Quantum gravity without additional theory

Compatibility of Schwarzschild metric and quantum mechanics

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The current notion of spacetime is marked by three assumptions which are in contradiction to special relativity and to the Schwarzschild metric, and this is the reason why the quantization of spacetime cannot work. Instead, the key to quantum gravity is the limitation of the notion of spacetime to its actual role, by the means of three insights:

1. Spacetime is not continuous, in particular not in spacelike direction, and thus it cannot be quantized.

2. For the solution of fundamental problems of physics about time, we must consider the notion of proper time instead of the coordinate time of spacetime.

3. Gravitation may be represented by Schwarzschild metric not only as the curved spacetime, but alternatively also as gravitational time dilation in absolute, uncurved space.

From these three insights are following the characteristics of quantum gravity. The result: Gravity appears within quantum mechanics in the form of gravitational time dilation.

0. Introduction

How is gravity represented within quantum mechanics? The problem of quantum gravity has been subject to reflection for 80 years. The approaches for the solution are contradictory, and there seems to be no resolution of the issue. However, at least when regarding the compatibility of Schwarzschild metric and quantum mechanics, the solution is very simple. One could even say that there is no problem at all - it would just be sufficient to rectify the existing concepts of spacetime according to the conclusions which are following directly from the special relativity and from the Schwarzschild metric:

1. The attempts of quantization of spacetime must fail because spacetime is no continuous manifold. The continuity of spacetime is an assumption which does not comply with special relativity, because the latter considers exclusively worldlines but not the vacuum between timelike worldlines. The universe is no fourdimensional spacetime manifold but - in accordance with the principles of quantum mechanics - a threedimensional manifold of space.

2. Time was universal according to Newton's absolute concept. In contrast, the theory of relativity includes two time concepts: One relative, universal concept of spacetime coordinates and one absolute, particle-related concept called the proper time. Although the absolute concept reveals to be the more fundamental concept of time, it is tried to resolve physical problems concerning time with the relative time concept of the coordinate time of spacetime. This cannot work.

3. The space in quantum mechanics is absolute, and it is not curved by gravitation. For this reason, the model of gravitation as curved spacetime may not apply in quantum gravity. However, it will be shown that gravitation may also be represented as mere gravitational time dilation in uncurved space. And now, all of a sudden, everything fits together.

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1. Impossibility of quantization of spacetime due to the lack of continuity

In the year 1908, Minkowski gave a moving lecture on space and time. Based on his insinuations which were not proven but rather seemed to be illustrating complements[1], the assumption of a continuous fourdimensional spacetime manifold emerged.

The unsuccessful attempts of the quantization of spacetime (e.g. by foliation) are based on this assumption of continuity. But such assumption is not required neither by special relativity nor by Schwarzschild metric, quite the contrary, from special relativity we can derive directly that there is no continuous spacetime manifold.

1.1 No continuity in the vacuum between mass particles

The problem is that special relativity does not deal with vacuum but with worldlines.

Special relativity may be represented by:

- the two postulates of special relativity

- *In all inertial frames of reference the same physical laws do apply.*
- *Light is propagating - from the point of view of all inertial frames of reference - with the speed c.*

- the equations of the Lorentz transformation

$t' = \gamma(v)\,(t - \frac{vx}{c^2})$ $\qquad$ $x' = \gamma(v)(x - vt)$ $\qquad$ $y' = y$ $\qquad$ $z' = z$

- the proper time equation

$$d\tau = \frac{1}{\gamma(v)}\,dt$$

Both postulates refer - according to their terms - only to inertial frames of reference (mass particles) and to processes which are happening at the physical speed limit c.

The Lorentz transformation and the proper time equation, which are both deriving directly from the two postulates of special relativity, and which express the contents of these postulates, require a relative velocity v and thus the possibility to define a relative velocity.

The following example shows the consequences of the requirement of the possibility to define a relative velocity:

[1] "In order to leave nowhere a gaping void, we imagine to ourselves that something perceptible is existent at all places and at every moment. In order to avoid using the words matter or electricity, I will use the word substance for this 'some thing'. "**[1]**

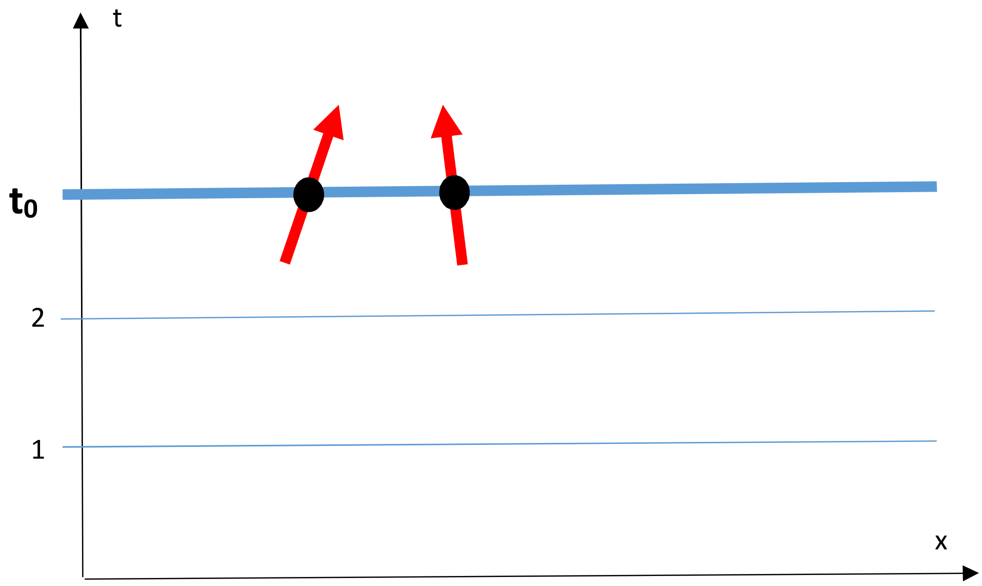

Fig. 1: Minkowski diagram with the continuous simultaneity line $t = t_0$

An observer observes two particles in his coordinate system. Both particles are located on the simultaneity line $t=t_0$, and the small gap between both particles is filled with vacuum - the result is a continuous line of simultaneity (the bold horizontal line) between both particles from the point of view of the observer. Spacetime seems to be continuous (fig. 1).

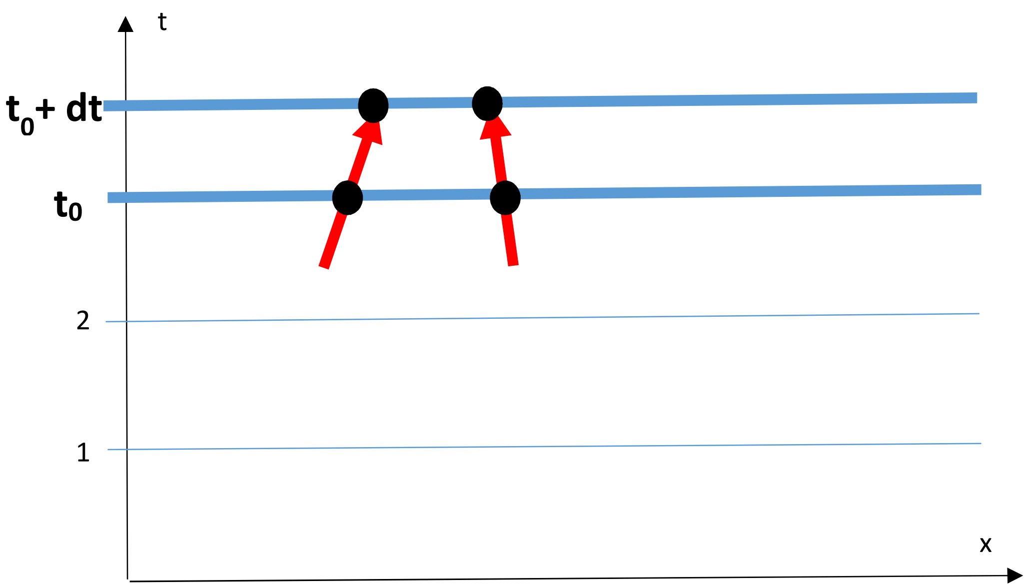

Fig. 2: Minkowski diagram with the continuous simultaneity line $t = t_0+dt$

A short time later the simultaneity line $t = t_0+dt$ is formed which also seems to be continuous: Both particles have changed their position in space according to their relative movement with respect to the observer (fig. 2).

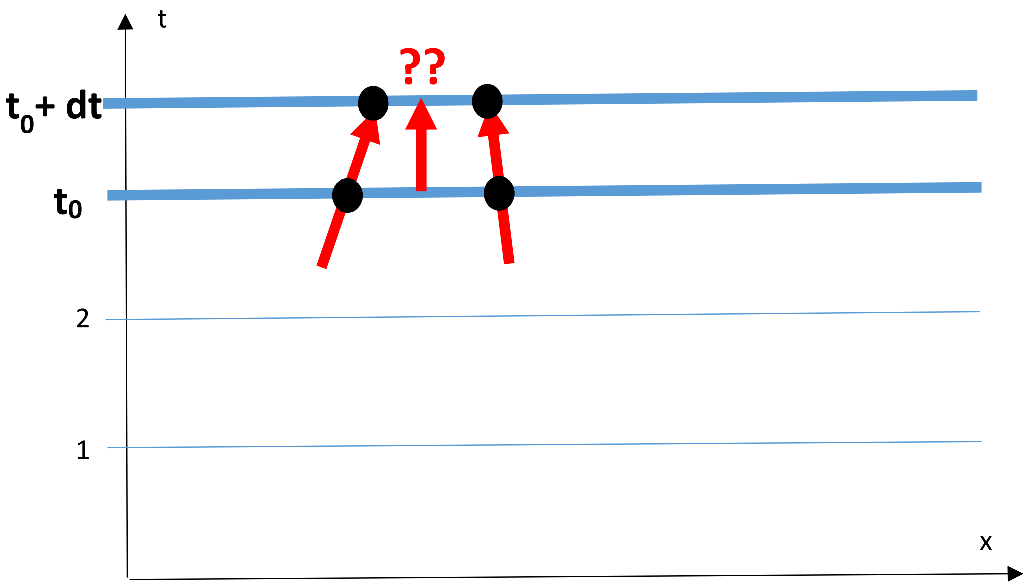

Fig. 3: Vacuum is timeless

However, the appearance is deceptive: The vacuum before cannot be assigned to the vacuum afterwards, because it is impossible to define any movement: Vacuum is timeless. If we would simply assume a standstill of the vacuum without movement, this would lead to a sort of "vacuum ether" which contradicts the first postulate of special relativity. Vacuum is unoccupied space within the spacetime coordinates of a subjective observer (fig. 3).

Special relativity does not even care about vacuum (reserved to quantum physics and cosmology), the spacetime consists of the totality of all worldlines at the exclusion of vacuum.

This fact reveals the real function of spacetime: Spacetime is a fourdimensional mathematical system for the synchronization of the worldlines of mass particles and of lightlike phenomena, by the means of an arbitrary reference system of an arbitrary observer, each observer finding the same particle events (contact of worldlines of particles with other worldlines), whatever is the employed spacetime coordinate system.

The gravitational time dilation of the Schwarzschild metric does not change the preceding conclusions because its only effect is the further dilatation of the ratio between τ and t which depends on the time dilation of special relativity. This dilatation factor of the gravitational time dilation cannot apply in the vacuum because of its lack of time evolution.

1.2 No definition of a time evolution of vacuum by the lightlike propagation of fields

One could suggest that the lightlike propagation of fields which takes also place between mass particles in the vacuum could define a time evolution of vacuum.

But this is not possible. This would imply a lightlike time evolution of vacuum. However, more than one field could be propagating through the same considered vacuum point. Two fields with opposite direction of propagation would provide a contradictory lightlike time evolution of the vacuum point (fig. 4):

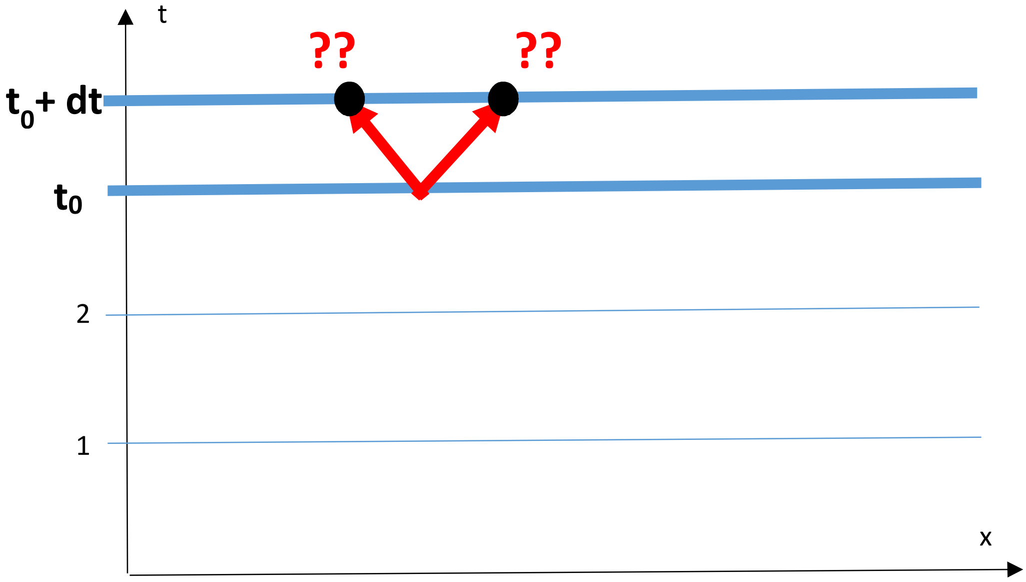

Fig. 4: Lightlike propagation of fields in vacuum

Conclusion: The fourdimensional spacetime is no continuous manifold. On the one hand, spacetime is the total of all worldlines (including all particle events). On the other hand, it is a relative coordinate system where each plane of simultaneity is continuous. However, as it was shown above, this continuity of the coordinate system does not have any equivalent within the real world.

By consequence, the fourdimensional spacetime manifold must be replaced by absolute concepts for time and for space:

- The fundamental time concept of the proper time of particles (see below section 2)
- The threedimensional manifold of absolute space, and we will show that the spacetime curvature by gravity is no obstacle for this concept.

These two concepts are compatible with quantum mechanics and they are indicating the way to quantum gravity.

2. The proper time as fundamental time concept , with the twofold concept proper time - coordinate time

2.1 Coordinate time must be derived from the more fundamental notion of proper time

Starting point is the proper time equation of special relativity,

$$d\tau = \frac{1}{\gamma(v)}\, dt$$

completed by the proper time equation of the gravitational time dilation

$$d\tau = \sqrt{1 - \frac{2GM}{c^2 r}}\; dt$$

which derives directly from the Schwarzschild metric.

The key question is: From an axiomatic point of view, which time concept is the more fundamental concept, coordinate time dt or proper time dτ? The answer to this question is surprisingly clear and results from the definition of proper time:

"The time measured by a clock following a given object".[2]

This definition of proper time does not refer to spacetime but only to the object, the particle. Each particle follows independently its own proper time frequency which depends of the local gravity and the speed of the particle. The mass particle produces proper time which subsequently may be observed in the form of coordinate time:

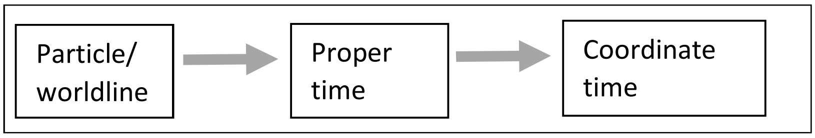

Fig. 5: Proper time as a product of objects

Conclusion: The proper time of the individual particle reveals to be the **external foundation** of the pseudo-Riemannian coordinate system:

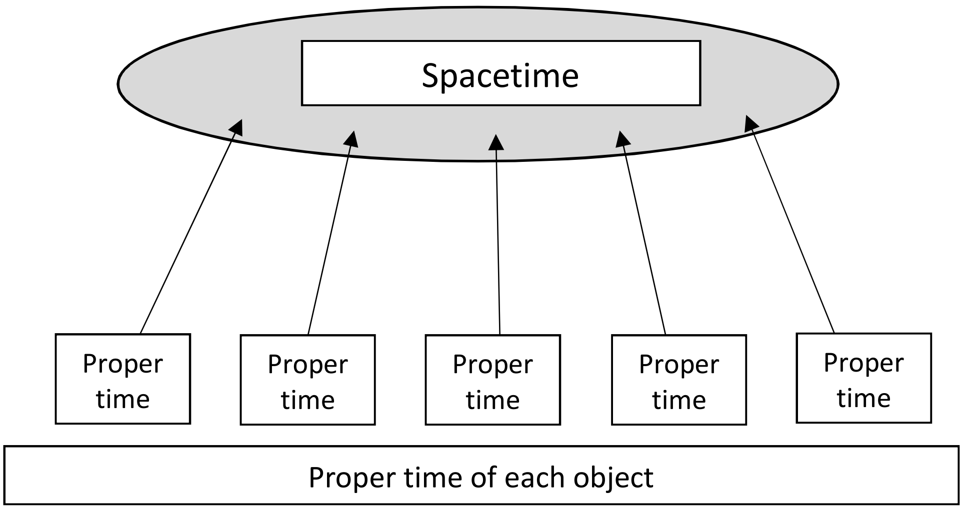

Fig. 6: The proper time of each particle as external foundation of spacetime

As a consequence follows the fundamental character of proper time:

As proper time is the more fundamental time concept, for fundamental physical questions on time we must refer to the concept of proper time and not to coordinate time.

2.2 The rule of timelessness

The first application of this principle is the rule of timelessness of the universe. For this purpose, we consider three important constituents of the universe:

1. Mass particles are producing proper time,
2. The proper time of lightlike phenomena is zero ($\tau = 0$, see below 2.3),
3. No proper time is defined for the vacuum between mass particles (see above section 1).

Only from proper time (including the zero proper time of lightlike processes) the coordinate time of spacetime can be derived. All processes of quantum mechanics for which no proper time has been expressly defined are timeless.

2.3 Time symmetry of lightlike phenomena

Another important application of this principle concerns lightlike phenomena such as fields:

According to the proper time equation, the proper time of phenomena propagating at speed of light is zero.**[3][4][5]** If we apply the principle that we must not refer to coordinate time but to proper time for fundamental questions, the result is the time symmetry of all lightlike phenomena. By consequence, in quantum mechanics all problems of lack of time reversibility of lightlike processes cease to exist.

2.4 Description of proper time as the time frequency of the objects

The proper time of mass particles shows that each particle "lives" according to its own time frequency. This does apply also to non-relativistic processes. It is obvious that the differences for non-relativistic processes are extremely small, but they reflect exactly the structure required by special relativity, in contrast to the Newtonian conception of the universe: Spacetime consists of individual worldlines without spacelike continuity.

Example: A prisoner is aging more rapidly than a shuttle bus driver:

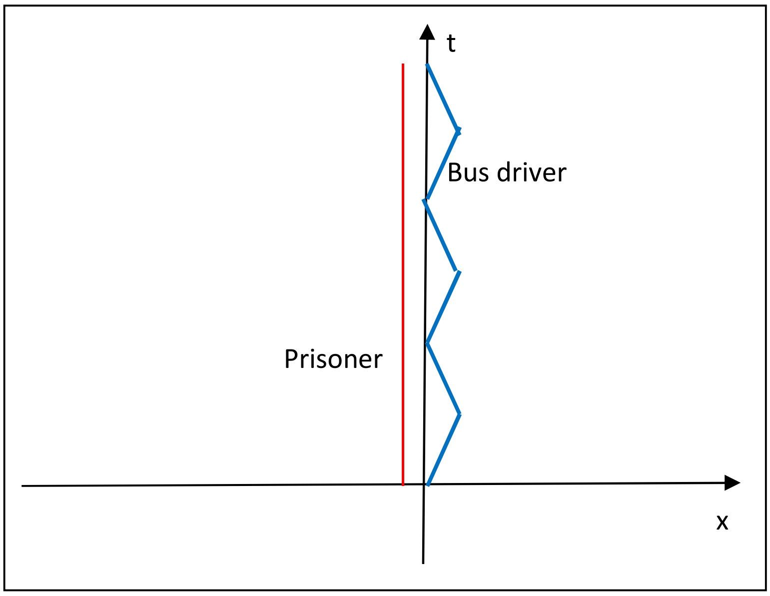

Fig. 7: Twin paradox at low velocities

Each particle of the universe has its own "pulse beat" and exists in its own time.

We are observing particles by the means of the coordinate time of our own Minkowski diagram. A Minkowski diagram does not show proper time. However, we may calculate proper time and inscribe it as shown below as a "pulse beat" frequency, symbolically and as an additional information. The pulse beat shows the time units which are elapsing.

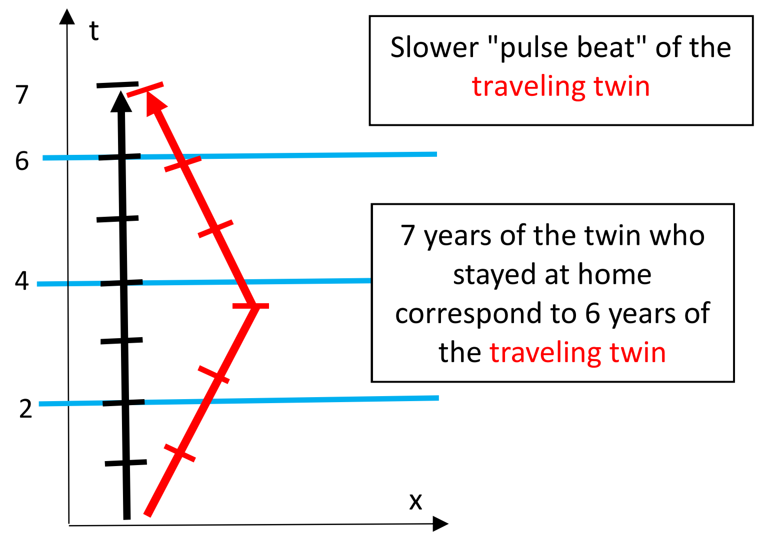

Fig. 8: Twin paradox with proper time "pulse beat"

By the means of this combined representation of coordinate time and proper time we may now provide a schematic view of the particles of the universe:

Quick particles and also particles exposed to high gravitation have a slower pulse beat, they are aging slower.

For this purpose, coordinate time and proper time have complementary functions: Coordinate time permits the representation of several particles (and even the whole visible universe) in one scheme. In contrast, proper time informs about the real aging frequency of each particle.

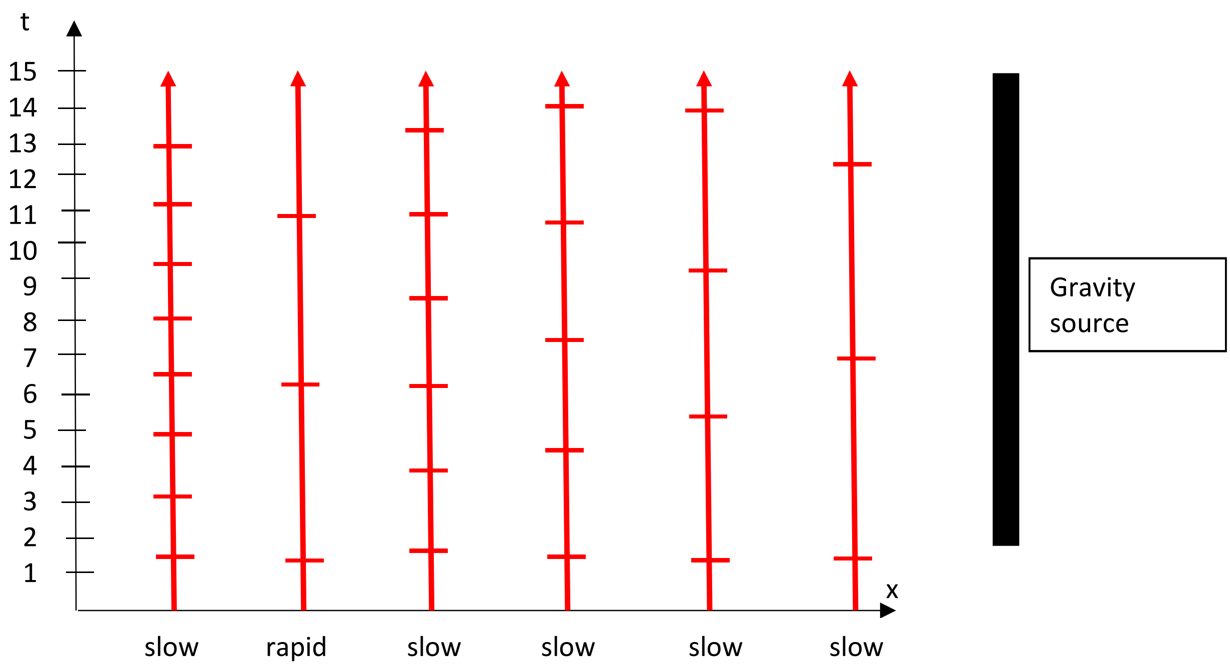

Fig. 9: Minkowski diagram with 5 slow and one rapid particle, more or less near to a gravity source, with additional inscription of the proper time frequency of the particles

3. Curved spacetime in uncurved space

The missing manifold character of spacetime shown above in section 1 (and also quantum mechanics) require the existence of a threedimensional space manifold. However, the curved spacetime of the Schwarzschild metric seems to exclude any threedimensional space manifold.

So, is there an error in the explanations above, or is there a way to describe the Schwarzschild metric in a flat space manifold which is independent of time?

The answer is surprisingly clear and simple. For this, we consider first the Schwarzschild metric of the curved spacetime in a two-particle universe:

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

Now we denote the gravitational time dilation with C, and the equation of the gravitational time dilation of the clock of a particle in a gravity field with reference to a far-away observer is:

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

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

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

and we compare this equation with the equation of flat Minkowski spacetime **[6]** :

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

We see that the curvature by gravity is exclusively a function of time dilation:

dt becomes *Cdt* and *dr* becomes $\frac{dr}{C}$.

By consequence, gravity may be represented in flat space as mere time dilation.

With the representation of gravity as gravitational time dilation in flat space instead of in curved spacetime, the description of the movement of the mass particles in the gravity field changes: In curved spacetime, the movement is caused directly by the curvature of spacetime. In contrast, in the representation of flat space the movement is caused by the tendency of particles to maximize their own time dilation. Both views are equivalent.

As gravity is mere time dilation, it may also be described within quantum mechanics where the time parameter is classical. This fact clears the way to quantum gravity.

4. The seven features of quantum gravity

Preliminarily, here is a simple scheme with features of traditional quantum mechanics:

- Absolute space
- Absolute time (laboratory clock)
- Two quantum systems including mass particles
- One gravity source whose effects on quantum mechanics were not clear up to now.

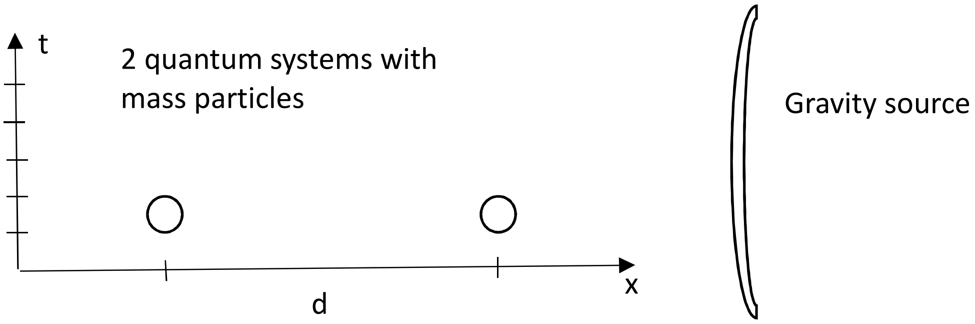

Fig. 10: Scheme with some features of traditional quantum mechanics

Here are the seven fundamental features which are characterizing quantum gravity in an exhaustive way:

Feature 1/7: Threedimensional space as universal manifold

In section 1 it has been shown that there does not exist any continuous fourdimensional manifold. The universe of quantum gravity is a threedimensional space manifold which is not curved by gravity.

Feature 2/7: Rule of timelessness

In section 2 it has been shown that for fundamental questions of physics on time we must refer to the notion of proper time. Proper time is a particular characteristic of particles. That means that time is not universal, but it is limited to processes for which a proper time is expressly defined. All other processes of quantum mechanics are timeless.

Feature 3/7: Time symmetry of lightlike processes

As proper time of the propagation of fields and of other lightlike processes is zero, these processes are time symmetric. Once more, the principle must be applied that for fundamental questions we must refer to proper time and not to coordinate time.

Feature 4/7: Production of proper time by mass particles

Proper time is produced by mass particles, and coordinate time derives from the produced proper time and from the zero proper time of lightlike phenomena.

Feature 5/7: Twofold time concept

The absolute time concept of quantum mechanics must be replaced by two complementary time concepts: a) the measured coordinate time (laboratory clock) corresponding to the old concept and b) the respective proper time of each particle and each lightlike phenomenon.

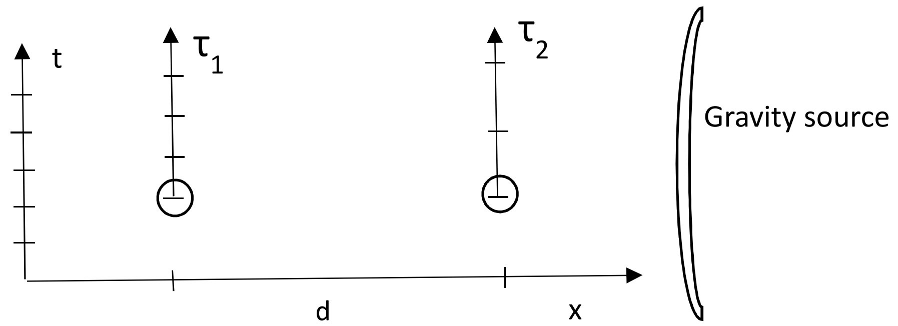

Fig. 11: Quantum gravity: Two quantum systems and one gravity source

Feature 6/7: Calculation of proper time from the measured coordinate time

Instead of by quantization of spacetime, quantum gravity must happen on particle level: All quantum systems must follow their own respective proper time frequency ("pulse beat") which may be calculated from the coordinate time of the laboratory clock and from data on velocity and gravitational field strength.

Feature 7/7: Gravity attraction as the tendency to maximize the own time dilation

Schwarzschild metric in the uncurved space of quantum mechanics: According to the Schwarzschild metric, the gravity described as curved spacetime is identical with the gravitational time dilation in uncurved space. The attraction of gravity in flat space consists in the striving of particles in the gravity field to maximize their own gravitational time dilation (with respect to the other particles).

5. References

[1] Hermann Minkowski: Space and time, Bulletin of the Calcutta Mathematical Society, Volume 1, pp. 135-141

[2] Landau/ Lifshitz, The Classical Theory of Fields, 1951, § 1.3. Proper time, p.8

[3] Wolfgang Rindler, Relativity, Special, General, Cosmological, 2001/2006, 3.5 Light cones and intervals

[4] Sexl/ Urbantke: Relativity, Groups, Particles, Springer-Verlag Wien 1992/2001, 4.3 Photons: Doppler effect and Compton effect

[5] James B. Hartle: Gravity, Addison Wesley 2003, p.91

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