Einstein-Poincare synchronization and general transformations of coordinates

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Abstract

Einstein-Poincare synchronization and deformation of space-time by gravity are sufficient for obtaining Lorentz transformation starting from Galileo transformation.

Einstein-Poincare synchronization of time for moving referent frame

If we have two inertial referent frames, one in rest and second moving we can write Galileo transformation of coordinates. Experimental fact is that speed of light can be regarded as constant in inertial frame.
Forgetting for moment dilatation of time and elongation of length, let us deal with how observer in frame at rest would see effort of observer in moving frame to synchronize clocks by use of light signals. Due to moving of frame classical observer would expect that speed of signal in respect to moving frame is modified by speed of referent frame. But moving frame is also inertial and observer in it can argue that speed of light is constant for him in any direction. In the end both would be right due to gravitational potential of fictitious forces.
Lets do synchronization of all clocks in moving frame with respect to referent clock that is at rest in coordinate beginning of moving frame. First step in Einstein-Poincare synchronization is loop in which electromagnetic signal is sent from referent clock to place of some other clock,than sent back. This is twice amount observer from moving frame expects it is needed for signal to travel from referent clock.Half-loop time is:

$$2t_{hl} = \frac{x'}{c-u} + \frac{x'}{c+u} = \gamma^2 \frac{x'}{c}$$

(1)

If we send another signal which has information of time moment of referent clock, observer from rest frame expects signal to arrive $\frac{x'}{c-u}$ later to the clock at point x' and moving observer expects it arrives t_{hl} later. Difference of viewpoint of observer at rest and moving observer alters Galileo transformation of time by:

$$\Delta t = \frac{x'}{c-u} - t_{hl} = \gamma^2 \frac{ux'}{c^2}$$

(2)

Transformation of time between two referent frames if there are no gravity or fictitious potential effects is:

$$t' = t - \Delta t = t - \gamma^2 u \frac{x - ut}{c^2} = \gamma^2 (t - u \frac{x}{c^2})$$

(3)

Time synchronized Galileo transformations by application of Einstein-Poincare procedure looks almost like Lorentz transformations:

Or in differential form when relative velocity is constant:

Gravity and fictitious forces potentials

Gravity and fictitious forces are connected by equivalence principle. If referent frames from previous section are considered only one thing that can be different in them is possible presence of potential due to fictitious forces if they got relative velocity one to another by accelerating due to forces that are not gravitational. in contrast if they accelerate one from other driven by gravity no fictitious forces are present.
In order to obtain Lorentz transformation from transformation with synchronized time one needs to apply one factor γ that dilate time and elongate length. Only one thing gives observer from rest frame the right to do that- deformation of coordinates by potential of fictitious forces present in moving frame if that frame accelerated to it's velocity from rest driven by some non gravitational force.
If moving frame obtained his velocity driven by gravity then one could argue that synchronized Galileo transformation (4) and (5) are valid for that situation.
So the roll of fictitious forces potential or gravitational potential is:

Metric for gravity derived from time-synchronized Galileo transformation

Applying synchronized Galilean transformations between locally inertial free falling frame and coordinate frame metric for gravity can be directly obtained. Transformations between free falling frame S and coordinate frame S_c are:

Metric is then:

$$1 = \dot{t}^2 - \dot{r}^2 = \gamma^{-2}\dot{t}_c^2 - \dot{r}_c \cdot \dot{r}_c - \gamma^2(u \cdot \dot{r}_c)^2$$

(4)

It has three parameters $u_{r(r)}$,$u_{\theta(r)}$,$u_{\phi(r)}$ related to relative velocities between frames. If we consider only radial coordinate and time, or angular parameters of metric are zeros, we get Schwarzschild type metric.Difference from Schwarzschild metric can be related to gravitational locking and rotation of free falling reference frame in respect to coordinate space.By suitable rotation of basis of free falling refernt frame we get Schwarzschild solution.

Einstein-Poincare synchronization and rotational referent frames

Sagnac effect in rotating frame is a example where such synchronization is not unique, so there it is not used.Transformation between rest and rotating frame can be obtained by applying only fictitious potentials correction factor for time $\gamma = \sqrt{1 - \frac{\omega^2 r^2}{c^2}}$ if frame started rotating driven by non gravitational force.For diameter and circumference there is ongoing debate since Born how should be transformed.

If rotation is consequence of free fall, then no deformation of coordinates is expected and Galileo transformation are valid:

Einstein-Poincare synchronization is not spontaneous process

In referent frames that undergone non gravitational acceleration and finally become inertial again clocks need to be synchronized by observer. If this is not done and speed of light is measured then results depend on direction. This is only because clocks are still synchronized in sense of before acceleration. Transformation before synchronization is:

Rate of time change in respect to starting frame is altered by fictitious potential. In general we cannot tell how much if we don't know that potential. That is we can't tell in twin paradox situation relative dilatation of times if we don't know whole acceleration history or are able to measure constant gravitational potential present. For example if twins did same acceleration in opposite directions from starting inertial frame then there can aged same. So is this starting frame a preferred frame in sense it give correct result? Not exactly because most of macro-scale motion in nature is driven by gravity.So even point on Earth that rotates and moves with great velocity can be regarded as locally inertial frame since its motion is driven by gravity. If body free falls by gravity ideal point-like clock rate does not change. If starting frame had no non-gravitational acceleration history then in case of symmetric twins accelerating from mother referent frame in opposite direction,they age is same.If just one accelerates then he ages less.

1 Einstein-Poincare synchronization and non-constant relative velocity

In general synchronization process takes time and can't be done in accelerating frame.But in case of gravity we have free falling frame that is locally inertial and coordinate frame that is already Einstein-Poincare synchronized.So differential form of Zahars transformations is valid.

Conclusion

It would be useful to obtain some sort of universal coordinate transformations as a generalization of Galilean and Lorentz transformations. Form of the metric in gravitational problems then would be not assumed but derived directly without use of field equations. Still there should be field equations that are in harmony with that generalized transformations.

Acknowledgments

It came to author's attention that synchronized Galileo transformation was obtained before by Elie Zahar (Elie, 1977) and possibly other scholars before him. Author has nothing but great respect for all that derived same result. Second step implementing these transformation into theory of gravity was not done before as long as author's knowledge goes.If any such attempt was possibly done author supports same ideas shared by people involved. Source for newly obtained information was (Olga Chashchina,Natalya Dudisheva,Zurab K. Silagadze, 2019).

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