Segmented Spacetime - Infalling Mater and Radiowaves

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Radiowave precursors observed around black holes and compact objects pose a long-standing puzzle, as classical general relativity provides no mechanism for low-frequency emission during spherically symmetric infall. In this paper we present a physical explanation based on the Segmented Spacetime (SSZ) model, which divides spacetime into an outer weak-segmentation region (g_1) and an inner strong-segmentation region (g_2). When matter approaches the g_1 – g_2 boundary, its gravitationally induced motion can be absorbed by g_2, but any additional kinetic component must be released. Because strong segmentation suppresses high-frequency modes, the excess energy is emitted almost exclusively as radiowaves, long before visible mass becomes observable. This framework reconciles symmetry constraints, energy conservation, and observational data, and suggests that radiowave spectra contain direct information about the original motion of infalling matter.

1. Introduction

Many astrophysical systems show precursor radiowave activity associated with black holes and compact objects. In classical GR, such emission mechanisms are unclear:

- the event horizon is non-radiative
- spherically symmetric collapse produces no gravitational waves
- infalling matter is redshifted and vanishes from view

Segmented Spacetime (SSZ) provides a geometric mechanism allowing radiowaves to emerge naturally during infall.

2. Segmented Spacetime (SSZ): Overview

SSZ distinguishes two domains (Wrede et. al, 2025):

g_1 – weak segmentation (outer spacetime)

classical gravitational field

outgoing expansion

standard physics

g_2 – strong segmentation (inner domain)

inward segmentation

time slowdown

increased spacetime density

radius shrinks towards the core

The boundary between g_1 and g_2 forms a natural energy horizon,not to be confused with the GR event horizon.

3. Dynamics of Infalling Matter

When matter approaches the $g_1 \rightarrow g_2$ boundary, its total effective velocity is:

$$v_{total} = v_{fall} + v_{Eigen}$$

$\boldsymbol{v_{fall}}$ is set by the gravitational segmentation field

$\boldsymbol{v_{eigen}}$ is the object's initial (external) motion

Key principle:

g_2 can absorb mass, but cannot absorb the free kinetic component v_{eigen}. Thus, the infalling object must shed this “excess energy”.

4. Why the Core Must Have a Finite Radius (r > 0)

A direct consequence of Birkhoff’s theorem is that a spherically symmetric gravitational field in the exterior region can only arise from a spherically symmetric mass distribution with a finite, non-zero radius (Birkhoff, 1923). The theorem strictly applies to the vacuum outside the mass, not to the interior itself. This means that spherical symmetry can only be defined if there exists an actual spherical surface that separates the interior region from the exterior vacuum.

A “point mass” at r = 0 does not satisfy this requirement. At zero radius, there is no spherical surface, no definable symmetry, and no physical notion of a density or interior geometry. The Schwarzschild solution cannot be meaningfully extended into such a region, because the geometry degenerates and the coordinates lose physical interpretation. Thus, the standard statement “the exterior looks like a point mass” always presupposes a finite-sized interior, even if that interior is not resolved by the exterior solution.

In physically stable configurations, a finite interior radius is therefore unavoidable. The gravitational field observed outside a black hole implies that the mass distribution inside must occupy a region with r > 0, supporting a well-defined spherical geometry and preventing the interior solution from collapsing into a mathematical singularity that general relativity itself cannot describe.

5. Infalling Matter, Excess Velocity and the Origin of Radiowaves

If the interior of a black hole possesses a finite radius r>0 , then infalling matter never reaches a mathematical point but instead interacts with this extended core region. Crucially, matter approaching the core carries two independent velocity components:

The gravitational infall velocity v_{fall} - This is the velocity imposed by the local gravitational field, which approaches relativistic values as the object moves deeper into the g_2 zone.

The intrinsic velocity v_{eigen} - This is the object’s own kinetic state before entering the strong-segmentation region.

Inside g_2 , this intrinsic component becomes the decisive quantity because v_{fall} is already maximised by the geometry.

As a result, the object arrives at the core with a total effective impact velocity

$$v_{total} = v_{fall} + v_{eigen}$$

but only v_{eigen} represents *excess* energy, energy not accounted for by the gravitational background.

The physics of the g_2 region does not permit the generation of high-frequency electromagnetic radiation. The strongly segmented interior lacks the fast charge dynamics and plasma conditions required to produce UV, X-ray, or optical emission. Instead, infalling matter that is partially re-ejected generates only slow, long-timescale disturbances. As this matter moves outward into regions of decreasing segmentation, these disturbances naturally manifest as low-frequency radiowaves, which are the only electromagnetic modes compatible with the local timescales and spacetime structure.

These radiowaves act as early signatures of matter that will later re-emerge into the g_1 region. When the infalling material interacts with the finite-radius core and a fraction of it is redirected outward, the first physical contact with the weak-segmentation zone occurs long before the outflow becomes optically visible. The radiowave emission therefore marks the moment when the re-ejected matter begins to re-couple to g_1 , well before its density or temperature is sufficient to produce a jet or any higher-frequency radiation.

Such behaviour is consistent with observations of several black-hole systems in which radiowave activity has been detected days to weeks prior to the onset of visible outflows. In these events, the radiowave flare precedes the jet, indicating that the earliest interaction between the returning matter and the outer spacetime is encoded in long-wavelength emission.

This provides a natural interpretation: Radiowaves are the first accessible signal of material that has already reached the core, reversed direction, and begun the transition back into the external spacetime.

Long–term monitoring of black–hole X-ray binaries already shows that strong radio flares can appear days before the clearest X-ray state transitions and resolved ejecta (e.g. GX 339–4; Fender et al. 2009), and that microquasars such as GRS 1915+105 exhibit synchrotron precursors and radio outbursts on timescales of weeks (Mirabel & Rodríguez 1999; Mirabel et al. 1998). In our SSZ picture, these radio episodes naturally correspond to matter that has already interacted with the finite–radius core and has begun its slow return towards the g_1 region, long before high–frequency emission from the fully developed jet becomes visible.

Observationally, it is highly important to distinguish between late-time radio emission produced in the extended jet and early low-frequency activity that may precede visible outflows. While classical synchrotron radio emission indeed develops only after the jet expands, several black-hole systems show weak, long-wavelength precursors days or even weeks before the main jet becomes visible.

6. Observational Predictions

The mechanism described above leads to a set of clear, testable observational predictions.

Because radiowaves originate from matter that has already reached the finite-radius core and begun its outward motion, their appearance should systematically precede any optical or high-energy signatures associated with the later outflow.

Radiowave precursors before visible outflows.
Radiowave flares are expected to occur well before the emergence of an optical jet, X-ray brightening, or any thermal emission from hot plasma. The time offset corresponds to the interval during which the re-ejected matter climbs out of the strongly segmented g_2 region and begins to re-couple to the outer spacetime.

Long-duration radiowave activity.
Because the ascent of the material is slow relative to the timescales of electromagnetic processes in g_1 , the radiowave precursor can persist for days or even weeks before the onset of the visible outflow. This matches observations in several accreting black-hole systems where long-lived, low-frequency flares precede major jet events.

Absence of high-frequency precursors.
No corresponding early emission should appear in the optical, UV, or X-ray bands. These frequencies cannot form in the strongly segmented interior and only emerge later, once the material has entered the less-segmented region and begun to heat through shear, collisions, and magnetic coupling.

Radiowave asymmetry and velocity signatures.
The structure of the radiowave emission should carry information about the intrinsic velocity of the infalling material. Faster or more oblique impacts are predicted to produce stronger or more asymmetric radiowave patterns, reflecting the kinetic energy that must be shed before the matter can rejoin the outer spacetime.

Correlation between radiowave strength and jet power.
Systems with stronger radiowave precursors are expected to produce more energetic jets, because both phenomena originate from the same re-ejected material. The radiowave flare represents the earliest stage of the jet's formation process.

Together, these predictions provide a coherent framework linking radiowave activity, infalling matter, and the segmented structure of spacetime near compact objects. They also offer a practical observational strategy: long-term low-frequency monitoring may reveal the earliest phases of accretion-driven outflows that are otherwise inaccessible to optical or X-ray telescopes.

7. Relation to General Relativity

The segmented spacetime model is fully compatible with the established results of general relativity in regions where classical curvature descriptions remain valid. In particular, the presence of a finite-radius core inside a black hole does not contradict the Schwarzschild exterior solution; instead, it follows naturally from the interpretation of Birkhoff's theorem, which requires a spherically symmetric mass distribution with a non-zero spatial extent. The exterior geometry remains indistinguishable from the classical Schwarzschild metric as long as spherical symmetry is maintained.

General relativity also predicts that spherically symmetric collapse cannot produce gravitational waves, because no evolving quadrupole moment exists in such configurations. This aligns with the SSZ picture: the interior segmentation suppresses any asymmetry, and the interaction between infalling matter and the finite-radius core is locally dissipative rather than radiative in the gravitational sense. SSZ therefore extends GR not by altering the exterior field equations but by adding a geometric constraint to the interior, preventing the physically problematic limit $r = 0$

Moreover, the radiowave emission inferred from SSZ is not in conflict with GR. Classical GR does not forbid low-frequency electromagnetic radiation in the transition region between the near-horizon interior and the outer accretion environment; it simply does not provide a mechanism for such emission under idealized collapse conditions. SSZ supplies this missing mechanism by introducing segmentation-dependent timescales that dictate which electromagnetic modes can form and propagate. The result is a consistent framework in which GR governs the exterior geometry, while SSZ explains the interior processes that give rise to observable radiowave precursors.

8. Discussion

The interpretation presented here offers a coherent physical picture that links the segmented interior geometry of compact objects to observable radiowave activity preceding jet formation or optical outflows. By assigning a finite-radius structure to the interior, SSZ avoids the pathological $r = 0$ limit of idealized collapse and provides a physical setting in which infalling matter can interact, dissipate kinetic energy, and reverse direction. This naturally leads to radiowave emission, which becomes the earliest detectable signature of the process.

An important consequence of the model is that radiowave precursors are not secondary or accompanying features but an integral part of the infall–outflow cycle. They reflect the moment when matter first re-couples to the g_1 region, long before the conditions for optical brightness or high-frequency radiation are met. This perspective integrates a wide range of observations: systems where radio flares precede major jet activity, where low-frequency bursts appear without immediate X-ray correlates, and where outflows appear delayed relative to their earlier electromagnetic signatures.

Several open questions remain. The precise mapping between intrinsic infall velocity and radiowave intensity requires further quantitative development, as does the role of angular momentum in shaping asymmetric radio emission patterns. Additionally, extended monitoring of black-hole environments may allow a statistical comparison between predicted radiowave precursor durations and observed delays between radio and optical jet signatures. Such studies could provide a direct test of the segmented spacetime framework and potentially reveal underlying universal patterns in accretion-driven outflows.

Overall, the SSZ interpretation of radiowave precursors provides a physically grounded mechanism that fits naturally within the geometric constraints of general relativity while extending the descriptive power of interior models. It highlights the importance of low-frequency observations in uncovering the earliest phases of black-hole activity and suggests a pathway toward a more complete understanding of infall–outflow dynamics.

9. Conclusion

The SSZ framework provides a consistent interior geometry in which infalling matter interacts with a finite-radius core rather than collapsing to $r = 0$. This interaction naturally produces radiowaves as excess kinetic energy is released during the transition from g_2 back into g_1. Because long-wavelength modes are the only electromagnetic signals compatible with the timescales of the strongly segmented interior, radiowave flares appear well before any optical outflow or jet formation. This interpretation links a wide range of observed early radiowave precursors to the internal dynamics of segmented spacetime and suggests that low-frequency monitoring may reveal the earliest stages of accretion-driven outflows.

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