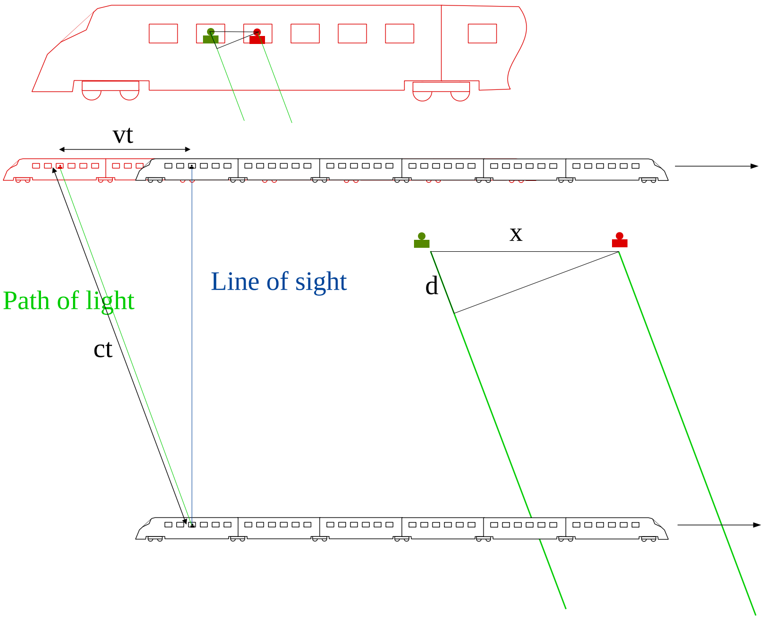
Looking at the past

Light travels at a speed of approximately 1 foot per nanosecond. While the foot is an ancient unit of length, the nanosecond belongs the world of computers. It is the pulse rate of a 1 GHz PC.

We see everything in past. The first clue to this came from observations of the eclipses of Jupiter's moons. It was discovered that they varied in time by nearly 20 minutes throughout the year as the distance between earth and Jupiter varied with the earth's position in orbit.

Einstein liked to explain the effects of relativity using examples of moving trains.

Imagine two trains moving along parallel tracks some distance apart. The trains are level with each other and moving at the same speed.



I am sitting by the third window from the end of near train and see someone sitting in the same window of the other train. I naturally assume that light travels along the line of sight between us. But if the trains are 2000 ft apart, the light takes 2000ns to reach me, a train travelling at 100 ft/sec will travel a quarter of a thousandth of an inch in this time. If we enter Einstein's imaginary world where trains travel very fast, the angle between the line of sight and the actual path taken by the light becomes significant. The position of the far train when the light left it is shown in red. Now lets take a closer look and we see a second person in the next window. The light paths from them to me are very nearly parallel, but the light path from the green man is longer than than that from the red man. The two triangles in the diagram are similar and we can write:

$$\frac{d}{x} = \frac{v\,t}{c\,t} \qquad \Rightarrow \qquad d = \frac{v\,x}{c}$$

And the time taken for light to travel that distance is:

$$t = \frac{v\,x}{c^2}$$

This term appears in the Lorentz transform $t' = \gamma\left(t - \frac{v\,x}{c^2}\right)$. In accounts of the theory of relativity, it is derived from the method of synchronising clocks. But we see here that it is a natural consequence of motion in a world where we see only the past because light takes a finite time to reach us.

The only thing we really know for certain about relativity is that we cannot observe any effects of our own motion. So if the two travellers in the other train hold up clocks which we view through a telescope, we would expect them to read the same time. The time lag term in the Lorentz transform is $-\frac{v\,x}{c^2}$ which tells us that clocks ahead of us will be slow and clocks behind fast. The green man's clock is fast by exactly the same amount of time as the time taken for the light to travel the extra distance, so we see both clocks reading the same time.

Einstein's theory of relativity states that it is time and space which are distorted. We dispute this notion. maintaining that we are dealing with real physical effects on clocks and rulers and the images we form in our eyes and cameras.

We view things in the past because light takes a finite time to reach us. If we know the distance then we can correct for this. However, the light might not be travelling directly towards us but at an angle due to our own motion through some background which moderates the speed of light. (Astronomers observe this effect as stellar aberration and so we know that it is real.) In the example we have examined, this results in an error to the time correction. Events behind our position of observation appear further in the past and events ahead of our position appear less in the past. After applying our inadequate correction, it may appear to us that events ahead of us occurred before they actually occurred.

However, and it is big however; the way we synchronise clocks by radio signals builds an equal and opposite error into the times we observe. So as I sit in my train viewing the two clocks on the other train, they appear in my view through my telescope to read the same time.

While all this seems to be only of academic interest, we do have moving clocks in orbit around the earth sending times signals which are so accurate that GPS equipment is able to measure distances to the nearest centimetre. This technology could easily see a time difference between the two clocks on the other train due to the earth's motion through space. We should be able to observe these effects.

HOWEVER, and this an even bigger however; clock rates really are affected by their velocity through the background. The amazing thing is that if the green man takes his clock and swaps it for the red mans clock, by the time he has sat down and held his clock up to the window, the two clocks will read the same time. As the green clock is carried forward at a speed w (through the train) to the next window, it moves though space at a speed of $v + w$ causing it to run slower during the time it is being moved. When the red clock is carried back, it is moving through space at a speed of $v - w$ and runs less slowly during this period with the result that it gains time. By some miracle, it would appear that nature has the mechanism of changing the time on moving clocks built in to her function.

Well no, its not a miracle, just a coincidence. The way in which the mathematical equations work is really quite limited because the units have to balance. If you are working out the area of carpet in a house, every bit of the sum has to have two lengths multiplied together. In the same way, the terms in the integrations we form to calculate the time lost or gained are very limited. In fact its not even a coincidence, it is just inevitable.

We can buy atomic clocks off the shelf, if we have the money, and once calibrated to their new height above sea level and set, they will be accurate to fractions of a nanosecond. As the earth revolves about its axis, a clock moves though space, relative to the sun, at different speeds. This is greatest at midnight and least at noon. This causes the clock to vary in rate (compared with a suitable calibrated clock at the centre of the earth) loosing time during the night and gaining it back during the day. This loss and gain in time is exactly the right amount to prevent us observing any strange effects.