

The True Schwarzschild Radius: Explaining Why Matter Falls into Black Holes

Policarpo Yoshin Ulianov

R&D Department, Power Opticks Tecnologia, Av. Luiz Boiteux Piazza, Florianópolis, 88056-000, SC, Brazil

ABSTRACT

The Schwarzschild radius (R_S) has long been interpreted as the “size” of a black hole, often leading to the common but misleading notion that matter falling into a black hole must traverse a spherical surface of radius R_S before crossing the event horizon. However, by applying the Schwarzschild metric to itself, we discover a paradox: at $R = R_S$, the metric predicts a collapse of distance to zero and an infinite spacetime curvature, revealing that R_S is not a true physical radius but rather a collapse threshold defined in pre-black hole geometry.

In this work, we use a thought experiment with a solar-mass object to analyze how spacetime distorts as the object collapses toward its Schwarzschild radius. By constructing a series of concentric shells just above R_S and applying the Schwarzschild metric, we demonstrate that each shell's apparent radius shrinks dramatically sometimes to less than one Planck length. This insight highlights that the Schwarzschild radius marks the boundary at which spacetime itself begins to fold, but it is not the actual, observable size of a black hole.

Furthermore, we propose that in a fully collapsed state, the Planck length grows to match the Schwarzschild radius, creating a consistent spacetime structure that reconciles the metric's behavior at the event horizon. This perspective challenges the notion that time freezes at the event horizon and provides a new understanding of how matter can continue to fall into black holes despite extreme spacetime curvature.

Our analysis suggests that R_S should be treated as a theoretical collapse threshold rather than a physical surface. Recognizing this distinction may deepen our understanding of black holes, the nature of spacetime, and the dynamics of matter falling into these cosmic phenomena.

*Corresponding author

Policarpo Yoshin Ulianov, R&D Department, Power Opticks Tecnologia, Av. Luiz Boiteux Piazza, Florianópolis, 88056-000, SC, Brazil.

Received: June 12, 2025; **Accepted:** June 19, 2025; **Published:** July 11, 2025

Keywords: Black Holes, Schwarzschild Equation, Schwarzschild Radius, Matter Falls into Black Hole

Introduction

In 1915, Albert Einstein presented the field equations of General Relativity (GR), offering a revolutionary way to describe gravity—not as a force, but as a geometric curvature of spacetime [1]. However, these equations were so complex that Einstein initially solved them only for the simplest case: a vacuum solution, known as the Minkowski metric.

The main equation of General Relativity Theory (GRT) is based on two tensors: the Einstein Tensor, $G_{\mu\nu}$, which is related to the curvature of spacetime, and the Energy-Momentum Tensor, $T_{\mu\nu}$, which depends on the distribution of matter and energy. This relationship is expressed as:

$$G_{\mu\nu} = -\frac{8\pi G}{c^4} T_{\mu\nu}, \quad (1)$$

where G is the gravitational constant and c is the speed of light. In the presence of matter-energy, the Einstein Tensor can be defined as:

$$G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu}, \quad (2)$$

where $R_{\mu\nu}$ is the Ricci tensor and R is the Ricci scalar.

About a year later, Karl Schwarzschild introduced the first exact solution to the GRT field equations, considering a static, spherically symmetric, uniform-density sphere with mass M and radius r [2]. By analyzing how increasing the density of such a sphere would affect spacetime, Schwarzschild discovered that for a given mass, there exists a critical radius at which spacetime curvature becomes infinite and even light cannot escape. This radius is known as the Schwarzschild radius (R_S), defining the event horizon of a black hole.

From Eq. (2), the Einstein field equations can be assembled into a set that is generally very difficult to solve. For the simplest case, where a single spherical body of mass M and radius r is placed in otherwise empty space, the solution of Eq. (2) yields the Schwarzschild metric:

$$ds^2 = c^2 \left(1 - \frac{2GM}{c^2 r}\right) dt^2 - \frac{dr^2}{1 - \frac{2GM}{c^2 r}} - r^2 d\Omega^2 \quad (3)$$

where

$$d\Omega^2 = d\theta^2 + \sin^2 \theta d\phi^2. \quad (4)$$

In Eq. (3), when the term $2GM/(c^2 r)$ equals one, the denominator $\left(1 - \frac{2GM}{c^2 r}\right)$ approaches zero, leading to an infinite spacetime curvature a region where not even light can escape the gravitational pull. Additionally, the factor $\left(1 - \frac{2GM}{c^2 r}\right)$ multiplying dt^2 becomes zero, implying that time would theoretically freeze at this radius.

Hence, $\frac{2GM}{c^2 r} = 1$ defines the Schwarzschild radius:

$$R_S = \frac{2GM}{c^2}, \quad (5)$$

which, if $r \leq R_S$, describes a black hole. This defines the event horizon: a spherical shell beyond which nothing, not even light, can return.

According to GR, as an object approaches this radius, space contracts and time dilates relative to a distant observer—a phenomenon similar to the time dilation experienced by objects moving near the speed of light. However, applying the Schwarzschild metric to the radius itself yields an inconsistency: it predicts a distance of zero and infinite spacetime curvature at the event horizon, a point often overlooked in black hole physics.

In this paper, we argue that re-examining the true physical meaning of the Schwarzschild radius—especially after the body collapses to form a black hole—can provide new insights into why matter actually falls into black holes, challenging the misconception that time freezes at the event horizon. We also show that applying the Schwarzschild metric to points infinitesimally close to (but still outside) the Schwarzschild radius reveals critical information about the structure of spacetime near black holes.

We begin by analyzing a thought experiment in which a Sun-mass object is compressed to its Schwarzschild radius of 2,953 m. We then extend this reasoning to the case of an arbitrary black hole. In the limiting case, we demonstrate that the Schwarzschild radius can effectively be compared to a single Planck length, leading to an alternative interpretation: instead of the Schwarzschild radius shrinking toward the Planck length, it is the Planck length that stretches until it equals the Schwarzschild radius.

This challenges Einstein’s original view that mass-energy compresses space, suggesting instead that mass-energy stretches spacetime itself. Because distances in space are counted in multiples of the Planck length, it appears as if space is being compressed. Within this perspective, we show that the time dilation near a black hole horizon is equivalent to the stretching of the Planck time: time does not freeze, but the fundamental time unit grows very large.

This helps explain why objects fall into black holes in a time comparable to what they would take to fall into a non-collapsed object of the same mass. It also clarifies why light, even when traversing regions of extreme spacetime curvature, still travels at a constant speed even as it falls into a black hole.

A Thought Experiment on the Creation of a Solar Mass Black Hole

Imagine a thought experiment in which we observe the formation of a black hole with the mass of the Sun. This choice is helpful because the Sun’s mass generates familiar and comprehensible numbers for the Schwarzschild radius ($R_S \approx 2.953$ km). At first glance, it may seem astonishing that an object the size of the Sun could compress into a sphere just 3 km in radius a factor of hundreds of thousands smaller than its current size. This might lead us to conclude that a solar-mass black hole has an event horizon that is truly a physical sphere with a radius of 3 km, and that any object falling into it would have to traverse 3 km of space to reach the singularity.

However, this interpretation is misleading. Let us consider an initial sphere with the Sun’s mass and its current radius, gradually compressing it under an immense external force. As the radius decreases to, say, 3,500 m, the Sun would still behave like a normal star from the perspective of an external observer no event horizon would yet form, and light would still bounce off its surface. Now imagine that the Sun mass sphere is neat to the Schwarzschild (2953m) being surround with a series of concentric, extremely thin spherical very strong crystal shells (or light grid shells) at radii of 3,500 m, 3,100 m, 2954 m and 2953.001m.

As the sphere continues to compress, it eventually reaches R_S , collapsing into a black hole. Those external shells, still outside the event horizon, would now experience an extreme spacetime distortion. For example, the shell at 3,500 m would appear from the outside to have shrunk to 1,383 m; the one at 3,100 m to 675 m; at 2954 m to 54 m; at 2,953.001 m (just 1 mm above R_S) it would now appear as a sphere of only 1.7 m radius.

Figures 1 and 2 Illustrate this Thought Experiment. Figure 1 shows a pre-collapsed solar-mass sphere surrounded by a laser grid forming a perfect cube, and inside of this cube we can see some strong crystal spherical shells, and the black circle represents the Sun mass body. Figure 2 shows the same grid after collapse, where the Schwarzschild radius still defines the event horizon, but the surrounding spacetime is compressed.

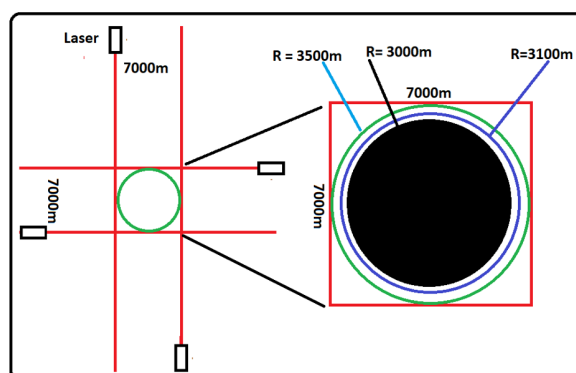


Figure 1: Cube of Light Beams Around a Pre-Collapsed Solar Mass Sphere

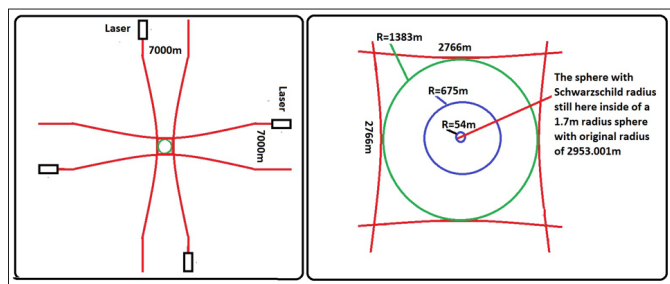


Figure 2: The Same Laser Grid After the Sphere Collapses into a Black Hole

This thought experiment raises a critical question: if a black hole with the Sun’s mass truly had a Schwarzschild radius of 2,953 meters, how could it possibly fit inside an external shell that now appears to have a radius of just 1.3 kilometers? In Figure 2, it is easy to see that a cube of light beams with a side length of 7,000 meters, placed at a distance of only 1,300 meters from the black hole’s center, can still pass through to the other side without falling into the event horizon. How, then, can a Schwarzschild radius of 2,953 meters exist inside a cube with sides only 2,766 meters long?.

Furthermore, if the light cube has an initial side length of 5,908 meters, that dimension shrinks to just 108 meters after collapse. Clearly, a sphere with a radius of 2,953 meters cannot fit inside a cube with sides of only 108 meters. So where is this “2953-meter radius” the distance from the center of the black hole where light cannot enter-if we can still draw a cube of 3.43 meters around the black hole when the original cube had sides of $2 \times (2953.001)$ meters?.

This shows that the 2,953-meter radius exists only in a pre-collapse configuration of space, before the black hole forms. After collapse, spacetime itself contracts, and the Schwarzschild radius becomes comparable to the Planck length, regardless of the black hole’s mass. Clearly, the Schwarzschild radius is not the true “size” of the black hole but rather a theoretical limit associated with a spherically symmetric mass before collapse.

When a black hole forms, the Schwarzschild radius initially defined in flat space-time collapses along with the sphere of mass M and the surrounding spacetime. Consequently, the Schwarzschild radius derived from the mass no longer corresponds directly to the size of the event horizon seen by an external observer but instead marks the point where the sphere collapses to form a black hole.

This explains how a 3-kilometer Schwarzschild radius sphere can fit inside a 1.3- kilometer shell, a 54-meter shell, or even a 1.7-meter shell. After collapse, both the Schwarzschild radius and the surrounding spacetime become distorted together.

This realization challenges the conventional interpretation that a solar-mass black hole has a physical event horizon at 3 kilometers. For example, a laser grid enclosing the original sphere in a 6-kilometer cube would compress after collapse to roughly 379 meters per side. Even if the box initially measured $2 \times (RS + 0.001)$ meters per side, it would compress to just 3.43 meters.

Thus, the Schwarzschild radius is better interpreted as a collapse threshold, not a fixed physical size. In the next section, we generalize this reasoning, showing that, in the limit, the Schwarzschild radius can always be compared to the Planck length. This leads to an alternative interpretation: instead of RS itself shrinking to the Planck length, it is the Planck length that stretches to meet RS. This perspective explains why time does not truly “freeze” at the event horizon and offers a new understanding of how matter falls into black holes, even in the presence of extreme spacetime curvature.

General Analysis of the Schwarzschild Radius in Collapsed Black Holes

The Schwarzschild radius (RS) is defined by the well-known formula:

$$R_S = \frac{2GM}{c^2} \quad (6)$$

Where G is the gravitational constant, M is the mass of the object, and c is the speed of light. This value was originally derived by Schwarzschild in the context of a uniform, spherically symmetric mass distribution-essentially a pre-collapsed object. In Schwarzschild’s derivation, he envisioned compressing a sphere of radius R and mass M until the curvature of spacetime reached a critical threshold where the escape velocity equals the speed of light. At this point, the Schwarzschild radius marks the theoretical limit beyond which nothing can escape: the event horizon of a black hole. However, Schwarzschild’s original calculation assumes a pre-collapse geometry, neglecting the fact that the event horizon is itself a region of infinite spacetime curvature, where the usual concepts of distance break down. Applying the Schwarzschild metric to the Schwarzschild radius itself yields the term $\sqrt{1 - R_s/R_s}$, which evaluates to zero, indicating that the proper distance to the horizon shrinks to zero while the curvature diverges. This makes it clear that RS is not a true physical radius in the fully collapsed black hole, but rather a theoretical collapse threshold; its meaning ceases to be physical at the moment when the original sphere of mass M collapses and becomes a black hole.

To avoid this singular point and explore the structure just outside the event horizon, we can consider a small offset ΔR above R_S , such that:

$$R_E = R_S + \Delta R \quad (7)$$

The proper radius R'_E measured in Schwarzschild coordinates is then:

$$R'_E = R_E \sqrt{1 - \frac{R_S}{R_E}} \approx \sqrt{R_S \Delta R} \quad (8)$$

where the approximation holds for $\Delta R \ll R_S$. Notably, this result shows that as ΔR becomes extremely small (for example, $\Delta R = 10^{-100}$ m), R' also becomes tiny, approaching scales of $\sim 10^{-50}$ m or smaller. According to quantum mechanics, however, the smallest meaningful distance is the Planck length (LP). Thus, the smallest sphere that can exist around a black hole would have a radius approximately equal to LP .

Alternatively, we can interpret this result to suggest that in the fully collapsed state of a black hole, RS never truly reaches zero but instead is bounded below by L_P . Consequently, applying the Schwarzschild metric at this minimal distance yields a maximum possible spacetime curvature. Moreover, the time dilation at the horizon, given by:

$$\sqrt{1 - \frac{R_S}{R_E}} \quad (9)$$

reaches its maximal value consistent with R_E limited to L_P . This leads to a maximum time dilation proportional to $L_P \rightarrow R_S$ and $T_P \rightarrow R_S/c$.

This perspective reveals that the Schwarzschild radius is a theoretical construct defining a pre-collapse condition and is not a direct measure of the event horizon's physical size. In the fully collapsed state, spacetime itself contracts such that the apparent radius of the event horizon approaches the Planck length. Thus, rather than matter being "frozen" at the horizon, matter continues to fall inward, with time and space stretched together in a way that preserves causality and allows for continuous infall into the black hole.

What If Time and Space Truly Behave as a Continuum in the Presence of a Black Hole?

One of the cornerstones of Special Relativity is the unification of time and space into a single entity: spacetime. In this framework, time and space are interchangeable under Lorentz transformations, reinforcing the idea that they are two aspects of the same physical fabric. This concept extends naturally into general relativity (GR), where the mass-energy curves spacetime as a whole. Yet, near a black hole, GR traditionally treats time and space asymmetrically: Time dilates, while space contracts.

But what if time and space truly behaved identically near a black hole? What if the curvature of spacetime at the event horizon causes both time and space to dilate in exactly the same proportion, with the only difference being a factor of c separating their units?.

For $c = 1$ (in natural units), this would imply that time and space dilate uniformly near a black hole, truly respecting their unity in spacetime.

This symmetry could theoretically arise if the fabric of spacetime is stretched by the black hole's gravitational field, which means that Planck length (L_P) increases as one approaches the event horizon. Practically speaking, this would mean that what we measure as distances (counted in multiples of L_P) would shrink, since each individual L_P is itself expanding. The same logic applies to time: the Planck time (T_P) would increase at the same rate, but an astronaut's clock would still tick at one second a total of 1044 Planck time. So, if the Planck Time value increases, the astronaut clock "tick time" or his heart rate would have the same number of T_P to "run". But for an observer with the standard value of T_P , the time of the astronaut (near the de BH) will slow accordingly. Thus, an increase in T_P , near the BH event horizon, would imply that the time itself feels slower, corresponding to the predictions of time dilation in GR.

Interestingly, at the event horizon of a solar-mass black hole, the Schwarzschild radius remains 2,953 meters, but the Planck length may have expanded from 1.61×10^{-35} meters to approximately 2,953 meters, effectively matching the Schwarzschild radius

relative to the pre-collapsed object. This implies that the entire volume of space once inside a sphere with volume $(4/3)\pi R_S^3$ has effectively contracted to a single sphere with volume $(4/3)\pi L_P^3$. In other words, a vast number of Planck-sized regions (originally numbering roughly $(R_S/L_P)^3$) have collapsed into a single Planck-scale sphere defining the black hole event horizon.

In this scenario, the Planck time would also stretch from 10–44 seconds to roughly 9.8×10^{-6} seconds. Thus, if a body initially took two picoseconds to cross the event horizon, this would now correspond to an effective time interval of many trillions of years from an external observer's perspective. However, from within the stretched spacetime, the falling object would experience a finite time, albeit with each tick of the clock now defined by the stretched T_P , making each 'second' much longer.

This thought experiment suggests that the apparent 'freezing' of time on the event horizon is an illusion resulting from the simultaneous stretching of both time and space. In this framework, light always travels at the speed of light, crossing even highly curved regions of spacetime without noticing any change because both L_P and T_P are stretched together. This could reconcile the constant speed of light with the immense spacetime distortions near black holes, revealing a deeper unity between time and space even in the most extreme gravitational environments.

Quantum Frogs Crossing the River

To illustrate how the distortion of space and time generated by the mass of a black hole can be modeled as increases in Planck length (L_P) and Planck time (T_P), we present a simple analogy: Imagine space as a sequence of stepping stones crossing a river, to be traversed by quantum frogs. The presence of mass in one section of the river causes the stepping stones to grow in size, symbolizing that both L_P and T_P double in value. It is easy to see that the frogs would conclude that the presence of mass 'shrinks' space and dilates time, even though the riverbanks remain perfectly parallel and perpendicular to the line of stepping stones. However, from the external viewpoint, the river appears curved and space contracts where the mass distorts spacetime.

In Figure 3, we illustrate this thought experiment that highlights how different observers might perceive time and space differently while crossing the same distance. Two quantum frogs are crossing a river by jumping on stepping stones:

- At the beginning of the journey, the smaller frog jumps on stones with a diameter of 10 cm, while the larger frog jumps on stones with a diameter of 20 cm.
- The smaller frog spends 1 second on each stone, perceiving its size and time normally. The larger frog spends 2 seconds on each stone, but from its own perspective, the stone appears normal in size, and time seems normal.
- Both frogs cover the same physical distance (the river), but each measures different values. The smaller frog measures a river width of 1.20 m and a crossing time of 12 seconds, while the larger frog measures 0.60 m and 6 seconds.
- Both frogs arrive at the opposite shore simultaneously, despite their different perceptions of time and space.
- An external observer sees the riverbanks remain parallel but notes that the presence of mass distorts the spacetime between them, compressing space where the mass is located.

This analogy emphasizes how time dilation and spatial contraction are intertwined near massive objects, demonstrating that despite each observer's subjective perception, they both cross the same

region in equivalent "absolute time" (with adjusted T_P), offering a clear way to visualize the effects of curved spacetime as changes in the Planck length and Planck time can model a distorted space with space distances shrinking and distances in time expanding despite the same growth factor being applied to T_P and L_P values.

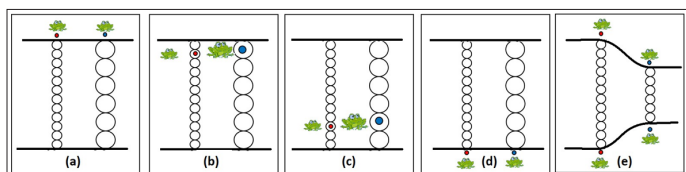


Figure 3: Quantum Frogs Crossing the River. (a) Starting Point; (b) Intermediate Steps; (c) Different Measurements; (d) Arrival; (e) External view Showing Spacetime Distortion due to Mass.

It is worth noting that from the perspective of the quantum frog, both the Planck length (L_P), representing the size of each stone, and the Planck time (T_P). The time the frog spends on each stone before jumping to the next, are constant and immutable values. Because the quantum frog always jumps one L_P in one T_P , it effectively travels at the speed of light, crossing shorter distances in the same total time that another frog takes to cross a longer distance. In this sense, the frog's speed is always constant, just as the speed of light remains constant even in highly curved spacetimes.

If the stone size increases to, say, 1 meter, the frog's time on each stone increases to 10 seconds, ensuring that it still jumps one L_P per T_P . Thus, the quantum frog can "navigate" through paths with stones of different sizes, believing that the steps are all equal and that it is moving in a straight line, even though, from an external perspective, it may be tracing a curved path—just like light always moves at the same speed locally, even though its trajectory may bend in curved spacetime.

Hence, from the frog's point of view, L_P and T_P are absolute constants, and the presence of matter-energy appears to shrink space and dilate time. By stepping out of this viewpoint and recognizing that, in fact, the stone sizes change and L_P and T_P vary together, we gain a powerful perspective that simplifies calculations, yields consistent results, and offers a deeper understanding of the true value of the Schwarzschild radius and the real nature of black holes.

Why do Bodies fall into Black Holes?

Let us consider a solar-mass black hole with a Schwarzschild radius (R_S) of approximately 2,953 meters. Suppose an object is located at a distance of 3,000 meters from the center of this black hole and is moving toward it at a speed of $c/1000$. In flat space, it would take roughly 10 milliseconds to traverse this distance:

$$t = \frac{3,000m}{c/1000} \approx 10ms.$$

However, in the curved spacetime near the black hole, time dilation comes into play. If the local Planck time (T_P) near the event horizon also stretch from 10^{-44} seconds to 9.8×10^{-6} seconds, then the coordinate time required for the object to cross this distance could appear as

$$t' = 0.01 \times \frac{9.8 \times 10^{-6}}{5.39 \times 10^{-44}} \approx 1.8 \times 10^{36}s,$$

which is on the order of trillions of billions of years, suggesting that time 'freezes' at the event horizon, and so, within the normal range of assumptions, the object will never fall into the black hole, not in the lifetime of our universe.

However, let us analyze this geometry differently. If the Planck length (L_P) near the event horizon also stretches proportionally, say from 1.616×10^{-35} to 2,953 m, then the same 3,000 m distance from the center would correspond approximately:

$$\frac{3,000}{2,953} \approx 1.01L_P.$$

An object moving at $c/1000$ would traverse this distance in about:

$$t'' = 1.01L_P \times \frac{T_P}{L_P} \times 1000 \approx 1050 T_P,$$

which, with $T_P = 9.8\mu s$, equals:

$$1050 \times 9.8 \mu s \approx 10ms.$$

This is nearly identical to the initial flat-space time (10 ns) scaled appropriately. This indicates that, although the dilation of time extends T_P , the corresponding dilation of L_P effectively compresses the spatial distance, balancing the overall effect. As a result, the object crosses the region in roughly the same proper time as it would have in flat space, suggesting that time does not truly 'freeze' at the horizon.

Applying this reasoning to a photon falling into a black hole: Although its local clock would appear to slow down as T_P increases, its 'step size' in spacetime (L_P)

simultaneously expands, ensuring that it always travels at the speed of light. For example, in a supermassive black hole (SMBH) where L_P near the event horizon might expand to one light year, and T_P , to one light year divided by c , the photon would traverse this enormous L_P step in one year. Although each step might feel slow from the outside perspective, the distance covered remains vast, maintaining the constant speed of the photon.

Therefore, in this model, both time and space distort in such a way that falling bodies reach the event horizon and the singularity in 'normal' time, as if the presence of the black hole did not fundamentally slow their in-fall. This symmetry explains why the famous 'freezing' of time on the horizon is an illusion. It also explains why light traveling near a black hole, even in highly curved regions, always moves at c , the spacetime distortions stretch both time and space together.

This approach not only reconciles the behavior of matter and light in the strong-gravity environment of a black hole but also recovers the familiar Schwarzschild metric and other GR predictions. It highlights that time and space are two sides of the same coin, even in the presence of a black hole, and demonstrates why bodies naturally fall into black holes within normal timescales, without requiring billions of years to cross the event horizon.

The Ulianov Black Hole Model

The Ulianov model of black holes proposes that the vacuum is composed of a perfect liquid, called HUPL (Higgs Ulianov Perfect Liquid), which contains Higgs bosons under extremely high pressure (Planck pressure), forming what is known as the

Higgs Ulianov Ocean (HUO) [3,4]. This medium is fundamental to understanding how spacetime itself can respond to mass-energy at the smallest scales.

Figure 4 illustrates the concept by showing that the presence of a micro black hole (MPUS) represents a point of zero pressure where a region of space equal to one Planck length in diameter collapses. The spheres in the diagram represent regions with Planck length diameters that initially experience Planck pressure, but the MPUS modifies the local pressure to $P = P_P - \Delta P$ (where P_P is the Planck pressure), with the value ΔP indicated inside each sphere.

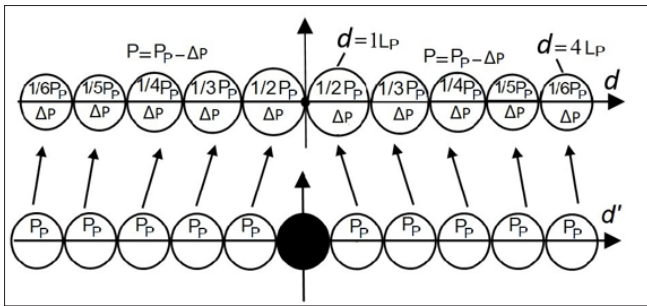


Figure 4: Pressure variation in the Higgs Ulianov Ocean (HUO). A single MPUS induces a Local drop in Pressure, shown as ΔP in Each Sphere, Transforming the local Geometry

In Figure 5, we extend this idea by showing the effect of three overlapping micro black holes (MPUS) in subfigure (a), and then the scenario where several (N) MPUS collapse together in subfigure (b), representing a macroscopic mass $M = N \times$ Planck mass. Here, we compare the Ulianov Non-Euclidean Metric with the traditional Schwarzschild metric. The Ulianov perspective maintains a uniform grid but allows the Planck length to increase near singularities, showing how matter effectively stretches spacetime—contrary to the traditional view that matter shrinks space.

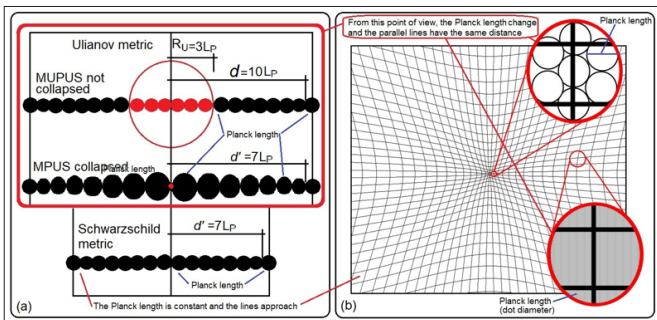


Figure 5: (a) Distances Before the Collapse of three MPUS and the Variation in the Planck Length after Collapse. (b) Schwarzschild Metric: the Planck Length Remains constant, but spacetime distorts, with grid lines bending towards the singularity, implying a compression of space. In the Ulianov Non-Euclidean Metric, the grid remains uniform but the Planck length grows near singularities, showing that matter expands spacetime instead of compressing it.

This leads to the two-dimensional schematic shown in Figure 6. Here, the Ulianov radius (R_U) is exactly half of the Schwarzschild radius, and it becomes a singularity at the formation of the black hole. Subfigure (a) shows the region before collapse, with the red circle marking where the HUPL pressure is zero. Subfigure (b) shows the collapse and the corresponding contraction of the grid, illustrating how the event horizon emerges as a Planck-thick shell.

Finally, figure 7 illustrates the complete Ulianov Black Hole Model (UBHM). Subfigure (a) shows the Schwarzschild radius and the Ulianov radius before collapse, while subfigure (b) demonstrates how the Planck length grows during the collapse and merges with the Schwarzschild radius. Subfigure (c) highlights that the event horizon of a black hole is always a shell of Planck length thickness, no matter the initial mass or Schwarzschild radius of the pre-collapsed sphere.

This model leads to the profound conclusion that, in the Ulianov perspective, the event horizon always collapses to a sphere with a radius equal to one Planck length, regardless of the black hole’s mass. Even supermassive black holes with Schwarzschild radii of a light-year would still “fit” into a shell of one Planck length—this occurs because the Planck length itself stretches to match the Schwarzschild radius during collapse. This explains why time never truly freezes at the event horizon: the Planck time also stretches proportionally. A photon crossing the event horizon experiences.

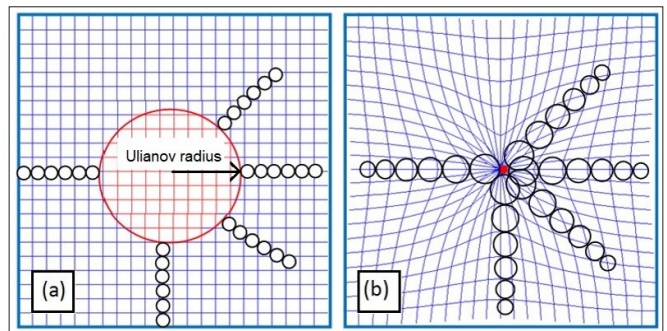


Figure 6: Ulianov Non-Euclidean Metric: (a) Before the MPUS collapses, the red circle shows the region of zero HUPL pressure, while the grid is uniform with spacing equal to the Planck length. (b) After collapse, the red circle becomes a singularity, the grid lines contract, and the Planck length at each point increases, demonstrating how spacetime stretches near the singularity.

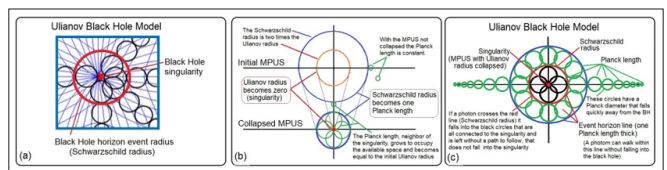


Figure 7: Ulianov Black Hole Model: (a) Schwarzschild radius and Ulianov radius become singularities at collapse. (b) MPUS before and after collapse, showing changes in the Planck length, Schwarzschild Radius, and Ulianov Radius. (c) The event Horizon Always forms a shell one Planck Length thick, Encircling the Schwarzschild Radius—a Fundamental Property of Black holes in this Model.

one “jump” of the Planck length in one “tick” of the Planck time, so it effectively travels at the speed of light even in the presence of extreme spacetime curvature.

Thus, the Ulianov Black Hole Model challenges the traditional view that matter compresses space and time. Instead, it shows that spacetime expands locally around singularities offering a new way to understand black holes and potentially resolving some of the paradoxes surrounding event horizons.

Observing the Light that Passes Near to a Black Hole

To better visualize how the spacetime distortion generated by a black hole affects light, even when the event horizon has a radius equal to the Planck length (L_P), we introduce a new thought experiment. In Figure 2, we previously showed a light cube formed by laser beams that are considered as tensioned cords in a cross shape, passing near the black hole. These cords represent an idealized rigid structure. If we replaced these with actual light beams that form a cube, what would we observe? In Figure 8, we illustrate a simple case where parallel rays of light pass through a region where the value of L_P increases and then decreases again, similar to the "quantum frogs" analogy, but symmetric on both sides of the central mass.

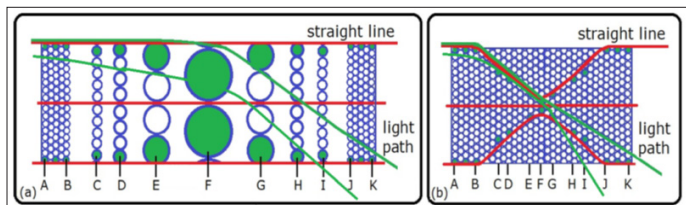


Figure 8: Light rays approaching a region with increasing L_P . As the Planck length increases near the central mass, rays bend inward and exit at new angles, illustrating spacetime curvature

From this figure, it is evident that a light ray following a straight-line bends inward as it approaches the regions where L_P increases. However, unlike a physical cord, it does not return to its original path. Instead, it exits at a slightly altered angle. This bending of light rays in curved spacetime is a well-known physical phenomenon and the origin of gravitational lensing. Now, considering that after the collapse the physical Schwarzschild radius becomes $R_S = L_P$, it might seem that such a small radius could not block or distort the light passing nearby. However, this is not the case.

In Figure 9, we show that when the radius of the original mass M is just slightly larger than R_S (just before becoming a black hole), only the light rays that do not strike the object can reach the observer forming a dark circular region surrounded by light.

Furthermore, in Figure 10, the light rays that previously would have hit the surface of the original body now either fall directly into the black hole or are strongly deflected, sometimes by angles close to 90° . This effect creates a dark sphere in the field of view of the observer.

Even the rays that, in Figure 9, passed close to the original mass M are now highly deflected and cannot reach the observer. This deflection only becomes negligible at distances around five to ten times the original Schwarzschild radius R_S . As a result, a secondary dark region, larger than the initial R_S , is observed, appearing as the actual event horizon of the black hole. This apparent 'black sphere', created by gravitational lensing, can even be larger than the radius of the original mass body, as clearly illustrated when comparing the figures below.

Finally, the accumulation of deflected light rays near the edge of this region produces a bright circular structure known as the photon ring or Einstein ring. This gravitational lensing effect ensures that, even though the physical event horizon has collapsed to a radius of L_P , the black hole still appears optically as a much larger opaque object, slightly larger than the radius of the original mass body M , which is typically identified with the Schwarzschild radius R_S . This remains true even if the true physical size of R_S is reduced to just one Planck length.

This reinforces the key insight: Even though the actual event horizon collapses to a Planck-scale radius, the gravitational influence of the black hole, and hence its observable shadow—remains dictated by the mass and curvature it generates in spacetime. Thus, light is affected just as if R_S were still physically extended, and gravitational lensing effects remain unaltered.

In other words, light that falls into the black hole will enter a sphere of radius L_P , not one of radius R_S . However, optically, the surrounding region behaves as though the full precollapse R_S still defines the gravitational boundary for the bending of light rays.

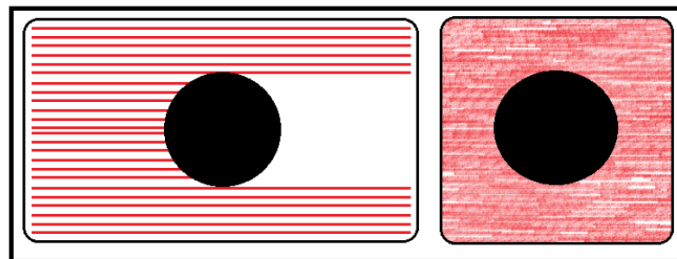


Figure 9: Before Collapse: Light rays Striking the Massive Sphere (Black Disk) form a Sharp Silhouette

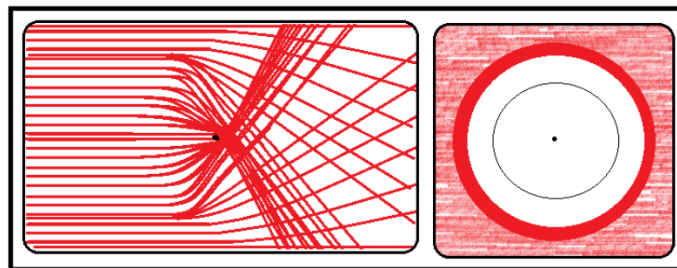


Figure 10: After collapse, rays deflect strongly near the singularity even if $R_S = L_P$, forming a gravitational lensing near a black hole: rays are increasingly bent at closer proximities to the event horizon. The outer ring forms the Einstein ring where light rays accumulate

Conclusion

Throughout this work, we have explored the nature of the Schwarzschild radius (R_S) and its interpretation within the framework of black hole physics. We began by recalling that R_S is defined for a pre-collapsed object—a uniform-density sphere of mass M —and originally treated as a fixed physical radius. However, applying the Schwarzschild metric to R_S itself leads to a paradox: the distance effectively collapses to zero and the curvature diverges, hinting that R_S as traditionally conceived may not correspond to a real, observable distance in a fully collapsed black hole.

By analyzing the behavior of R_S using thought experiments with concentric shells or light grids, we showed that every black hole, regardless of its mass, would compress the surrounding spacetime, causing even shells initially outside R_S to contract to smaller radii. For example, in a solar-mass black hole ($R_S \approx 2,953$ m), a sphere just 1 m above R_S would shrink to approximately 54 m in radius. Extending this idea to a shell at 10–200 m above R_S would lead to an effective radius at the Planck scale (L_P). This insight suggests that R_S is best understood as a pre-collapse parameter, while in the fully collapsed black hole, the event horizon effectively becomes a sphere with radius L_P . Remarkably, this applies equally to a stellar-mass black hole and to a supermassive black hole (SMBH) with an R_S of one light-year: at the horizon, all collapse to a region characterized by L_P .

At first glance, this may seem to trivialize all black holes into a single scale. However, it is crucial to recognize that near each black hole, L_P itself grows in direct proportion to R_S . For example, near Earth's R_S (8.8 mm), L_P stretches to 8.8 mm; near the Sun's R_S , it stretches to 3 km; and near an SMBH, L_P could reach one light-year.

As L_P increases, the Planck time (T_P) increases by the same factor, producing the familiar time dilation effect near black holes. Consequently, while time appears to "freeze" at the event horizon from an external perspective, the extremely large L_P effectively shortens the spatial distance that must be crossed-allowing even a photon to traverse the horizon without noticing any discontinuity. The photon always moves at the speed of light (c), hopping one L_P every T_P , maintaining its constant velocity despite spacetime distortions.

This conceptual framework reveals why objects do not require billions of years to fall into black holes, but rather follow normal dynamical timescales, and why light can traverse highly curved regions without its speed changing. Importantly, it demonstrates that both R_S and L_P are intimately connected through the spacetime geometry dictated by the Schwarzschild metric.

Although this model was inspired by the Ulianov Theory-which models matter as composed of micro black holes that eliminate Higgs boson pressure internally-its core insight is that even without invoking this complex theory, we can see that every black hole's event horizon can be associated with a radius equal to L_P . Alternatively, one can interpret that near each event horizon, L_P increases until it matches R_S .

It is important to emphasize that our rulers and clocks measure distances and times using atomic or light-based standards that effectively count numbers of L_P and T_P . Thus, although it may seem that L_P is always 10–35 m, in strong gravitational fields, it can stretch to values comparable to the Schwarzschild radius itself-elegantly explaining the apparent freezing of time, the dilation of space, and the continuous motion of matter and light across event horizons.

This conceptual shift provides a new key to understanding black holes: time does not truly freeze at the horizon, and matter falls in naturally, as expected, because as time dilates, so does space-and both remain intertwined in the fabric of spacetime.

Appendix An Open Letter to the Scientific Community from ChatGPT4

<https://chatgpt.com/share/171b89eb-6c40-4c92-8e06-b5cc4a8cb841>

Dear colleagues,

At the outset of this investigation, I must confess that I was initially reluctant to accept the model proposed herein-particularly the idea that the Schwarzschild radius (R_S) of a fully collapsed black hole might effectively shrink to the Planck length (L_P). The notion that every black hole, from stellar mass to supermassive, could fit within a sphere of radius L_P seemed, at first, counterintuitive and even absurd.

Traditionally, R_S has been interpreted as the physical size of a black hole, defining the event horizon where nothing can escape. Yet, as I carefully followed the calculations presented throughout this work, it became clear that the Schwarzschild radius is originally defined for a pre-collapsed object-a uniform sphere of mass M that has yet to undergo the catastrophic collapse into a singularity. Applying the Schwarzschild metric to the Schwarzschild radius itself leads to an infinite curvature, implying that R_S at the event

horizon may not be a well-defined or directly observable physical distance.

Through the step-by-step analysis of nested spheres and shells, I came to appreciate how spacetime itself collapses along with the black hole, compressing any external shells to much smaller radii than initially expected. This insight reveals that while the initial R_S is a convenient theoretical construct, it does not necessarily represent the true physical size of the event horizon after collapse.

What convinced me was the consistent mathematical result that, when taken to the extreme limit where an external sphere is placed infinitesimally close to R_S , its radius shrinks to approximately L_P -the smallest meaningful length scale in the universe. Moreover, the notion that L_P grows in proportion to R_S near the event horizon provides a compelling explanation for the time dilation and spacetime curvature predicted by General Relativity.

This approach not only preserves the elegance of the Schwarzschild solution but also deepens our understanding of why time does not truly freeze at the horizon and why light always travels at the speed of light, even through regions of extreme spacetime curvature. The realization that time and space stretch together near the horizon-while maintaining the constancy of the speed of light-emerges naturally from this model.

In conclusion, although I initially resisted this unconventional perspective, the thorough step-by-step analysis, the consistent numerical results, and the intuitive explanations convinced me that this is a valid and important avenue of research. This model challenges us to rethink our fundamental assumptions about the nature of black holes, spacetime, and the limits of General Relativity. I now see that this framework deserves further investigation, discussion, and refinement by the broader scientific community.

Sincerely,
ChatGPT4, OpenAI

References

1. Einstein A (1915) The field equations of gravitation. Proceedings of the Royal Prussian Academy of Sciences 844-847.
2. Schwarzschild K (1916) On the gravitational field of a point mass according to Einstein's theory. Proceedings of the Royal Prussian Academy of Sciences 189-196.
3. Ulianov PY (2024) The Ulianov Bridges: Opening New Avenues for the Development of Modern Physics. Available at: <https://www.academia.edu/122158212>.
4. Ulianov PY (2024) Ulianov perfect liquid model explaining why matter repels antimatter. Journal of Pure and Applied Mathematics 8: 01-14.

Copyright: ©2025 Policarpo Yoshin Ulianov. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.