# White Holes: Time‑Reversed Solutions of the Schwarzschild Metric and Their Physical Implications

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## Abstract

White holes arise in general relativity as the exact time‑reverse of black holes: spacetime regions from which matter and light can escape but into which nothing can enter. Although no direct astrophysical evidence yet exists for their realisation in nature, the solutions illuminate deep issues in gravitational thermodynamics, cosmic censorship, and the arrow of time. This paper reviews the canonical Schwarzschild white‑hole metric, its global structure in Kruskal–Szekeres coordinates, extensions to rotating and charged cases, and the reversal of Hawking flux. We examine junction models that dynamically generate one‑off white‑hole bursts and discuss the speculative link between primordial white holes and the Big Bang singularity. Observational constraints, including gamma‑ray burst energetics and hypothetical Planck‑mass remnants, are evaluated. The analysis highlights white holes as a fertile thought‑laboratory whose mathematical consistency contrasts with their apparent physical elusiveness.

## 1  Introduction

Black holes—the gravitational sinks predicted by Einstein’s field equations—have graduated from theory to observation over the past half‑century. Their less celebrated twins, \*\*white holes\*\*, were first noted implicitly by Kruskal (1960) and explicitly by Penrose (1964) as the past‑chronological counterparts of black holes in maximally extended solutions. In essence, a white hole is a region that \*expels\* all causal trajectories. This work surveys the essential geometry and physics of white‑hole spacetimes, situating them within contemporary discussions of quantum gravity and cosmology.

## 2  Schwarzschild Metric and Time Reversal

We begin with the vacuum solution

$$

ds^{2}= -\Bigl(1-\tfrac{2GM}{c^{2}r}\Bigr)c^{2}\,dT^{2}+\Bigl(1-\tfrac{2GM}{c^{2}r}\Bigr)^{-1}dr^{2}+r^{2}d\Omega^{2},

$$

where reversing the temporal boundary conditions at the horizon $r\_{h}=2GM/c^{2}$ flips the ingoing null generators to outgoing ones, defining a white hole.

### 2.1  Kruskal–Szekeres Extension

The coordinate transformation

$U=-e^{-u/4GM/c^{2}},\quad V=e^{v/4GM/c^{2}}$

with null coordinates $u=T-r\_{\*},\;v=T+r\_{\*}$ and tortoise radius $r\_{\*}=r+2GM/c^{2}\,\ln\lvert r/r\_{h}-1\rvert$ yields

$$

ds^{2}= -\frac{32G^{3}M^{3}}{c^{6}r}\,e^{-r/2GM/c^{2}}\,dU\,dV+r^{2}d\Omega^{2}.

$$

Quadrant I ($U>0, V<0$) corresponds to a white‑hole region from which null geodesics propagate toward the external universe (quadrant II).

## 3  Rotating and Charged White Holes

Replacing the Schwarzschild seed with Kerr or Reissner–Nordström metrics preserves the dual‑horizon structure. For Kerr,

$$

\Delta=r^{2}-2GMr/c^{2}+a^{2},\qquad r\_{\pm}=GM/c^{2}\pm\sqrt{(GM/c^{2})^{2}-a^{2}},

$$

the time‑reversed interior ($r<r\_{-}$) ejects matter bearing specific angular momentum $a=J/Mc$.

## 4  Thermodynamic Reversal

Hawking’s particle‑creation rate

$$

\dot M\_{\text{BH}}=-\frac{\hbar c^{4}}{15360\pi G^{2}M^{2}}

$$

changes sign under time reversal, implying a \*mass increase\* for an isolated white hole via absorption of negative‑energy partners while emitting positive‑energy particles outward.

## 5  Cosmological White Holes and the Big Bang

The Friedmann–Lemaître–Robertson–Walker (FLRW) radiation‑dominated solution $a(t)\propto t^{1/2}$ resembles a global white‑hole explosion. We review arguments equating the Big Bang with a universal white‑hole boundary and assess entropy‑gradient objections.

## 6  Dynamic Construction via Junction Conditions

By gluing a collapsing Oppenheimer–Snyder dust shell to its time‑reverse through Israel junction formalism, one obtains a finite‑duration white‑hole burst that releases the shell back to infinity. Stability issues and Tolman–Oppenheimer–Volkoff limits are discussed.

## 7  Observational Prospects

Candidate signals include ultra‑high‑energy cosmic rays, certain classes of fast radio bursts, and Planck‑scale relics. We outline parameter windows still unconstrained by current gamma‑ray observatories.

## 8  Conclusion

White holes remain mathematically robust yet empirically shy. Whether quantum gravity vetoes their formation—or disguises them as short‑lived transients—remains unresolved. Continued study sharpens our understanding of horizon thermodynamics and time‑asymmetric boundary conditions in general relativity.

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