Quantum gravity without additional theory

Compatibility of Schwarzschild metric and quantum mechanics

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General relativity and quantum mechanics both have been confirmed by experiments. In order to unify them, a new theory of quantum gravity is searched, but without success.

In the following it will be shown that quantum gravity does not require any kind of new theory, and in particular that Schwarzschild metric and quantum mechanics are not contradicting each other, but fitting together harmoniously. The problem is that our current perception of spacetime is based on 3 wrong assumptions which are not complying with general relativity and obstructing our view to the solution. The following 3 corrections are following directly from the two postulates of special relativity and from Schwarzschild metric:

1. Spacetime is no quantizable continuous manifold.

2. For the solution of fundamental problems of physics about time, we must refer to the fundamental parameter of proper time instead of coordinate time.

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

From these 3 insights are following the 7 basic characteristics of quantum gravity. The result: Gravity acts within quantum mechanics in the form of gravitational time dilation.

0. Introduction

110 years ago, Minkowski's spacetime replaced Newton's concepts of absolute space and time. Based on Minkowski's ideas, the assumption of an R^4 manifold replacing the R^3 space manifold seemed to be the natural consequence, and since then, our concept of the universe became 4-dimensional.

In the following it will be shown that the assumption of a 4-dimensional manifold is in contradiction with the two postulates of special relativity. Furthermore, it is not compatible with quantum mechanics. For quantum gravity, we must derive 3 things from special relativity and from Schwarzschild metric:

1. Spacetime is no continuous manifold, and thus it cannot be quantized (section 1).

2. The absolute time concept: When we try to resolve fundamental problems of physics about time (such as quantum gravity), we must refer to the parameter of proper time of the particles instead of the coordinate time of spacetime (section 2).

3. The absolute space concept of a flat R^3 space manifold: Gravitation may be represented by Schwarzschild metric not only geometrically as the curved spacetime, but alternatively also as gravitational time dilation in absolute, uncurved space (section 3).

These absolute concepts for time and space are compatible with quantum mechanics, and gravity is acting within quantum mechanics in the form of gravitational time dilation (see the 7 characteristics of quantum gravity, section 4).

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

In the following, 5 different approaches are showing independently that the manifold character of spacetime has no foundation:

a) The manifold character of spacetime is a mere assumption, it cannot be derived from general relativity

In the year 1908, Minkowski gave a groundbreaking lecture on space and time. In his lecture he introduced the assumption of the manifold character of spacetime:

"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]**

Thereafter, nobody seems to have minded in the last 110 years that there is no evidence for this assumption although it is the crucial obstacle to the harmonization of general relativity and quantum mechanics.

b) Vacuum is not defined in special relativity

The two postulates of special relativity say that 1) the laws of physics are the same in all inertial reference frames, and that 2) speed of light is measured with the same value c in all inertial reference frames.

Manifestly, both postulates are treating inertial reference frames (and also lightlike phenomena), but not the vacuum.

c) Vacuum between worldlines is not defined

The vacuum is defined in quantum physics and possibly in cosmology (in the form of dark energy), but vacuum has no place in Lorentzian spacetime concepts with light cones such as special relativity or the Schwarzschild metric.

In order to show this, we consider a Minkowski diagram of an arbitrary observer with two simultaneity lines. It seems that the simultaneity lines are perfectly continuous, and there seems to be no kind of problem to slice spacetime into spacelike hypersurfaces.

Fig. 1: Minkowski diagram with two continuous simultaneity lines

Now we consider two particles in spacetime, each of them has its well-defined position and velocity.

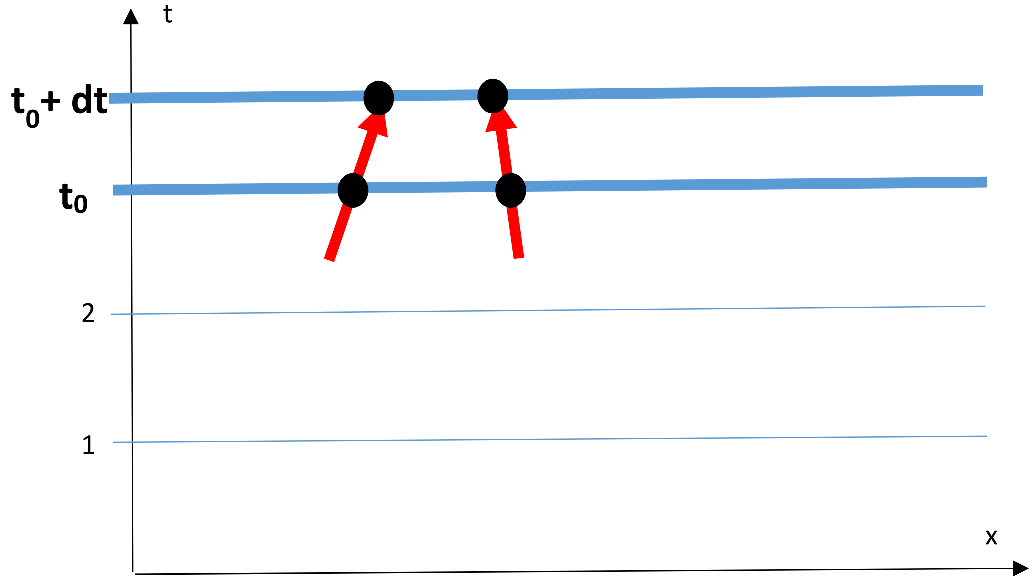

Fig. 2: Two particles with well-defined worldlines

The problem appears if we try to consider some vacuum point between the two worldlines of the two particles. The vacuum point has no time evolution. It cannot go straight upwards in time direction, because this would suppose a preferred observer, a vacuum point has no worldline, that means that it is just void between the worldlines - this confirms that vacuum is not defined by special relativity.

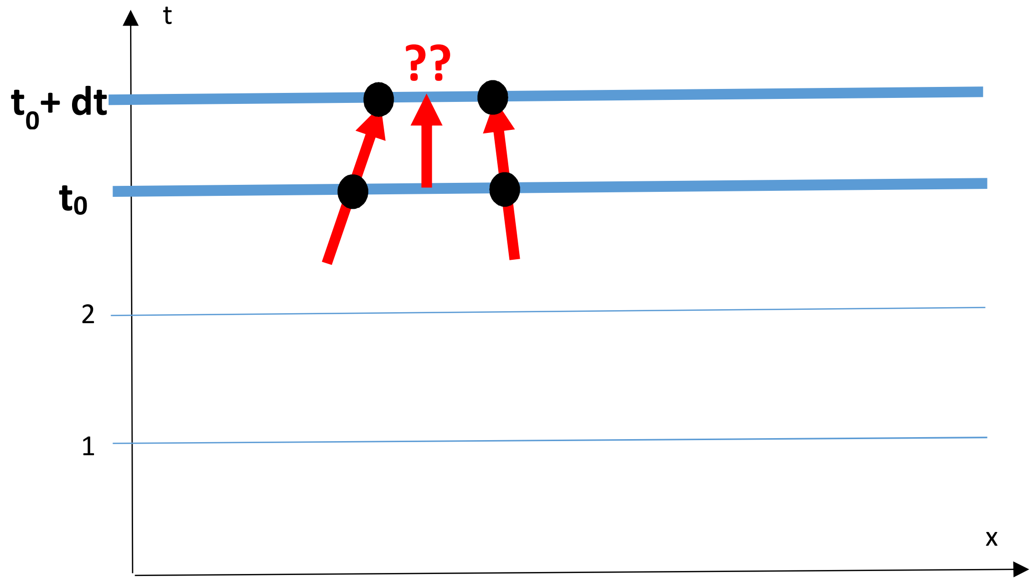

Fig. 3: Vacuum is timeless

The problem is a different one for lightlike phenomena.

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):

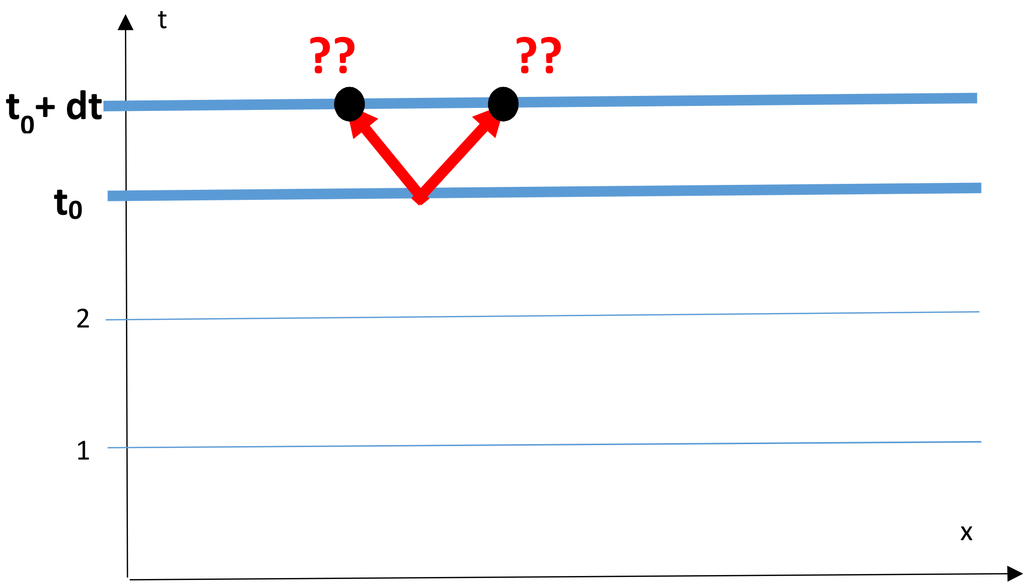

Fig. 4: Lightlike propagation of fields in vacuum

d) Observation and reality

In the last subsection c) we saw that the continuous lines of simultaneity correspond to the observation of the observer the Minkowski diagram is belonging to. We can say in a general way that Minkowski diagrams, and more generally, spacetime manifolds, correspond to what an observer is observing, but they do not correspond to reality. These observations are relative, i.e. the spacetime manifold of another observer will be different, each observer has his own vision of the universe. The reality of the universe is described by its absolute values such as the spacetime intervals and the proper time of the particles (see section 2). Another example for absolute values is the "fact that a particle event happened": Even if observers do not agree on the coordinates of a particle event, they will agree on the fact that the particle event happened. And later (see section 3) we will see that there is an R^3 manifold providing absolute space coordinates.

e) Square roots of negative numbers

The problem of the missing continuity of the spacetime manifold should have appeared when it was tried to define intervals in fourdimensional spacetime - but fatally, in order to save the manifold character, an unclear situation was accepted which masked the reality:

Two different metric signatures (-,+,+,+) and (+,-,-,-) are coexisting in the pseudo-riemannian metric, and sometimes the spacetime interval is defined as a squared interval only, avoiding the extraction of the square root. All this is masking the fact that the root function of the spacetime interval has real and imaginary solutions, but both solutions are currently considered as physical values - spacelike and timelike intervals.

We will see below in section 2 that timelike spacetime intervals (the proper time) are of fundamental importance for spacetime. However, if we consider timelike intervals as real values, that implies that we must assign imaginary value to all spacelike intervals. It is mathematically not possible to assign real values to both kinds of intervals - and also physically there is no justification.

Conclusion:

The fourdimensional spacetime of special relativity is no continuous manifold, it may be defined as the set of all timelike worldlines (including all particle events), and vacuum points are not part of spacetime.

The apparent continuity of spacetime refers to relative observation. The R^4 coordinate system of an observer is perfectly continuous, and any arbitrary transformation to another observer will yield a different continuous R^4 coordinate system. However, these coordinate systems are always observation only, and they do not correspond to a real manifold. The key to quantum gravity is to go beyond observation, and to analyze the underlying observer-independent reality. Coordinates and tensors may transform from one observer to the other, but they are all based on an underlying absolute, observer-independent concept of time and space:

- The absolute, local time concept of proper time (see below section 2)
- The R^3 manifold of absolute space, and we will show that the spacetime curvature by gravity is no obstacle to this concept (see below section 3)

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

2. 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 rest energy of mass particles produces proper time which subsequently may be observed and synchronized in the form of coordinate time:

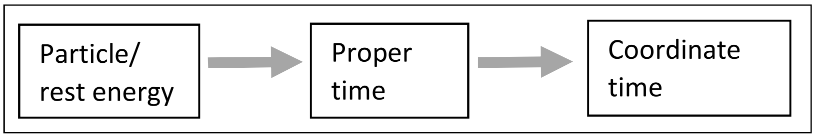

Fig. 5: Rest energy at the origin of time production

Proper time is time before time dilation, and coordinate time is time after time dilation. 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.

Two examples for this principle are the rule of timelessness **(section 2.2)** and the time symmetry of lightlike phenomena (**section 2.3)**

2.2 The rule of timelessness

One 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).

The coordinate time of spacetime can only be derived from the proper time of physical processes (including the zero proper time of lightlike processes). All physical processes for which no proper time has been expressly defined are timeless. This principle is complying smoothly with quantum mechanics.

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 for fundamental questions we must not refer to coordinate time but to proper time, the result is the time symmetry of all lightlike phenomena, because zero proper time cannot show any time asymmetry. By consequence, in quantum mechanics all problems of missing time reversibility of lightlike processes cease to exist.

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

The Lorentz factor is a function of relative velocity between observer and observed particle, and it is a sort of conversion factor between their respective time t and τ:

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

Similarly, the factor between dt and $d\tau$ in the Schwarzschild metric is a function of gravitation:

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

We see that time dilation is always a factor, and for different observed particles there are different factors. Conversely that means that each particle has its own proper time and its own time frequency, its own "pulsebeat". This conclusion is illustrated in **fig. 6**:

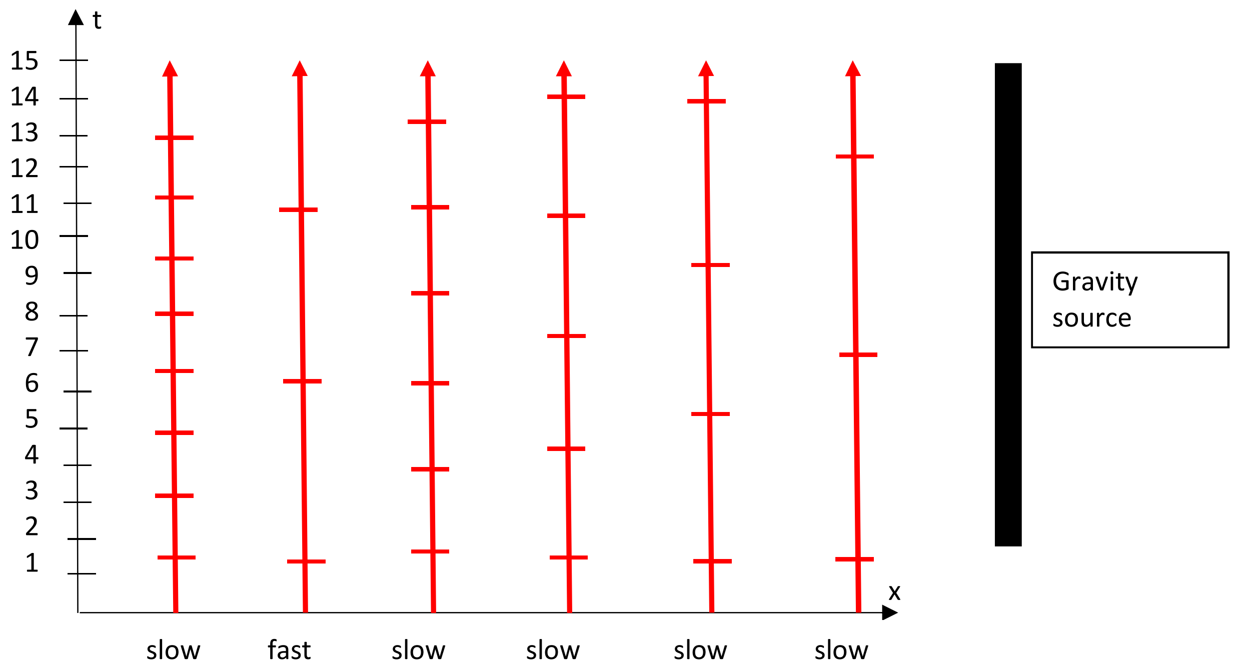

Fig. 6: The proper time pulsebeat in a Minkowski diagram with six worldlines of one fast and five slow particles more or less near to a gravity source (note: the particle movements are not represented, assuming that they are moving in y- or z-direction, and they are at rest with respect to the x-axis)

Normally, proper time does never appear within a Minkowski diagram. But we may add to a Minkowski diagram the frequency marks of the pulsebeat of the particles. By doing this, we may oppose the proper time (the marks on the worldlines) to the coordinate time (the marks on the t-axis). Quick particles and also particles exposed to high gravitation have a slower pulse beat, they are aging slower.

The pulsebeat may also be represented in the context of the twin paradox, as shown in **fig. 7**:

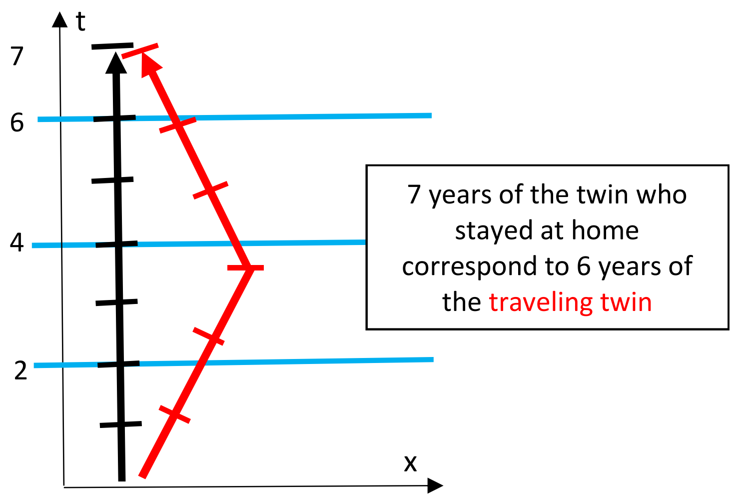

Fig. 7: Twin paradox with proper time pulsebeat

In **fig. 7**, the Lorentz factor of both twins with respect to the observer (following the t-axis) is constant, even for the travelling twin if we assume that the squared velocity of the traveling twin is constant.

From the velocity of the traveling twin we can determine the Lorentz factor and assign time intervals (e.g. years) to the traveling twin which are always longer than the intervals of the twin at home.

Each particle "lives" according to its own time frequency in a timeless environment, and this is a universal principle which does not only apply to relativistic processes, but 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:

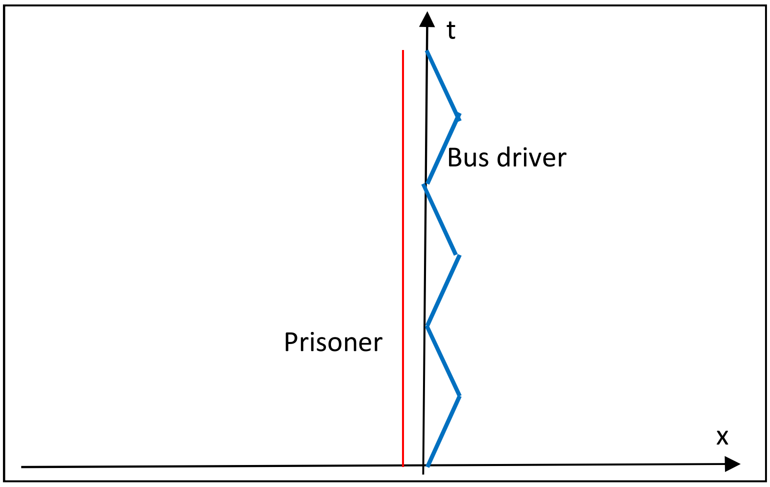

Fig. 8: Twin paradox at low velocities
The pulsebeat of the prisoner is running faster than the pulsebeat of the bus driver.

2.5 The role of spacetime

As we saw in section 1, the spacetime manifolds turn out to be simple coordinates of observers. The coordinate systems may be transformed arbitrarily from one observer to the other, but they do not correspond to some physical reality, they always are just given coordinates.

However, there is an important role left for spacetime. For this purpose, we may imagine two particles in R^3 space without R^4 spacetime, with proper time as parameter of their respective worldlines. Such proper time worldlines do not appear in any Minkowski diagram, and the two proper time worldlines of two particles cannot be represented together. Now let us suppose that the worldlines of two particles are approaching the same point in space. The question is: Will both particles cross this point at the same time, in this case there will be a particle event. Or will they go through the point one after the other, in this case there will be no particle event.

For the answer to this question, we must take into account spacetime (or, alternatively: time dilation, what would be equivalent). Spacetime, even if observer-dependent, synchronizes the two worldlines, which - without spacetime - are not timely related one with the other. And it is exactly this synchronization function which represents the function of spacetime. Instead of being a manifold, spacetime reveals to be an operation (of synchronization of worldlines). Moreover, such an operation is observer-independent, because all observers will agree that there is a particle event (or that the particles are going through the point in space one after the other, without particle event).

The starting point is always the proper time of the particles, and in order to know if there will be a particle event, we must use spacetime.

3. Curved spacetime in uncurved space

The missing manifold character of spacetime shown above in section 1 requires the existence of a threedimensional space manifold. However, the curved spacetime of the Schwarzschild metric seems to exclude any R^3 space manifold.

So, did there happen 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:

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

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

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

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

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

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

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

We see that the Schwarzschild metric and the Minkowski metric are very similar:

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

Three important facts can be deducted:

a) Gravity and gravitational time dilation are equivalent notions

The comparison of the last two equations - the Schwarzschild metric with gravitation and the Minkowski metric without gravitation - shows that gravity is described entirely by the factor "C". Gravity means gravitational time dilation, and gravitational time dilation means gravity.

b) Gravity may be represented in flat space as mere gravitational time dilation.

For this purpose, we must distinguish the two sides of the Schwarzschild equation: On the right side we find exactly the same time coordinate t and the same radial coordinate r as in Minkowski metric - that means that both coordinates are flat. The flat coordinates t and r are submitted to the operations of the Schwarzschild metric on the right side (multiplication with/ division by C etc.), and it is not the "input" t and r on the right side, but the "output" ds, the result on the left side, which is subject to "stretching and squeezing" effects of gravity. ds, however, is the proper time of the particle which is subject to the gravity field.

c) Accordingly, instead of by spacetime curvature, the attraction force of gravity may be described as the tendency of particles to maximize their own time dilation.

When representing gravity as gravitational time dilation in flat space instead of as spacetime curvature, the description of the attraction force must change. There is no more curved spacetime causing directly the attraction of particles. Instead, it is replaced by the tendency of particles to maximize their own gravitational time dilation.

Gravity in the form of gravitational time dilation is a force which is acting exclusively on the time parameter of particles. In quantum mechanics, however, the time parameter is not an operator, it is a classical parameter. Such a classical time parameter may be subject to some modulation such like gravitational time dilation. This fact clears the way to quantum gravity: Gravity in the form of gravitational time dilation modulates the time parameter of quantum mechanics.

4. The seven features of quantum gravity

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

- 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.

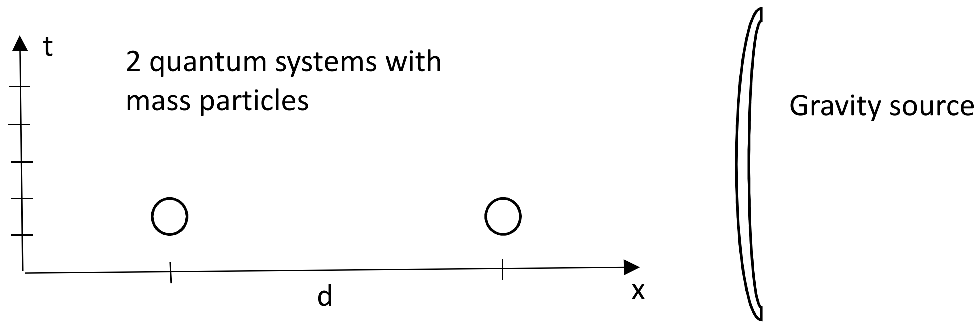

Fig. 9: Scheme with some features of traditional quantum mechanics

The following seven fundamental features 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 R^4 spacetime manifold. The universe of quantum gravity is an R^3 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 parameter of proper time. As a consequence, time is not universal, but it is limited to processes for which a proper time is expressly defined, such as particle worldlines. All other processes of quantum mechanics are timeless.

Feature 3/7: Time symmetry of lightlike phenomena

As proper time of the propagation of fields and of other lightlike processes is zero, these processes are time symmetric (see section 2.3). Once more the principle must be applied that for fundamental questions on time 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 may be derived from the produced proper time of mass particles and from the zero proper time of lightlike phenomena (see section 2.1).

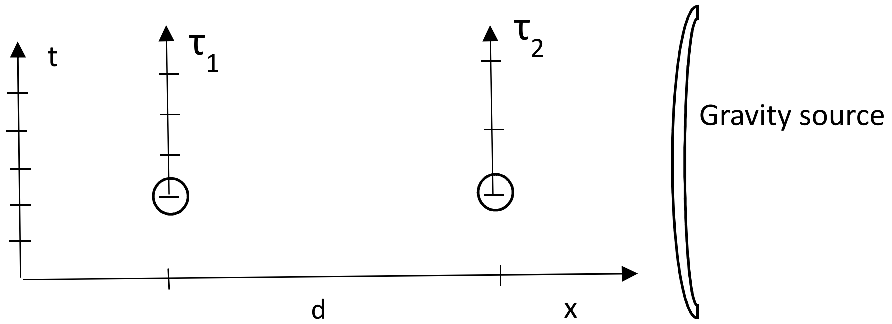

Fig. 10: Quantum gravity: Two quantum systems and one gravity source, with inscription of the respective proper time "pulsebeat" of the mass particles

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) and b) the respective proper time which corresponds to each particle and each lightlike phenomenon.

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

In experiments, the laboratory clock measures the coordinate time. From this measured value can be retrieved the proper time of mass particles, taking into account their respective velocity and the gravitation field strength they are exposed to (time dilation).

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

Traditionally, gravity is described geometrically as an effect of curved spacetime. In a model of uncurved space where gravity is described as gravitational time dilation, there is a description which is perfectly equivalent: The attraction force is generated by the tendency of particles to maximize their own gravitational time dilation. Example: In **fig. 10** we see two particles and a source of gravity. The time dilation of the particle near the gravity source is higher than the one of the second particle. Both particles are striving towards the gravity source in order to increase their own gravitational time dilation. This is how gravity is acting within quantum mechanics.

5. References

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