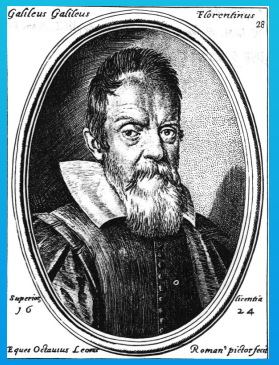
The Galilean Velocity Transformation and Newtonian Simultaneity



by

Robert J. Buenker

Bergische Universität Wuppertal

Fachbereich C-Mathematik und Naturwissenschaften

Gaussstr. 20

42119 Wuppertal

Germany

The Galilean Velocity transformation (GVT) is a very useful tool in everyday life. For example, consider a truck passing someone standing on a street corner. The truck is moving at a constant speed of $v=40$ km/h relative to him. The driver reports that there is a car moving ahead of him in the same direction with a constant speed $w = 30$ km/h. One can therefore conclude on the basis of the GVT without any doubt that the car is moving with a speed of $k=v+w=70$ km/h relative to the street corner.

This answer may not be so obvious since speed is a ratio of distance travelled to elapsed time. Adding ratios is more complicated than necessary in this example, however.

A simpler way to look at the example is to compute the distances travelled in a certain time period T by multiplying the value of each *constant* speed by T and adding the two results. Clearly, the distance K travelled relative to the street corner in the same period is equal to the sum of these two values, i.e. K =vT + wT. By definition, the corresponding speed k is equal to K/T, which is equal to the GVT result of v+w.

Next make a change so that the car is now a light pulse moving with speed c away from the truck/light source. The distance travelled by the light pulse relative to the truck is now cT (no longer wT) but the distance between the truck and street corner is the same as before (vT). Adding these two results gives the distance K = vT +cT between the light pulse and the street corner at time T. As before, by definition, the corresponding speed k is K/T = v+c, which is the value obtained from the GVT.

Einstein's light-speed postulate (LSP) obtains a different result. It says that the speed of the light pulse is equal to c relative to both the light source/truck and the street corner. This means that the distance between the light source and the street corner is cT. But that is the same distance as between the truck and the light pulse. The LSP does not account for the distance between the light source/truck and the street corner of vT. The LSP is wrong, but the GVT is correct.

This is not an insignificant example. It can be extended to cover the speed of the light pulse relative to any two rest frames in the universe. It should be noted that what has been referred to as the GVT is known by a more general term in mathematics, namely vector addition. As such, it can extended to any two rest frames in three-dimensional space.

One mistake leads to another. Einstein used the LSP in a famous example in which two lighting strikes hit a train at different positions simultaneously as it passes the station platform with speed v. One strike occurs at position 0 on the platform. The other occurs at position 2L. An observer P standing at position L, i.e. at the midpoint on the platform, will see each light pulse from the strikes arrive at the same time. The elapsed time will be TP=L/c.

The point Einstein was making is that the two light pulses will not arrive at the same time for the observer R on the train. To be specific, we assume that R is also at position L when the strikes occur. Einstein made the following calculation. In order for the light pulse that started at the front of the train to reach R, a gap of a distance of L has to be bridged. We define the elapsed time for this to occur to be T1, from which it follows that $cT1 + vT1 = L$. Note that here is where Einstein invoked the LSP. The speed of the light pulse for R is independent of v.

It follows that $T1 = L/(c+v) < TP = L/c$.

When the LSP is used for the other pulse from the rear of the train, the corresponding time is $T2 = L/(c-v) > TP$.

It is clear that T1 is not equal to T2, so the pulses do not arrive at the same time at R's position. This is what Einstein wanted to prove with this example and he succeeded. The problem for him is that he used a false assumption, namely the LSP, to obtain his result. It is therefore inconsequential. On this basis, it is not clear that the light pulses do not arrive at the same time for R.

The GVT must be used instead because P and R are in different rest frames observing the same object/light pulse. When the GVT is used , the two strikes are found to occur simultaneously for both the platform and train observers, as shown in the next slide.

We will use the same method as before, namely to compute distances at various times. The locations of the strikes after time T has elapsed are 2L+vT and vT, respectively. The same coordinate system is used as before, with the midpoint at L.

The GVT requires that observer R on the train sees the light from the front of the train to move with speed –(v+c) downward. So the current position of this pulse at time T is obtained by adding 2L + vT to -(v+c) T = 2L – cT. This is the same location as measured by P.

The other light pulse is observed by R to be at cT at time T because the speed of light for this one is (c-v) according to the GVT. The current location is thus vT + (c-v)T = cT, again the same as for P. So R also finds that both pulses arrive at the same time T=L/c and at the midpoint of the platform located at L. Everything is consistent for R and P. They agree on the time when the two light pulses arrive, i.e. simultaneity is observed when the GVT is used.

Einstein also overlooked something crucial in his derivation, however. The clocks used to measure the two time differences are inertial, that is, they are freely translating through space. As a consequence, their rates are perfectly constant. They cannot change spontaneously. This is because of the Law of Causality. Newton's First Law of Motion (Law of Inertia) operates on the same principle.

This means that the ratio of the rates of the two clocks (Q) must also be a constant. As a result, time differences for the same two events must always be in the same ratio, i.e. $\Delta t' = \Delta t/Q$. Therefore, if one of the time differences is zero, the other must be as well. That is Absolute Simultaneity, which is the opposite of RNS. This rules out the space-time mixing characteristic of the LT:

$$\Delta t' = \gamma (v) (\Delta t - v \Delta x/c^2)$$

The LT is therefore invalid. It is not consistent with the Law of Causality.

Eliminating the LT means that the following misconceptions of Einstein's theory of relativity can be ignored as well:

1) RNS (events do not occur simultaneously for different observers)

2) Time-reversal (the time order of events can be different)

3) The GVT only holds in the low-velocity limit.

4) Two observers each find that the other's clock is running slower than his own. The same "symmetry principle" holds for all physical properties.

5) The Lorentz-FitzGerald length contraction effect.

The example of the train is again useful. If the clock on the train runs slower than the one on the platform, then Q>1 for the platform observer P. This means , however, that the corresponding constant Q' for the train observer R is equal to (1/Q)<1. This reciprocal relationship is quite normal in everyday life. For example, since $1.00 is worth 100 cents, one cent is worth 1/100$ or $ 0.01 .

By contrast, Einsteins' theory (STR) is subjective . It claims that P thinks the train clock is running slower by a factor of $\gamma(v)$, whereas R thinks the clock on the platform runs slower than his by the same factor of $\gamma(v)$. This is a necessary result of the LT, but it can be ignored once it is realized that the LT is not a valid transformation.

The question is therefore: can we fix the problem without destroying the theory as a whole? The ratio $\Delta t' / \Delta t$ must be a constant for any pair of inertial rest frames, i.e. $\Delta t' = \Delta t / Q$. But is the clock-rate proportionality compatible with Einstein's two postulates?

One can make a different transformation by starting with the RVT

$$u_x' = \Delta x'/\Delta t' = \eta\,(u_x - v)$$

$$u_y' = \Delta y'/\Delta t' = \eta\, u_y/\gamma$$

$$u_z' = \Delta z'/\Delta t' = \eta\, u_z/\gamma \qquad \eta\,(u_x, v) = (1 - v\Delta x/c^2\Delta t)^{-1}$$

and multiplying each equation with $\Delta t' = \Delta t/Q$.

$$\Delta x' = \eta\,(\Delta x - v\,\Delta t)/Q$$
$$\Delta y' = (\eta/\gamma Q)\,\Delta y$$
$$\Delta z' = (\eta/\gamma Q)\,\Delta z$$
$$\Delta t' = \Delta t/Q.$$

This is called the Newton-Voigt transformation (NVT) .

The NVT also satisfies Galileo's Relativity Principle (RP). Einstein and his colleagues thought that only the LT can satisfy the RP. This was a key misjudgment. The NVT has a different light-speed postulate, namely that the speed of light relative to its source in free space is equal to c: Michelson-Morley null-interference result

The NVT requires an explicit value of the parameter Q to be applied for any pair of rest frames; this quantity must be determined by experiment. How to do this was shown in two key studies, one in 1960 for x-rays combining the Moessbauer effect with a high-speed rotor (Hay et al.) and the other with atomic clocks carried on circumnavigating airplanes in 1970 (Hafele and Keating).

What they show is that the rates of clocks decrease as the clocks increase their speed relative to a definite rest frame (objective rest frame ORS). The value of Q can be obtained using a law of physics.

- The experimental result is known as the Universal Time – dilation Law (UTDL):
- $\Delta t' \gamma(v') = \Delta t \gamma(v)$
- The measured elapsed time on one inertial clock moving with speed v relative to the ORS is inversely proportional to $\gamma(v)$. Combining the UTDL with $\Delta t' = \Delta t / Q$ from the NVT leads to the following result:
- $Q = \gamma(v')/ \gamma(v)$
- Note that the inverse of this equation leads naturally to:
- $Q' = 1/Q = \gamma(v)/ \gamma(v')$
- This is in agreement with the Objectivity Principle of the NVT, in contrast to the subjectivity of the LT and STR.

The UTDL is used in the operation of the Global Positioning System (GPS). It is critical that atomic clocks on the GPS satellites run at the same rate as those on the ground. The engineers must change the rates of atomic clocks to accomplish this goal and the UTDL is used for this purpose (there is also a gravitational effect which must be accounted for).

It is often claimed that the alteration of atomic clocks is a successful verification of STR, but this is only partially true. Arranging that the ground and satellite clocks run at the same rate only makes sense if events occur simultaneously in both rest frames. This is inconsistent with RNS and STR, but fits in perfectly with the NVT.

It is important to see that such proportional relationships as the UTDL are also valid for all other physical properties.

In order for the speed of light to be the same in different rest frames, it is necessary that observers in both frames agree on the unit of speed/velocity. In fact, they must agree on the values of all *relative* speeds to be consistent with the light-speed constancy.

For this to be true, it is necessary that the lengths of objects increase with acceleration in exactly the same proportion as clocks are slowed. This is the opposite of what is expected by the LT and Lorentz-Fitz-Gerald length contraction effect.

In summary, both the units of time and distance scale with Q, while that of speed scales as $Q^0=1$. Experiment (Bucherer 1909) also indicates that inertial mass scales as Q.

For all other physical properties, one can compute the corresponding scale factor from knowledge of its composition in terms of the fundamental units of inertial mass, distance and time (mks system). The appropriate scale factor is then obtained as a power of Q. For example, energy scales as Q and angular momentum scales as Q^2.

These definitions guarantee that all physical laws hold in each inertial system, consistent with the RP. For example, take $E=mc^2$. The power of Q on the left is +1 (for energy), while the corresponding powers on the right are 1 (mass) and 0 (speed), so the sum on the right is also 1.

Next consider Planck's law: E= hf, h has a unit of angular momentum with power of Q equal to 2, while frequency f is the reciprocal of time and thus corresponds to a power of -1. The sum of the powers is thus +1, which is the same as the power of energy on the left.

It is possible to do something similar with gravitational effects. Only now we need a different factor S instead of Q. It is easy to compute S if you know the respective positions of the two rest frames in their gravitational fields.

As before with Q, the scale factors are powers of S in this case. But the powers are different, namely -1 for inertial mass and time and 0 for distance. You can compute the corresponding power for S by knowing the composition of the property in terms of the three fundamental quantities.

Examples: Energy mc^2, the power sum is obtained by converting the unit to mass times $distance^2/time^2$, so the sum is -1+0+2=+1; Planck's constant or angular momentum $mvr=mr^2/t=$, so the sum is -1+0/-1=0. So h is invariant to gravitational scaling.

It is also possible to scale electromagnetic quantities. To do this, you can assume that the Coulomb has a unit of energy (Nm) and ε_0 has a unit of N = mass (r/t^2). According to Coulomb's Law, force in N = Coulomb ^{2} / $\varepsilon_0 r^2$ or $(Nm)^2$ / Nm^2 = N.

Summary

1)The LT is invalid because it falsely claims RNS is possible. Einstein, Lorentz and Larmor ignored the fact that inertial clocks must run at a constant rate and cannot change their rate spontaneously.

2)The above argument about the rates of inertial clocks indicates that two such inertial clocks will find elapsed times for two events which differ in the same proportion as their constant rates, i.e. $\Delta t' = \Delta t / Q$.

3) Experiments have shown that there is simple proportionality relationship (UTDL) which allows Q to be measured for any pair of rest frames, This requires knowledge of an objective rest frame (ORS) relative to which the speeds of the clocks are to be measured.
4)A different transformation exists (NVT) that is consistent with absolute simultaneity and includes Q explicitly in its equations.
5)A similar law exists for all other physical properties. One just needs to know the composition of the property in terms of the fundamental units of inertial mass, distance and time to compute the corresponding factor as a power of Q.
6)There is an analogous method for computing gravitational factors .
These relationships are possible because the revised version of relativity is perfectly objective, in contrast to STR, which is a subjective theory

alternativelorentztransformation.blogspot.com

Click on publications

i