



Singularities and Breaking Space-Time Around Black Holes: Consequences for General Relativity and Quantum Mechanics and Elements of Black Hole Physics

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Abstract: Our knowledge about space-time around black holes is based on general relativity and it is based on the 4D Minkowski-spacetime. All approaches to describe spacetime around black holes were based on the wrong assumption, that 4D space-time exists everywhere in the Universe and this leads to singularities around black holes. By solving the black hole information paradox with three corresponding theories, we arrive to the conclusion that the time dimension of the Minkowski-spacetime must end at the event horizon. This means that Minkowski-spacetime separates into spatial and time dimensions: spatial dimensions enter the black holes, while the time dimension ends (curved up) at the event horizon. The theory presented in this article explains the singularities and anomalies around black holes and is in line with the major laws of thermodynamics and gravity. The theory explains the limits of general relativity and quantum mechanics around black holes - and it also provides an explanation how we can describe black hole interiors with gravity, strong force and electric charge.

Keywords: General Relativity, Quantum Physics, Dirac Equation, Gravitational-Electromagnetic Interaction, Black Holes, Gravitational-Electromagnetic Confinement, Electromagnetism, Quantum Optics, Einstein spacetime, Spacetime Curvature, gravity, Big Bang, Standard Model of Particles

INTRODUCTION

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By solving the black hole information paradox with three corresponding theories, we arrive to the conclusion that the time dimension of the Minkowski-spacetime must end at the event horizon. This means that Minkowski-spacetime separates into spatial and time dimensions: spatial dimensions enter the black holes, while the time dimension ends (curved up) at the event horizon. The theory presented in this article explains the singularities and anomalies around black holes and is in line with the major laws of thermodynamics and gravity.

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GENERAL RELATIVITY AND QUANTUM MECHANICS ON BLACK HOLES

Since the prediction of their existence by Karl Schwarzschild in 1916, black holes were described as regions of spacetime where time dilation becomes infinitely big at the event horizon and we find a spatial singularity in the centre of black holes with infinite density and infinite curvature of spacetime. General relativity also predicts that within the event horizon time and space swap within the 4-dimensional Minkowski-spacetime. Quantum mechanics [2] also breaks down around the event horizon of black holes due to the collapse of the wave function.

The two singularities predicted by general relativity are:

- A time singularity at the event horizon and
 - A spatial singularity in the centre of black holes.
- A. The time singularity is a result of the time dilation around black holes. The time dilation equation around the event horizon [Eq. 1.]:

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - (v^2/c^2)}}$$

If $v \sim c$ at the event horizon of the black holes, then $\Delta t' \rightarrow \infty$, so the time dilation becomes infinitely big - *leading to a time singularity*.

- A. The spatial singularity predicted by general relativity is a point-like singularity in the center of black holes with infinite density and infinite curvature of spacetime.

This interpretation arises from the wrong interpretation that the Minkowski-spacetime exists within black holes. We observe black holes via direct and indirect observations and we are able to detect gravitational waves after mergers of black holes - we observe that the mass of black holes is not a point-like singularity, but a very dense object resulting from a spherical collapse.

The conclusion is that the 4D Minkowski-spacetime breaks already at the event horizon of black holes. *Within black holes 4D spacetime does not exist, only space with three dimensions, without time. There is no point-like spatial singularity in the center of black holes, but an object as a result of symmetrical spherical collapse.*

THE BREAKING OF MINKOWSKI-SPACETIME AROUND BLACK HOLES

General relativity implies, that spacetime breaks around black holes. This is right as the 4D Minkowski-spacetime indeed breaks into parts around black holes. As we can observe black holes with the 3 known spatial dimensions and we have gravitational wave observations, we have the proof that spatial dimensions do not disappear. So, the only possibility is that *spatial dimensions separate from the time dimension at the event horizon*.

The time dimension stays at the event horizon as described by general relativity: with an infinite time dilation - *time effectively stops at the event horizon*. We can say that the time dimension is curved up on event horizon, with the entropy linked to it - providing an explanation to the black hole information paradox as confirmed by three independent theories [3, 4, 5].

The three spatial dimensions enter the black hole, as spatial and time dimensions separate - so black holes are regions of the Universe with spatial structure, but without time as we know it. As described in Figure. 1.

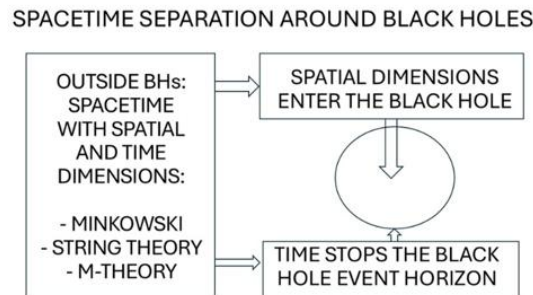


Fig. 1: Separation of spatial and time dimensions at the event horizons of black holes

Roger Penrose [6] correctly identified the possible reasons of a space-time singularity in 1965 (stating that (a), (b), (c), (d) the possibilities:

- a) Negative energy occurs,
- b) Einstein's equations are violated,
- c) The space-time manifold is incomplete,
- d) The concept of space-time loses its meaning at very high curvature -possibly because of quantum phenomena,

The right answers are (b), (c) and (d):

- a) Einstein's equations are violated

Indeed, the equation defining the metric of 4D Minkowski-spacetime:

$$ds^2 = -c^2 dt^2 + dx^2 + dy^2 + dz^2$$

when time stops, due to time dilation and disappears, the metric becomes ($t=0$),:

$$ds^2 = dx^2 + dy^2 + dz^2$$

- b) The space-time manifold is incomplete

As the time dimension disappears, while spatial dimensions continue to exist, indeed the space-time manifold becomes incomplete: it disappears as a manifold.

- c) *The concept of space-time loses its meaning at very high curvature - possibly because of quantum phenomena,*

Indeed, the concept of space-time loses its meaning, as the time dimension disappears. There is only space in the interiors of black holes. The reason being partly quantum phenomena [4], but the also the disappearance of the whole time dimension, both at macro level [5].

We need to note that the separation of spatial and time dimensions can be applied for not only Minkowski-spacetime, *but for any spacetime system with a time dimension*: string theory's 9 and M-theory's 10 spatial dimensions [7] would also enter the black holes, separated from the time dimension (different question what happens to the 6 or 7 curled

up dimensions in black hole interiors). The original and corrected diagram of Roger Penrose [6] on spherically symmetrical collapse is presented on Figure. 2.

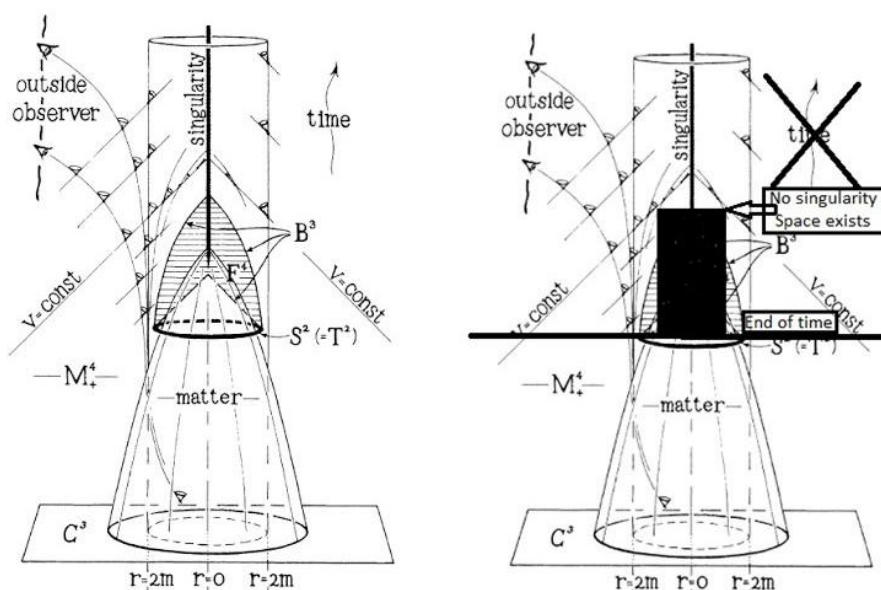


Figure 2: The original (left) and corrected (right) diagram of Roger Penrose on spherically symmetrical collapse (Diagram by R. Penrose - Phys. Rev. Letters, 1965)

QUESTIONS ABOUT THE BLACK HOLE INFORMATION PARADOX AND BLACK HOLE INTERIORS

The mathematical theorem of Goedel states that in every mathematical or logical system we may pose a question where the answer leads out from this logical system. For general relativity and quantum mechanics this question is the black hole information paradox - the key issue in the understanding of black holes.

The black hole information paradox arises from the fact that material falling into a black hole carries entropy, when black holes evaporate through Hawking radiation, only certain properties associated with the black hole, namely its mass, electric charge, and spin, are reflected in the emitted radiation. This contradicts the 2nd law of thermodynamics, that the entropy of a closed system cannot decrease.

The second question which cannot be answered within general relativity or quantum mechanics is the description of the interior of black holes. There is no spatial singularity with infinite density and infinite spacetime curvature in the centre of black holes - since we observe their mass, rotation and via gravitational waves we can get information on their interiors during black hole mergers and near misses.

The classical visualization and presentation of black holes - as presented on Figure 3 - is wrong. The 4D Minkowski-spacetime ends at the point marked, but only the time dimension and the 4D space-time ends there - spatial dimensions continue to exist over this singularity of time, as visualized on the right.

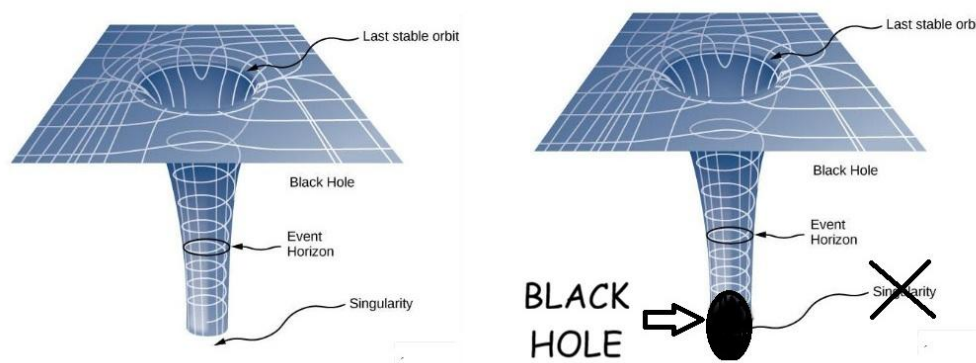


Fig. 3: The classical (left) and modified (right) description of black holes. The classical view of spatial singularity is wrong: only time ends and space-time breaks at the event horizon, space exists within black holes (see the modified view on the right).

SOLUTIONS OF THE BLACK HOLE INFORMATION PARADOX WHERE ENTROPY STAYS AT THE EVENT HORIZON

The black hole information paradox arises from the fact that material falling into a black hole carries entropy, when black holes evaporate through Hawking radiation, only certain properties associated with the black hole, namely its mass, electric charge, and spin, are reflected in the emitted radiation. This conflicts the 2nd law of thermodynamics, that the entropy of a closed system cannot decrease.

The solutions proposed for the paradox can broadly be divided into two groups: those in which entropy enters the black hole and those in which entropy remains associated with the event horizon.

The major problem with the theories where entropy enters the black hole is that the entropy of the presumed quantum state of matter inside the black hole may not account for the information required to preserve the total entropy. This raises the question of how the associated entropy could subsequently be represented in Hawking radiation. Conversely, if entropy remains associated with the black hole until the end of its evaporation, the question arises of how entropy, which is related to the event horizon, changes during the evaporation process while remaining consistent with the second law of thermodynamics.

The most known framework in which entropy remains associated with the event horizon is the holographic principle [Susskind, 1995]. Another research considers the issue from a quantum perspective and proposes that information is encoded on the event horizon of a black hole in a 'quantum memory matrix' [Neukart et al., 2024]. A third approach is provided by the three-dimensional time hypothesis, in which entropy is linked to the first and second time dimensions is being curved onto the event horizon [Cseko, 2025].

So, these three theories approach the black hole information paradox from three directions, as presented on Figure. 4.:

- The *holographic principle* [3] from the direction of *general relativity* ('World as a Hologram').

- The *quantum memory matrix* [4] from the direction *quantum mechanics* (how information is encoded at the event horizon).
- The *three-dimensional time theory* [5] from the direction of *gravity* (gravity bends time dimensions similarly, but in greater extent than spatial dimensions).

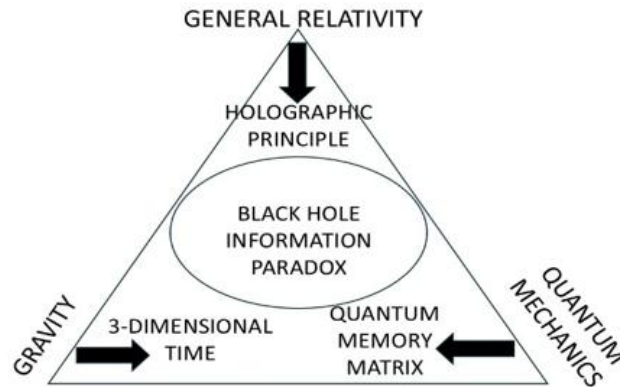


Fig. 4: The three theories proposing that entropy stays at the event horizon of black holes address the black hole information paradox from three perspectives

All the mentioned three theories suggest the same: entropy stays at the event horizon. The here-dimensional time theory provides the explanation: time dimension(s) or the time dimension of Minkowski-spacetime *being curved up at the event horizon by gravity*.

WHAT THIS THEORY ON THE BREAKING OF SPACE-TIME AND DISAPPEARANCE OF TIME DIMENSION DOES EXPLAIN IN PHYSICS?

This explanation of the breaking of Minkowski and other spacetimes at the black holes' event horizons into time and to spatial dimension provides explanations:

1. *General relativity*: confirms the infinite time dilation (from the outside) at the event horizon and a time singularity as described by general relativity.
2. *General relativity*: explains why the 4D Minkowski-spacetime (and other space-time systems) break at the event horizon - due to the loss of the only time dimension. This explains the time and 4D spacetime singularity - from the outside point of view of black holes.
3. *General relativity and quantum mechanics*: Provides an explanation for the black hole information paradox, where entropy stays at the event horizon in line with the holographic principle, the quantum memory matrix theory and the three-dimensional time hypothesis (see point 3.).
4. *Quantum mechanics*: provides an explanation for the collapse of the wave function (as the time dimension disappears). It also in line with the quantum memory matrix theory, which describes the encoding of information at the event horizon at quantum level.
5. *Thermodynamics and entropy*: Is in line with the 2nd law of thermodynamics (entropy of closed system may only increase, as entropy stays at the event horizon) and the

Bekenstein-Hawking entropy [8, 9] of black holes (proportional to their event horizons).

6. *Gravity*: is in line with the black hole observations - black holes exist in 3-dimensional space, as a result of a spherically projective collapse towards the centre of mass, but without a spatial singularity of one point with infinite density.
7. *Weak force and electromagnetism*: provides an explanation why weak force and electromagnetic force (unified by Weinberg [9]) cannot enter black holes: due to their time-related elements. The W and Z bosons' wave function disappears at the event horizon
8. *Strong force, electric charge and gravity*: exist and function within black holes - as they are independent of time, related to quark 'colours', electric charge and mass.

CONSEQUENCES FOR GENERAL RELATIVITY OF THE DISAPPEARANCE OF THE TIME DIMENSION

The consequence for general relativity is clear: since the Minkowski-spacetime breaks at the event horizon, black holes are outside the system described by GR as its reference system collapses.

It also explains why the weird *spatial singularity at the centre of black holes is wrong*: it is based on a wrong interpretation, that 4D Minkowski-spacetime (with a time dimension) exist in the interior of black holes. Since it does not exist there, *there is no spatial singularity in the centre of black holes*. This was presented on the Penrose-diagram of spherically symmetric collapse on Figure 2.

The next major consequence is for *gravitational waves*: if there is no time dimension entering the black holes, *then gravitational waves cannot exist in the interiors of black holes neither*. This deduction is hypothesis now and can be tested by observing ringdown phases after black hole mergers.

CONSEQUENCES FOR QUANTUM MECHANICS OF THE DISAPPEARANCE OF THE TIME DIMENSION

For quantum mechanics, the main issue is the collapse of the wave function [11]. The time-dependent part of the wave function is:

$$f(t) = e^{-iEt/\hbar}$$

Where E is the energy eigenstate value, t is time and $\hbar$ is the Planck-constant. At $t=0$ it will become 1 for all values:

$$f(t) = e^0 = 1$$

This means that the energy eigenvalue is zero and particles are in a static and stationary status.

This collapse has a consequence for the wave-particle duality according to the Copenhagen-interpretation: the wave nature should disappear at the event horizon, *so only the quantum particles of particle nature enter the black hole*.

This means that first generation particles (electrons, protons, electron neutrinos) enter, while second and third generation particles (muon and tau neutrinos, muons, photons, bosons) decay towards the outside at the event horizon.

So quantum particles must pass the event horizon as particles due to gravitational pull or they must decay into radiation towards the outside as described on Figure 5.

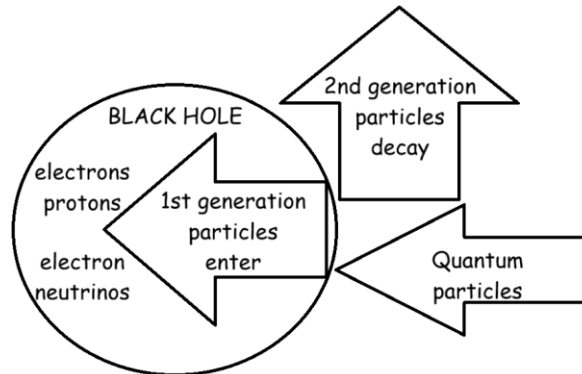


Figure 5: Result of the collapse of the wave function at the event horizon of black holes: 1st generation particles enter - 2nd and 3rd generation particles decay

Other consequences for quantum particles are: the disappearance of quantum entanglement and quantum superpositions. Within black hole interiors there is no uncertainty about positions of particles, so the uncertainty principle of Heisenberg [11] does not apply neither.

Quantum mechanics basically stops at the event horizon, similarly to general relativity. It is reduced to a strong force-gravity-electrostatics system based on quark colours, mass and electric charge. One possible solution for a reduced quantum mechanics is the Wheeler-DeWitt equation [12]:

$$\hat{H}\Psi = 0$$

Where H: The Hamiltonian constraint operator derived from General Relativity, Ψ is the wave function of the Universe. The value 0 demonstrates the Hamiltonian constraint (the total energy of the system is treated as zero). As the time evolution disappears, this equation may replace the Schrodinger-equation within black holes (treating the total energy of the black hole as zero, not that on of the universe).

CONSEQUENCES OF THE DISAPPEARANCE OF THE TIME DIMENSION FOR ENTROPY AND THE DESCRIPTION OF THE BIG BANG BY THE STANDARD MODEL

As space and gravity are related, time and entropy are related (and attached) to each other too. The 'end of time' at the event horizon and the entropy staying there (see point 3.), confirm that entropy and time are close linked and inseparable from each other. If there is no time, there is no entropy and if there is no entropy, there is no time. (Details on the time-entropy relation will be given elsewhere.)

This also means that time emerges with entropy and time ends when entropy ends - as it happens at the event horizon of black holes.

This also means that at the first seconds after the Big Bang - when the quantum-sate matter had no entropy yet, - there was no time.

This is the reason why the Standard Model cannot describe the first 10^{-43} seconds after the Big Bang (Planck-time). General relativity and quantum mechanics give contradictory, nonsensical results for this period.

These nonsensical results emerge again from the wrong interpretation of spacetime: as time did not exist, spacetime cannot be the framework for describing the first period of the Big Bang until time emerged.

Not 10^{-43} seconds are missing to be described, but time is missing as a parameter during the first phase of the Big Bang. (Details on a possible modified description of the Big Bang will be given elsewhere.)

ELEMENTS OF PHYSICS OF BLACK HOLE INTERIORS

The previous points addressing the consequences of loss of time dimension for general relativity and quantum mechanics and on the solutions for the black hole information paradox provide orientation on how the description of black hole interiors could be described. The relation of black hole physics with general relativity and quantum mechanics is presented in Figure 6.

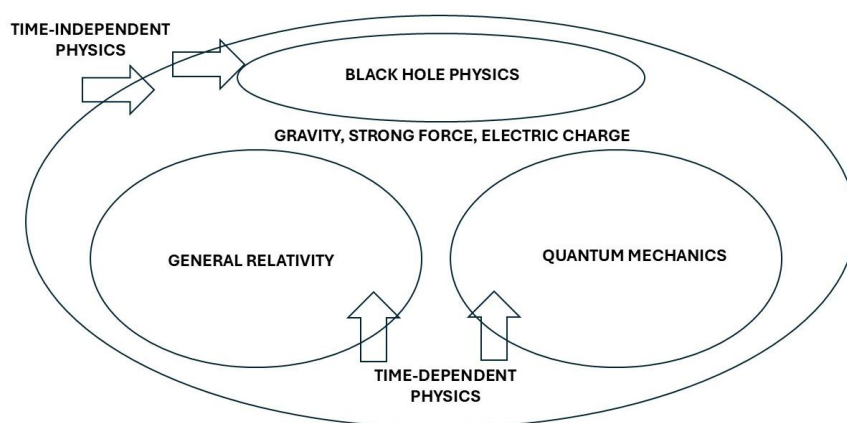


Figure 6: Elements of black hole physics by division into time-dependent and time-independent parts

The major elements of black hole physics are the following:

1. With the loss of the time dimension, we need to eliminate all temporal factors from equations, and we need to end using space-time as reference system.
2. This means general relativity and quantum mechanics end at the event horizon - as their reference framework ends there.
3. The weak force and electromagnetism also end at the event horizon as W and Z bosons must decay towards the outside of the event horizon due to their wave function and electromagnetic field also end due to the loss of temporal dimension.

4. Gravity, electric charge and the strong force exist in the same format within and outside black holes - as mass, electric charge and colours of quarks do not change. Protons and electrons entering the black holes keep their mass, quark colour and electric charge.
5. Quantum gravity by the Wheeler-De Witt equation could describe a reduced quantum state of matter in black hole interiors.
6. Electric charge exists within black holes as it is not linked to time.

CONCLUSIONS

The provided explanation for the breaking of Minkowski-spacetime explains the limitations of general relativity due to the disappearance of the time dimension. It is in line with the description provided by general relativity on the time-like singularity at black holes event horizons. It is in line with the solutions of the black hole information paradox by the holographic principle, the quantum memory matrix and three-dimensional time theories. It is also in line with the 2nd law of thermodynamics (entropy of closed system may only increase, as entropy stay at the event horizon) and the Bekenstein-Hawking entropy of black holes (entropy proportional to their event horizons).

The theory is in line with the black hole observations - black holes exist in 3-dimensional space, as a result of a spherically symmetric collapse towards the centre of mass, but without a spatial singularity of one point with infinite density.

For quantum mechanics the theory provides an explanation for the collapse of the wave function (as the time dimension disappears) - in line with the description of Roger Penrose [6]. It also in line with the quantum memory matrix theory, which describes the encoding of information at the event horizon at quantum level.

The deductions made based on the disappearance of the time dimension and collapse of the Minkowski-spacetime provide an orientation for black hole physics: all time related parameters must disappear thus limiting general relativity, quantum mechanics, the weak force and electromagnetism for the regions outside the event horizon. This explanation confirms that the three physical properties entering the black holes are indeed mass, electric charge and spin.

The theory provides an explanation on why only the first generation particles enter the black holes - due to the collapse of the wave function. The time-less physics theory for black hole interiors is in line with the Wheeler-DeWitt equation.

The theory also explains the incapacity of the Standard Model to describe the first 10^{-43} seconds of the Big Bang: as there was no time and no spacetime, we cannot describe the Big Bang within this framework.

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