Segmented Spacetime and the Dark Star Problem - A Historical and Geometric Reassessment of Light Escape in Strong Gravity

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This work re-examines John Michell's 1783 "dark star" argument and places it in direct conceptual comparison with the general relativistic description of gravitational collapse. While Michell reasoned within Newtonian dynamics that sufficiently compact masses could prevent light from escaping, general relativity replaced the notion of material concentration by a region of spacetime curvature encoded purely in the metric. This shift - from mass as substance to mass as geometry - offers explanatory power, but also introduces conceptual ambiguities surrounding the nature of singularities.

We show that the standard interpretation, in which the collapsing core is mathematically replaced by a curvature singularity without internal physical description, leads to an unresolved tension: If the total mass-energy remains conserved and continues to define the external field, then some form of intrinsic frequency or wavelength associated with that mass should persist. This motivates the question of whether the classical assumption of a strictly inward-pointing, smooth geometry is complete, or whether alternative models - including fuzzball/gravastar proposals, near-horizon quantum effects, or the Segmented Spacetime framework - may offer mechanisms through which radiation or information can re-emerge.

By tracing the historical evolution from Michell and Laplace to Einstein, Oppenheimer, and modern quantum-gravity-inspired models, we clarify how the concept of mass inside collapsed objects has been successively abstracted. We argue that the interior cannot simply be dismissed as mathematically undefined, and that its physical properties, if any remain, must have observational consequences, especially regarding the frequencies at which such remnants could emit or recouple energy.

1. Introduction

John Michell's dark star [1] is a theoretical concept from 1783 in which Michell effectively laid the foundation for what we now call black holes. He proposed a simple but remarkable thought experiment:

If we take the Sun and increase its radius by a factor of about 500, the escape velocity at its surface would exceed the speed of light. In that case, light could not escape, and the star would appear completely dark. Because of this, Michell called such an object a dark star.

However, there are two major issues with Michell's reasoning:

- Photons are not literally held by gravitation. Light would take longer to escape from a strong gravitational field, but it would not be permanently trapped unless spacetime itself were curved to the point where all escape paths close - something Michell did not consider.

- Michell did not take into account that the mass of an emitting body determines the wavelength of the light it produces. The greater the gravitational mass of a star, the longer the emitted wavelength becomes, since local gravity stretches the temporal scale of emission at the source.

The concept of the dark star was later revived in modern astrophysics and transformed into what we now call a black hole. In this framework, the collapsing core of a massive star is no longer treated as an ordinary dense object, but effectively replaced by a singularity, a region where the classical description of matter breaks down and only the gravitational field remains in the equations. During a core-collapse supernova, the outer layers are blown off while the inner core collapses. The resulting gravitational field is then attributed not to a visible remnant in the classical sense, but to this collapsed core, which general relativity encodes as a singularity surrounded by an event horizon.

In general relativity, the collapse of a massive stellar core is described not as a concentration of ordinary matter, but as the formation of a region of spacetime curvature characterized by a single parameter, M, the total mass–energy of the system. After the supernova explosion, the outer layers are expelled, while the inner core collapses beyond the limits of matter pressure [2]. The resulting solution of Einstein's field equations is no longer expressed through a material object, but through the geometry of spacetime itself, encoded in the Schwarzschild (or Kerr) metric [3].

In this picture, the parameter M continues to determine the gravitational field measured from the outside. Yet the physical substance that once generated this field is no longer represented as matter. Instead, it is mathematically replaced by a singularity, a point at which curvature and density diverge, and the equations cease to be meaningful.

The concept of mass itself is thereby replaced by geometry: What was formerly described as a quantity of matter is now expressed through the curvature of spacetime. Mass no longer appears as a physical substance within the equations, but as a source term that determines how spacetime bends. Once this curvature is established, the mass parameter becomes indistinguishable from the geometry it produces and loses any independent physical description.

As a result, when a stellar core collapses beyond the limits of matter pressure, general relativity does not describe what the mass is, but only how its gravitational field shapes spacetime around it. The singularity that forms is therefore not treated as matter, but as a point where the geometric representation itself breaks down. This suggests that the very concept of the singularity is often misunderstood, especially within mainstream interpretations of general relativity. If mass still exists within the interior, then it must also possess a characteristic wavelength. From a purely logical standpoint, any remaining mass implies the presence of a frequency, and therefore an intrinsic wave nature.

Considering the geometry of spacetime curvature and the extreme inward fall velocities, which, in coordinate terms, exceed the speed of light, one would expect this intrinsic wavelength to be shifted far into the radio domain, as suggested by the Segmented Spacetime framework[4]. In that sense, the singularity would not represent an abstract point of infinite density, but rather a state of matter or field oscillation compressed into extremely long wavelengths by the gravitational potential itself.

If the total mass–energy of the system is conserved and still defines the external gravitational field, then why is the singularity - the very point to which this energy collapses - not regarded as the mass itself? If there remains mass, should it not exhibit a wavelength? And if so, could that wavelength, under extreme curvature, naturally fall into the radio domain?

Historically, Oppenheimer’s collapse model was never meant as a realistic description of nature. It was a mathematical idealization motivated by nuclear-physics analogies, assuming zero internal pressure and no explosive mechanisms. Einstein immediately rejected such complete collapse as unphysical. Segmented Spacetime provides the missing mechanism that replaces these mathematical non-physicalities by discrete geometric thresholds.

2. Historical Framework - Michell, Laplace and the Dark Star Concept

Michell's thinking is rooted in Newtonian principles: Light are particles (corpuscles) that are accelerated/decelerated by gravity just like any other particle. Michell makes no mention of wavelength shifts, because his entire framework predates the grand wave theory.

Let us mentally travel back in time. We are now in the late 18th century:

The corpuscle theory (Newton) is still dominant. Dispersion, refraction, etc., are known experimentally, but not as "gravitational redshift". It is not until 1801 that Young's interference experiments [5] are published, followed by Fresnel's ideas [6]. The concept of light as a wave in the ether gains acceptance. But here, in this wave theory, it was completely unclear how a Newtonian gravitational field could act on a wave in the ether. This is precisely why modern historians write, that after the discovery that light is a wave, it became unclear how light waves would be affected by a Newtonian gravitational field; the idea of dark stars was dropped.

Independently of Michell, Laplace argued in 1796 [7] that a sufficiently massive and compact star would have an escape velocity greater than the speed of light and be invisible. In his Newtonian framework this appears as a literal superluminal fall or escape speed.

With the advent of special and general relativity [8], this picture was not explicitly refuted in detail by Einstein, but rather replaced. Gravity was no longer described by a velocity field in flat space, but by geodesics in curved spacetime with a locally invariant speed of light. In that geometric language, $v>c$ ceases to be a meaningful invariant statement. Instead, the concept of an event horizon takes over the role that Laplace had assigned to superluminal escape speeds.

Einstein never discussed fall-velocity because he eliminated the concept by replacing fall- and escape-velocity and force with geodesics and metrics [9]. In general relativity, there is no longer a local velocity of falling, but only timelike geodesics, null geodesics and spacelike geodesics. All local velocities are normalized to a maximum speed c. Therefore, the question, if something can be faster than light can no longer be asked. It is simply no longer a physical concept. However, this is not a refutation, but a linguistic obliteration of the term.

Michell/Laplace were rejected because of the wave theory, not because a clean theory of wavelength-shift already existed. Back then, there was no consistent theory of gravity for waves.

Let's continue our journey through history. In 1907/1911 Einstein made his first clear predictions that gravity shifts spectral lines (gravitational redshift) [10].

But it was not before 1959 Pound and Rebka [11], then later Pound and Snider [12] carried out the first precise laboratory measurements of gravitational redshift using γ-quanta with an accuracy of ~1%.

Perhaps, you as a reader are wondering now: What happened to Michell's idea in the 19th century? Historical studies are surprisingly unanimous: Michell's and Laplace's dark or invisible stars were largely forgotten in the 19th century. They were not systematically discussed, but rather ignored.

The reason, according to sources such as the MPIWG and Queens' Archives, is:

- Corpuscle theory → out
- Wave theory → in
- No clear coupling of gravity to waves → speculation seems "unmotivated"

There is not a single known source in which someone from 19th centuy says:

"Michell is wrong because he ignores the redshift."

This is indeed a modern reconstruction.

Michell was rediscovered in the 1970s, when people began to systematically reconstruct the history of black holes. Simon Schaffer wrote "John Michell and Black Holes" in the Journal for the History of Astronomy in 1979 [13], which can be seen as a rehabilitation article. The world was ready to take Michell's dark star into consideration again, but not ready to fully understand the impact.

3. Geometry of Light Escape

Classical GR is often summarized by the statement, that light cannot escape a black hole, but this is a simplification that hides several important details. General relativity does not describe a physical membrane or a material surface. It describes a geometric condition:

Inside the Schwarzschild horizon, all null geodesics point inward. This is a coordinate statement, not a physical mechanism that stops or absorbs light.

At the horizon itself, the situation is different: The only allowed null direction is tangential. A photon at the horizon can neither move outward nor inward. Its geodesic becomes spiral-like along the horizon. This is fully compatible with standard GR and well-known in the analysis of the photon sphere.

Because of this geometry, any emission occurring near or inside the horizon boundary experiences extreme gravitational redshift and path-deformation. A spiral-like trajectory that gradually aligns with the decreasing curvature naturally produces radiation that escapes at much lower frequencies, often in the radio domain [14].

This matches precisely what observations detect: Only long-wavelength radiation emerges from near-horizon regions. And it raises a conceptual point that is often overlooked:

If matter inside the horizon (or near it) undergoes collisions, reflections, or internal emission events, GR offers no physical "blocker" that would forbid outward-going light. The prohibition arises entirely from the mathematical structure of the idealized Schwarzschild solution. Any deviation from the perfectly smooth, singular interior (quantum structure, segmentation, discrete geometry) reopens outward-directed null directions.

This is indeed consistent with:

- Hawking radiation (semi-classical) [15,16]
- fuzzball / gravastar models
- near-horizon QFT [17]
- and Segmented Spacetime, where geometry is not smooth and therefore not strictly inward-pointing.

Thus, the event horizon is not inherently a "one-way street" for light. It becomes one only if we assume a perfectly smooth classical geometry and a strict singularity. But, once local structure, segmentation or internal emission dynamics are allowed, outward null trajectories, heavily redshifted and spiralized photons become physically plausible.

This offers a natural explanation for why we observe radio emission from near-horizon regions, but not visible light. The path and the frequency are transformed by curvature itself.

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