Quantum gravity by elimination of spacetime

René Friedrich, Strasbourg

A new approach is presented here for quantum gravity, and for the question why curved spacetime is not compatible with quantum mechanics. The answer: Curved spacetime is not fundamental because it is not Lorentz-invariant. We show that Lorentz-covariant spacetime is only the way how the universe of general relativity is perceived and measured by observers, it is a sort of projection. The underlying unobservable universe of quantum gravity is Lorentz-invariant, it is easy to retrieve, and it provides Lorentz-invariant concepts for 1. time, 2. worldlines, 3. space, 4. velocity, 5. fields and 6. gravity.

0. Introduction: How to resolve the problem of quantum gravity

How is it possible that we are still struggling with quantum gravity today? Quantum mechanics and general relativity are two extremely well elaborated matters, but all attempts of unification are failing.

Half of the answer to the question lies in the question itself. The excellent mastery of general relativity and quantum mechanics seems to call for a simple solution, by the means of the unbiased reassessment of the basics of general relativity, instead of any added mathematical artifice.

1. Time - The basic principle

"Elimination of spacetime" - what does that mean? The basic principle is shown at the example of time:

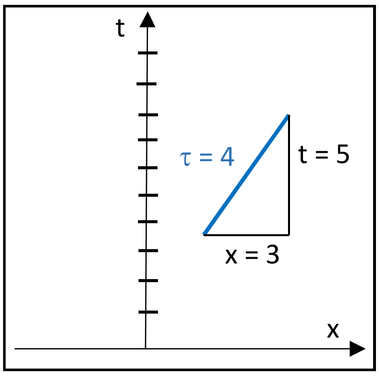

Fig. 1: Retrieving the Lorentz-invariant proper time $\tau = 4$ from coordinate time t = 5

Coordinate time is observer-dependent, but all observers agree on the proper time of a displacement. Coordinate time (the result of experimental measurements) is a mere projection of the underlying proper time, and proper time is the Lorentz-invariant "root" of coordinate time.

In the same way as it is possible to retrieve from coordinate time the Lorentz-invariant concept of proper time, it is possible to retrieve from spacetime the underlying Lorentz-invariant form of the universe which complies with quantum mechanics.

rene_friedrich@orange.fr

2. Worldlines - The redundancy of Minkowski spacetime

Worldlines may be parameterized by their respective proper time instead of coordinate time. For a better understanding of this concept we take a closer look on the transition from Newtonian spacetime to Minkowski spacetime. Both are mapping the same universe of events and worldlines with space and time coordinates, but with two fundamental differences:

1. Newtonian spacetime has no metric while Minkowski spacetime introduced a Lorentzian metric with light cone.

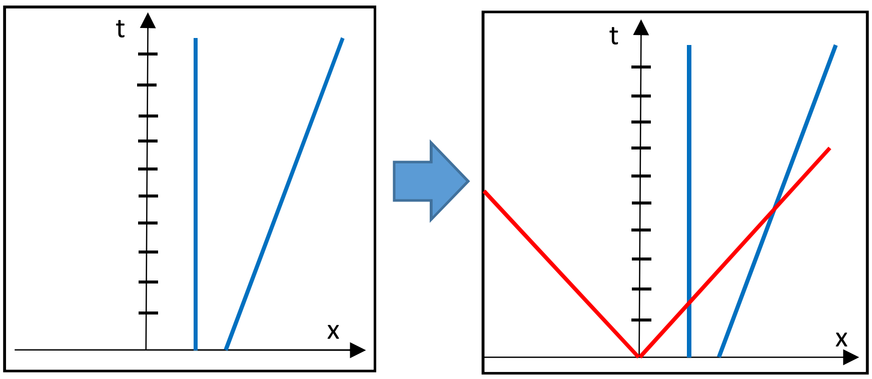

Fig. 2: Two worldlines within Newtonian spacetime and within Minkowski metric

2. Newtonian spacetime is observer-independent, with one absolute time axis for all observers, while each Minkowski spacetime manifold refers to the reference frame of one observer, or more generally: of one mass particle, and each mass particle has its own clock, its own time axis and its own Minkowski manifold:

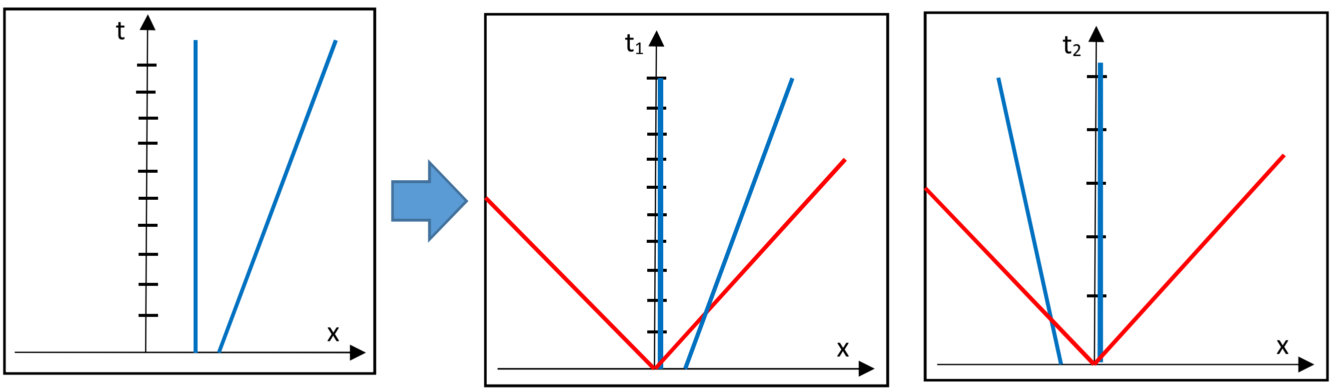

Fig. 3: The absolute Newtonian time axis is replaced with several Minkowski diagrams with different time axes, one diagram for each mass particle

As a result, we get as many spacetime manifolds as there are particles in the universe. This representation is very redundant. Currently, this redundancy is eliminated by the reduction of all spacetime manifolds to one single spacetime manifold, all the other spacetime manifolds are obtained by transformation.

This representation is not Lorentz-invariant, but there is an alternative way for the elimination of the redundancy: In order to retrieve the Lorentz-invariant nature of the universe, we have to "extract" the Lorentz-invariant part of each spacetime manifold, that is its respective time axis.

The time axis of a spacetime manifold corresponds to the clock (= the Lorentz-invariant proper time) of the mass particle which is moving along the time axis, such that the coordinate time on the time axis is equal to the proper time of the mass particle:

$$t = \tau$$

The result are zillions of independent time axes of worldlines, each of them parameterized by the proper time of the corresponding particle:

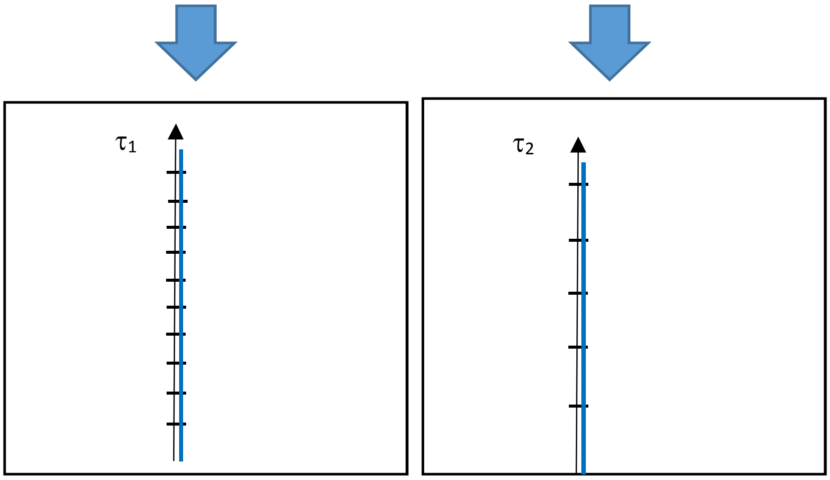

Fig. 4: Lorentz-invariant representation of a universe of two particles with different time axes

This is the Lorentz-invariant universe of special relativity: There is no absolute time axis, each particle worldline is parameterized by its respective proper time, according to the action of a point particle:

$$S = mc^2 \int d\tau$$

These "worldlines parameterized by their respective proper time" are the basic elements of the universe. In short we may say that the universe consists of zillions of clocks in absolute space.

3. Absolute space

Spacetime is not a Lorentz-invariant manifold, for quantum gravity it must be replaced with a threedimensional absolute space manifold.

The spatial localization of worldlines is unambiguously defined by the events on the worldlines which are reference points in space: Each event is happening at a certain place, such that it is possible to assign absolute space coordinates to each event, and they are marking the corresponding particle worldline they belong to.

4. Absolute velocity

As the worldlines are parameterized by their respective proper time, they are provided in absolute space with a sort of Lorentz-invariant velocity: The measured velocity of particles

$$\vec{v} = \frac{\vec{s}}{t}$$

is replaced with the observer-independent "absolute velocity" parameter

$$\vec{v}_{abs} = \frac{\vec{s}}{\tau}$$

For lightlike movements, this parameter goes to infinity, but this does not infringe the speed limit of special relativity because this "absolute velocity" is not an observable parameter.

5. Lightlike phenomena such as fields and photons in vacuum

What about the light cones of the Minkowski diagrams in **fig. 2** which represent lightlike phenomena such as photons in vacuum or electromagnetic or gravity fields? The spacetime intervals on a light cone are zero, this is why the light cone is reduced to an independent point:

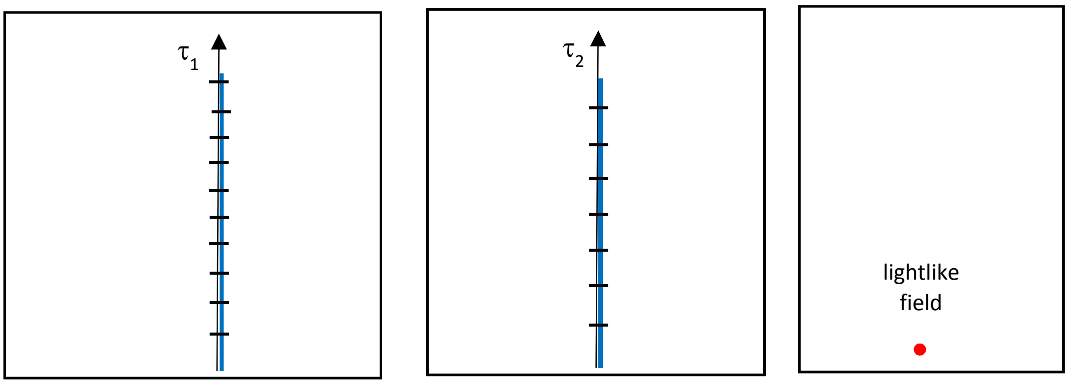

Fig. 5: Lorentz-invariant universe with two particles and one lightlike field

The result is a point without any time axis. Lightlike phenomena have no reference frame, their zero spacetime intervals are not observable and may only be retrieved by calculation. Curiously, we get this point twice at different points in space, at the place of emission and the place of absorption although the spacetime interval between both events is zero. This is due to the fact that the "absolute velocity" (see **section 4**) of lightlike phenomena goes to infinity.

6. Lorentz-invariant gravity

It has been shown that spacetime is mere observation, and that the underlying universe is Lorentz-invariant. But how can this concept apply to gravity?

The answer: Gravity may not only be described as curved spacetime but alternatively by the perfectly equivalent concept of gravitational time dilation in flat, uncurved space.

In order to show the full equivalence between gravity and gravitational time dilation, we start with the Schwarzschild metric of curved spacetime:[1]

$$ds^2 = -c^2\left(1-\frac{2GM}{c^2r}\right)dt^2 + \frac{dr^2}{1-\frac{2GM}{c^2r}} + r^2(d\Theta + sin^2\Theta\, d\phi^2)$$

Now we denote by **C** the gravitational time dilation of the clock of a particle in a gravity field with reference to a far-away observer:

$$C = \frac{\tau}{t} = \sqrt{1-\frac{2GM}{c^2r}}$$

By inserting C into the equation above, we get a modified form of the Schwarzschild metric:

$$ds^2 = -c^2(\boldsymbol{Cdt})^2 + \left(\frac{\boldsymbol{dr}}{\boldsymbol{C}}\right)^2 + r^2(d\Theta + sin^2\Theta\, d\phi^2)$$

Now we compare this equation with the equation of flat Minkowski metric **[1]**:

$$ds^2 = -c^2\boldsymbol{dt}^2 + \boldsymbol{dr}^2 + r^2(d\Theta + sin^2\Theta\, d\phi^2)$$

We see that the Schwarzschild metric and the Minkowski metric are very similar, and the gravitational time dilation C is the only difference between curved and uncurved spacetime: The term *dt* becomes *Cdt* and the term *dr* becomes $\frac{dr}{C}$. If C = 1, we get the Minkowski metric, and C < 1 indicates gravity. By consequence, gravity and gravitational time dilation are equivalent, and gravitational time dilation is able to produce all effects of gravity.

The fourdimensional gravity concept of spacetime curvature is replaced with the onedimensional concept of time dilation. Quantum gravity in only one sentence: Gravity in the form of gravitational time dilation acts on the Lorentz-invariant time parameter of the worldlines of quantum systems.

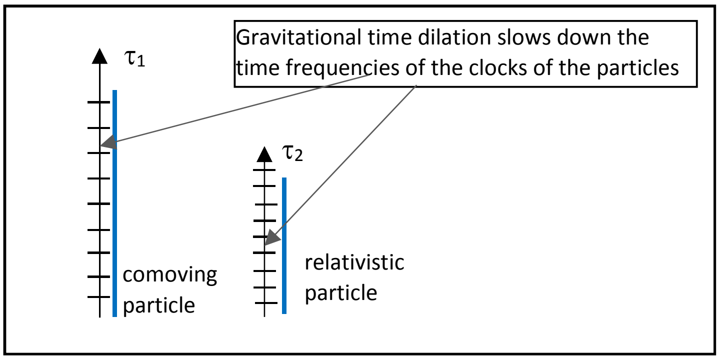

Fig. 6: Quantum gravity: Gravitational time dilation acts on the worldlines which are parameterized by their respective proper time

[1] Following the current sign convention (- + + +)

The attractive force of gravity is due to the fact that each mass particle within a gravity field is striving to maximize its own gravitational time dilation.

7. Summary

The Lorentz-invariant universe consists of the following basic elements:

1. Worldlines of quantum systems with mass (mass particles) are parameterized by their respective proper time ($S = mc^2 \int d\tau$).
2. Lightlike elements such as electromagnetic and gravitational fields are reduced to simple points (τ= 0).
3. The underlying manifold is an $\mathbb{R}^3$space manifold, and velocity is represented by absolute velocity $\vec{v}_{abs} = \frac{\vec{s}}{\tau}$.
4. Vacuum points in space are timeless (τ is not defined).
5. Gravity is represented by gravitational time dilation.

8. Outlook: The twofold time effect

One remarkable feature of the Lorentz-invariant concept for gravity is the twofold effect of rest energy with respect to time:
a) The rest energy of mass particles is producing time in the form of proper time, by increasing the age of the particle (each spin rotation may be considered as a tick on its clock), according to the equation $S = mc^2 \int d\tau,$ and
b) simultaneously, the rest energy is dilating the proper time of other nearby particles (by its gravity which is equivalent with gravitational time dilation). Gravity appears to be a "side effect" of the production of proper time.

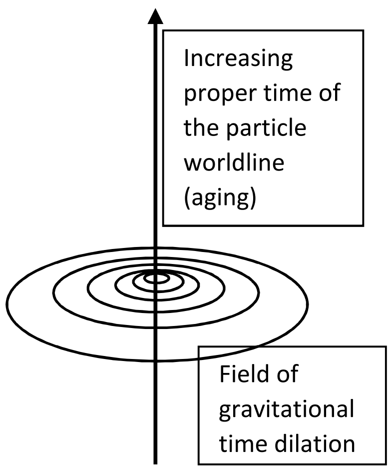

Fig. 7: Gravity as a field of time dilation, surrounding the time generation process of the particle

9. Reference

[1] Robert M. Wald: General Relativity, 1984, p.271