

The mistaken assumption of a Lorentzian spacetime manifold in quantum gravity

René Friedrich¹, Strasbourg

Current theories of quantum gravity are based on the assumption of a Lorentzian (pseudo-Riemannian) spacetime manifold. However, incredibly, this assumption proves to be a 100-year-old optical illusion, an impossible object: Light rays and light cones in a spacetime manifold confirm its Euclidean metric, because if it were Lorentzian, the length of lightlike phenomena would be reduced to zero. Starting from the observer-dependent Euclidean spacetime, the invariant Lorentzian metric may be retrieved by calculation, however, the Lorentzian metric does not in any way parameterize the spacetime manifold, but only its worldlines and fields. - These concerns have been known informally for nearly ten years (viXra:1612.0056), but they have been disregarded by official research. As a non-physicist, the author argues that the assumption of Lorentzian spacetime manifold should be reviewed by professional physicists on the basis of the objections raised, because in case of their confirmation, this could possibly pave the way to quantum gravity.

1. The misunderstood distribution of roles between Euclidean and Lorentzian metric

The metric of spacetime, is it Euclidean or Lorentzian? The answer can be found in a simple spacetime diagram with a light ray, sketched on a sheet of paper:

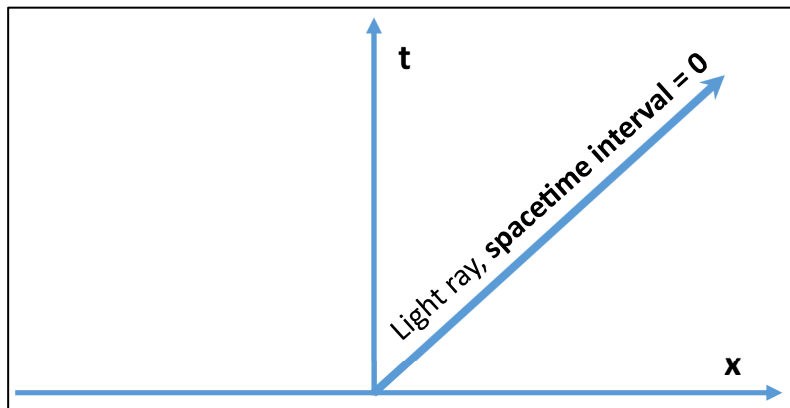


Fig. 1: Spacetime with light rays must be Euclidean

Spacetime with light rays must be Euclidean, just like the sheet of paper on which it is sketched, because if it were Lorentzian/ pseudo-Riemannian, the length of the light ray would be reduced to zero, since it represents a lightlike spacetime interval.

The Euclidean metric is the metric that can be determined using Pythagoras' theorem or directly by diagonal length measurement. It is absolutely indispensable for the representation of spacetime with light cone, but it has no intrinsic physical meaning, as it measures only the distances "on paper" (or in any other kind of spacetime representations).

The Lorentzian metric, in contrast, does not appear in a spacetime manifold. For example, the zero spacetime interval of a light ray is hidden and may only be found by calculation.

¹ rene_friedrich@orange.fr

The crucial insight is the role distribution in two steps: The Euclidean metric is the metric of spacetime, whereas the Lorentzian metric is the metric to be calculated from spacetime.

Consequently, spacetime with its Euclidean metric is only an intermediate step towards the retrieval of the Lorentz-invariant universe: In a first step, an observer observes and measures spacetime (e.g. measuring the spatial distance and the time interval between two events), and only based on this, he can calculate in a second step the underlying Lorentzian metric (e.g. the spacetime interval between both events). Accordingly, spacetime is only a sort of observable interface between the observer and the unobservable reality:

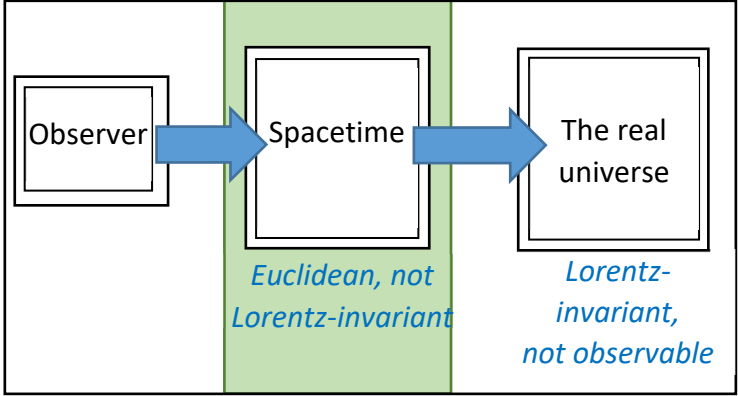


Fig. 2: Spacetime is the observational interface between the observer and the unobservable real universe

Currently, both steps are mixed up: On the one hand, spacetime is considered observer-dependent, but on the other hand, the observer-independent Lorentzian/ pseudo-Riemannian metric is regarded as the metric of spacetime.

Furthermore, the Lorentzian metric cannot be the metric of a spacetime manifold because, as will be shown in the following section, it does not refer to spacelike intervals but only to timelike and lightlike worldlines.

2. The spacetime interval, a law of nature

Hermann Minkowski's great achievement in his lecture "Space and time" was the introduction of the Lorentzian spacetime interval into special relativity. Before, spatial distances and time intervals were known, but no mixed space-time intervals, since the Euclidean metric did not provide meaningful results for space-time diagonals.

Unfortunately, after introducing the Lorentzian spacetime interval, Minkowski apparently felt obliged to build up a Lorentzian spacetime manifold on it, even though this was impossible: After presenting the Lorentzian squared metric which he called "F":

$$"F = c^2t^2 - x^2 - y^2 - z^2" [1],$$

it was obvious that this pseudometric could not be always real, since the equation provided negative squares for spacelike intervals, corresponding to an imaginary metric.

Manifestly, even Minkowski himself had realized that spacelike spacetime intervals were not defined, because, with the intention to arrive nevertheless at a Lorentzian manifold, he forced the result by

introducing the distinction between spacelike and timelike intervals, and by simply reversing the sign for spacelike intervals, with the second, opposite metric "-F":

$$"-F = x^2 + y^2 + z^2 - c^2t^2 = k^2" \text{ [1].}$$

Today's Lorentzian spacetime manifold is uniquely to be credited to this improper artifice (and also to the fact that Minkowski's representation, which, by the way, was not quite as explicit in the original as it is simplified here, was interpreted accordingly and accepted by contemporaries and posterity).

By this, the actual discovery of Hermann Minkowski and Hendrik Lorentz, namely the Lorentzian spacetime interval, had been seriously distorted, neglecting the fact that they had discovered a veritable law of nature: The law of the fundamental relationship between space and time. Exactly this law of nature tells us that it does not apply to spacelike intervals but only to timelike and lightlike intervals. The crucial conclusion is that the Lorentzian metric does not parameterize any spacetime manifold but only timelike and lightlike worldlines and fields. Unfortunately, this insight got lost.

In conjunction with the conclusion from section 1 that the observed spacetime represents only an intermediate step towards the retrieval of the Lorentzian metric, it follows that the universe consists fundamentally of worldlines and lightlike fields, each of them parameterized by its respective proper time. This concept is perfectly compatible with quantum mechanics since there is no need for the quantization of spacetime, because spacetime is regarded as a mere observational interface. Complementary to this, gravity, too, can be represented in accordance with quantum mechanics, without resorting to curved spacetime (see annex 1).

Today, unfortunately, the pseudo-Riemannian spacetime that does not distinguish between the observed Euclidean spacetime and the Lorentzian metric to be calculated is widely accepted, however, the corresponding Lorentzian spacetime interval is one of the most ill-defined, obscure and contradictory chapters in physics: There is a multitude of diverging "conventions" with different signatures and either imaginary intervals or negative squares, every author seems to have his own convention, but despite all these efforts, each of these conventions requires a twofold pseudometric.

One example is the textbook "Gravitation" by Misner, Thorne and Wheeler that uses explicitly two different metrics for the proper time and the space time interval, $+g_{\mu\nu}$ and the opposite metric $-g_{\mu\nu}$:

$$"\Delta S^2 = -\Delta\tau^2 = g_{\mu\nu}(x^\alpha)\Delta x^\mu\Delta x^\nu" \text{ [2],}$$

and thus correspondingly:

$$\Delta\tau^2 = -\Delta S^2 = -g_{\mu\nu}(x^\alpha)\Delta x^\mu\Delta x^\nu.$$

Particularly noteworthy is the equation on the left-hand side, equating a positive square with a negative square, that means: On one side we have the square of a real number, and on the other side that of an imaginary number, in other words: Real equals imaginary, imaginary equals real. This is just the definition of wishful thinking (!).

3. Conclusion

The notion "Lorentzian/ pseudo-Riemannian spacetime" involves two errors, and accordingly there are two ways to refute it: First, it does not distinguish between two steps for the retrieval of the Lorentzian metric (spacetime as the interface between the observer and the Lorentzian metric, see section 1), and

second, it fails to recognize that the Lorentzian metric can refer neither to spacelike spacetime intervals nor to spacetime manifolds, but only to worldlines (see section 2).

This erroneous concept proved suitable for the representation of general relativity, but it is doomed to fail when attempting to develop a theory of quantum gravity.

Annex 1: Gravity without resorting to curved spacetime

Based on Minkowski's Lorentzian metric, Albert Einstein and Marcel Grossmann developed for gravity the concept of curved spacetime that is today considered an integral part of general relativity, even though it is not compatible with quantum mechanics, and even though curved spacetime was originally intended rather as a mere tool for the description of gravity.

In the following it will be shown, based on the Schwarzschild metric, that gravity may be described not only as curved spacetime but also equivalently in the form of gravitational time dilation in absolute, uncurved, threedimensional space.

The Schwarzschild metric, in spite of its fascinating simplicity, is an exact solution of Einstein's field equations, including their effects (Mercury's perihelion precession, deflection of light). Its metric

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

turns out to be simply a combination of the flat Minkowski metric and gravitational time dilation. In order to show this, we denote the gravitational time dilation of the clock of a particle in a gravity field relative to the clock of a potential-free remote observer with the capital letter **C**:

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

Plugging **C** into the equation above, we get a modified form of the Schwarzschild metric:

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

Now we compare this equation with the equation of flat Minkowski metric:

$$ds^2 = -c^2 dt^2 + dr^2 + r^2 (d\theta + \sin^2 \theta d\phi^2) \quad [3]$$

It appears that the Schwarzschild metric and the Minkowski metric are almost identical, and gravitational time dilation **C** is the only difference between curved and uncurved spacetime: Time **dt** is multiplied by **C**, and distance **dr** is divided by **C**. Consequently, gravity can be described entirely without any spacetime manifold, only by gravitational time dilation in three-dimensional, flat space.

References

- [1] Hermann Minkowski: Raum und Zeit (1908), in: Space and Time, Minkowski's Papers on Relativity, Minkowski Institute Press 2012, p. 111
- [2] Charles Misner, Kip Thorne, John Archibald Wheeler: Gravitation, 1973, p. 305
- [3] Robert M. Wald: General Relativity, 1984, p. 271