless, this limiting case ⟨also⟩ is of fundamental significance for the theory of general relativity; because of the fact from which we started, namely that no gravitational field exists near a free-falling observer, this very fact shows that in the vicinity of every world point the results of the theory of special relativity are valid (in the infinitesimal) for a suitably chosen local coordinate system."

Einstein tried to reconcile GR and SR using his hypothesis of the free-falling observer that he suggested at the end of 1907. He suggested that SR is not applicable everywhere but only near a free-falling observer, where there is no gravitational field exists. From the dates of publishing SR and GR, it is clear that for several years Einstein did not have an explanation for SR's unexpected consequences.

The problem of SR validity in our matter universe can also be phrased so:

SR is based on two main postulates:

1. The laws of physics are invariant in all inertial frames of reference (that is, frames of reference with no acceleration or gravity).
2. The speed of light in the vacuum is the same for all observers, regardless of the motion of the light source or observer.

From postulate one of SR, it can be concluded that SR is applicable only far away from any celestial body, where there is no gravity. Therefore, using SR to solve problems in the universe where gravity exists is not applicable.

Nevertheless, SR has been validated, despite Einstein's claim, for over a century by many experiments and is used in places that are influenced by gravity, e.g., in the vicinity of Earth.

I will bring here the known example of the global positioning system (GPS), which is used many million times a day by users all over the world. The GPS includes a relativistic correction factor that is comprised of both GR gravitational time dilation and SR kinematic time dilation. Not using the relativistic correction factor renders the GPS useless.

I will explain with the example of GPS why SR is valid in the gravitational field of Earth.
Fig 1- shows schematically the structure of the GPS. The GPS is comprised of three different segments: the space segment, the control segment, and the user segment. The space segment includes 30+ navigation satellites circling Earth at an altitude of 20,000 km and a speed of 14,000km/h. The control segment is a ground station and the user segment e.g., cellular phone.

It is shown that the reference frame direction of the satellite orbiting Earth is constantly changing relative to the reference frame of the ground station

At the start of measurement, the reference frames of ground station G_0 and satellite frame S_0 are parallel. If the measurement time is big then the frames G_f and S_f are no longer parallel and are rotated by angle Φ. For example, if the measurement duration is one hour, then Φ1=~30deg and Φ2=~15deg. Thus, the relative rotation Φ =Φ1- Φ2=~15deg. The smaller the measurement time, the smaller Φ, and the reference frames stay nearly parallel.

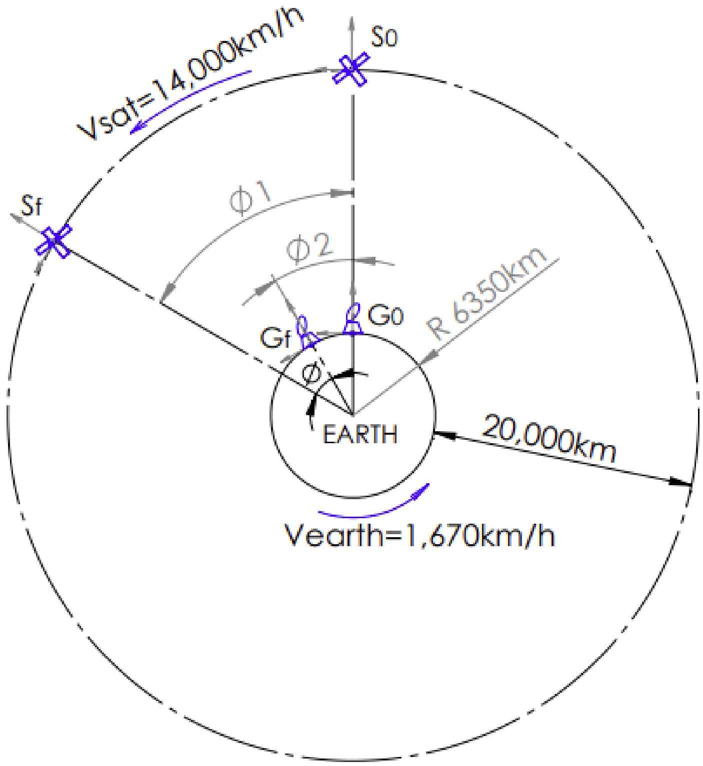

Fig 1. – Global Positioning System

According to Einstein, the rate of advance of two identical clocks placed one on the satellite and the other on the ground station, will differ due to the difference in the gravitational potential (GR) and the relative speed between them (SR). From GR, it can be calculated that the orbiting clocks in the satellites tick slightly faster than the clock at the ground station, by about 45 microseconds per day. On the other hand, from SR calculations the orbiting clock ticks slower, about 7 microseconds per day. The net result is that time on a GPS satellite clock advances faster than a clock on the ground by about 38 microseconds per day. If relativity compensation is not taken into account, it would cause navigational errors that accumulate to 10 km per day! **Note:** a detailed calculation is given at https://www.scienceofgadgets.com/post/how-relativistic-time-dilation-and-gps-are-related

Thus, the answer to the question of how SR is applicable in gravity fields, is that SR is applicable in limited cases where the measurement duration is "small enough" such that the change of references frame is negligible and therefore they can be considered inertial. The definition of "small enough" means that SR is an engineering approximation. It will be accurate if the time of measurement is infinitesimal.

Are there additional cases in which SR is valid?

One example of the usage of SR in the gravity field of Earth is the measurement of the atmospheric muon. This is also a case when the reference frames are inertial.

On the other hand, I claim that SR is sometimes used in cases that result in absurdity. For example, the tween paradox, or the grandfather paradox. I claim that these paradoxes cannot be solved using SR because their duration is long and thus the frame references cannot be kept inertial.

It should be noted that SR has been used to solve cases such as the Sagnac effect, Bradley stellar aberration, and the Michelson-Morley experiment. I think that using SR for these cases is not valid. I claim that all these observations can be explained by the frame-dragging of space by all spinning celestial bodies. Frame dragging was predicted in 1916 by GR and verified by the Gravity Probe B experiment.

The dragging of space by a spinning celestial body was suggested by Stokes (and others), to explain the Bradley stellar aberration. However, dragging by Earth showed that Stokes was wrong. **Nevertheless, I accept Stokes' proposal that space is dragged by a spinning celestial body. But it is not only space that is dragged by Earth rather the entire universe is being dragged by a universal central spinning neutron star.** More details in the paragraph on redshift in the universe.

Note: There is one experiment that was done by Hafele and Keating that I cannot explain it using the previous assumption, i.e., that SR is valid only for short durations of measurement, where the reference frames are inertial. In Hafele and Keating's experiment, two airplanes with atomic clocks on board started from the same place on Earth. An atomic clock was left on the ground. The airplanes were flown around Earth one eastwards and the second westwards. Finally, the airplanes were brought near the clock that stayed on Earth. Their measurements showed that there is a time dilation that can be explained by SR. I claim that SR does not apply to this experiment. Time dilation is not accumulated. The time dilation of the clocks, at the beginning has zero gravitational time dilation and zero kinematic time dilation. The same applies at the end of the experiment, there is no time dilation between the clocks.

I cannot explain Hafele and Keating's results except for noting that there is a paper by Kelly that criticizes the Hafele and Keating experiment based on the drift errors associated with the atomic clocks. http://www.cartesio-episteme.net/h%26kpaper.htm

The redshift in the universe.

An important tool scientists use to explain the structure of the universe is the redshift. With redshift measurement, the distance of a celestial object and its receding velocity from Earth can be determined.

In current cosmology there are three main causes of redshift:

1. The radiation travels between objects which are moving apart (kinematic redshift)

2. The radiation travels towards an object in a weaker gravitational potential (gravitational redshift).

3. The radiation travels through expanding space (cosmological redshift). The expansion of the universe was first observed in the 1920s by astronomer Edwin Hubble. He noticed that the light from distant galaxies was shifted towards the red end of the spectrum. This observation is known as Hubble's law and was later confirmed as evidence of the expansion of the universe.

My claim is that Hubble's law is wrong and therefore it is not proof that the universe is expanding. I explain the problems with Hubble's Law and claim that there is a way to resolve it in: https://www.academia.edu/51230191/Is_there_an_explanation_for_Hubble_s_constant_crisis

To sum up, the redshift measurement is the result of only the superposition of the kinematic redshift and the gravitational redshift. Therefore there is a resemblance between the structure of the Pivot universe and the GPS. Replace Earth with the Pivot neutron star and the galaxies in the universe with the GPS satellites. This confirms the universality of physical laws, i.e., all parts of the universe are subject to the same physical laws that we experience on Earth.