

Theoretical Prediction of a Lifelong Companion to the Galactic Center Black Hole Sgr A*

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Abstract

[Objective] To reveal that the bright companion of Sgr A* is not an accretion disk, but rather a self-organized magnetized plasma circulation generated by its own “selective ingestion-ejection” mechanism. [Methods] Based on plasma particle-level Lorentz decoupling and motional polarization effects, we propose that black holes screen particles through the intrinsic ingestion field strength (Z 's-Er) during high-accretion phases, and the ejected lightweight material forms an immortal sheath-core structure under low-frequency long-period electromagnetic perturbations. [Results] This elucidates the nature of the associated bright ring around companion-less black holes, resolves the accretion disk lifetime paradox, and predicts a joint angular momentum-magnetic rigidity stabilization mechanism for the circulation. [Limitations] The perturbation effects of interstellar medium collisions on the circulation, as well as the saturation behavior of Z 's-emf under extreme accretion rates ($\dot{M} > 10^{-4} M_{\odot}/\text{yr}$), are not quantitatively discussed. [Conclusion] Magnetized plasma circulation can serve as a lifelong companion to massive black holes, with an existence timescale exceeding the galaxy evolution period. **Keywords:** black hole evolution, selective ingestion, plasma self-organization, sheath-core structure, magnetized circulation, Z 's-Er. **Classification Numbers:** P145.8 (Black Hole Physics), P147 (Plasma Astrophysics).

Full Text

Title: The Eternal Companion of Black Holes: Magnetized Plasma Torus as the Persistent Structure Around Sgr A*

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Abstract

[Objective] To reveal that the bright companion of Sgr A* is not an accretion disk, but rather a self-organizing magnetized plasma circulation generated by its own “selective ingestion-ejection” mechanism. **[Methods]** Based on plasma particle-level Lorentz decoupling and motion polarization effects, we propose that during periods of high accretion, black holes screen particles through an intrinsic ingestion field strength ($Z's\text{-}Er$), while ejected light material forms an immortal sheath-core structure under low-frequency, long-period electromagnetic perturbations. **[Results]** This clarifies the nature of the bright ring accompanying a starless black hole, resolves the accretion disk lifetime paradox, and predicts a joint angular momentum-magnetic stiffness stabilization mechanism for the circulation. **[Limitations]** The perturbation effects of interstellar medium collisions on the circulation and the saturation behavior of $Z's\text{-}emf$ at extreme accretion rates ($\dot{M} > 10^{-4}M_{\odot}/\text{year}$) are not quantitatively discussed. **[Conclusion]** Magnetized plasma circulation can serve as a lifelong companion to massive black holes, with an existence timescale exceeding the evolutionary period of galaxies.

Keywords: black hole evolution, selective phagocytosis, plasma auto-organization, sheath nucleus structure, magnetized circulation, $Z's\text{-}Er$

Classification Numbers: P145.8 (black hole physics), P147 (plasma astrophysics)

This work represents the research findings of an independent researcher.

1.1 Research Motivation

This study originated from the author’s theoretical prediction regarding plasma beam confinement by double magnetic mirrors (March 2025), which was subsequently confirmed by JWST observations to be ubiquitous in star-forming regions [?, ?]. When the author first encountered the EHT image of Sgr A, *it was initially mistaken for a sheath-core structural circulation. What proved more perplexing was why conventional theory insisted on interpreting it as an accretion disk powered by a companion star—particularly since Sgr A has long since lost its companion.* The “corpse” of an accretion disk (a magnetohydrodynamic channel remnant without material supply) cannot exceed the viscous timescale (~ 0.1 Myr) [?]. This strongly suggests that its bright ring is fundamentally a different type of self-sustaining plasma structure—one that must possess independent material sources and energy maintenance mechanisms. Understanding its origin became the impetus for this research.

1.2 Key Breakthroughs

1. Particle-Level Decoupling of Lorentz Force

Unlike electron motion in conventional conductors where Lorentz force is trans-

mitted through the crystal lattice, each free charged particle in plasma independently generates closed magnetic field lines (directed Lorentz vortex rings) during directional motion, with intensity determined by both particle charge q and velocity v ($\text{MATH}_{\{\text{EXPRESSION}\}}$). This force-field decoupling at microscopic scales forms the basis for subsequent motion polarization and self-organization phenomena.

2. Motion Polarization Effect (Z's-polarization)

When plasma undergoes directional motion, the directed Lorentz vortex rings of positive and negative charges exhibit opposite polarity, generating mutual repulsion along the direction of motion. Although positive and negative charge numbers are equal, the mass ratio is substantial. Negative charges accelerate away from positive charges, causing dynamic charge separation.

3. Self-Organizing Sheath-Core Bidirectional Flow Structure

Plasma can self-organize into sheath-core bidirectional flow structures under appropriate frequency electromagnetic perturbations, which may originate from black hole rotation. This likely represents the optimal solution for plasma to maintain energy without dissipation. Recent JWST discoveries have confirmed the ubiquitous presence of sheath-core plasma structures from protostellar disks to active galactic nuclei, corroborating the natural universality of this mechanism.

2.1 Stage 1: Selective Ingestion During High Accretion

1. Ingestion Dynamics

Companion star material falls into the black hole through the accretion disk. Plasma particles in directional motion experience three forces:

- **Electrons:** Black hole gravity + polarization repulsion + ultra-high initial velocity (caused by accretion dynamics) \rightarrow penetrate deep inside the event horizon;
- **Nucleons:** Black hole gravity + negligible repulsion + low initial velocity (caused by accretion dynamics) \rightarrow remain at the event horizon surface.

2. Birth of Z's-Er

The ingestion dynamics enrich nucleons at the event horizon surface and electrons inside it, creating a static electric field between these points called Z's-Er.

This electrostatic field strength satisfies:

- Ingestion intrinsic field strength, $E \propto \alpha \times \beta$
- Mass correlation coefficient, γ
- Black hole mass, M_{BH}

This electrostatic field resists the ingestion of relatively light nucleons.

3. Selective Ingestion Threshold

The threshold varies with accretion rate. Nucleons with q/m values exceeding the threshold, along with electrically neutral electrons, will be collectively repelled outside the event horizon, forming a plasma soup. Although small-mass

black holes also possess ingestion intrinsic field strength, their lower mass and gravity result in slower ingestion rates, preventing them from excluding protons and thus ingesting everything. Photons are electrically neutral and cannot be ionized; moving photons have mass > 0 , but their q/m value = 0, making them easier to ingest than heavy nucleons.

2.2 Stage 2: Companion Star Depletion and Accretion Disk Demise

1. Silent Collapse of Spiral Channels

In the accretion disk's spiral channels, electron currents at relativistic speeds contract into the channel entrance first, while nucleon currents with greater mass and lower velocity follow with delay. Subsequently, the magnetic fields confining the channels disappear circle by circle (demise duration $< 10^5$ years).

2. Rise of Sheath-Core Structure

The plasma soup expelled by selective ingestion driven by the intrinsic ingestion field strength self-organizes into a multi-layered sheath-core structure toroidal beam flow under low-frequency electromagnetic perturbations from black hole rotation (modulated by spin). Its stability derives from:

1. Centrifugal force from angular momentum conservation resisting black hole gravity;
2. A robust internal-external skeleton composed of magnetic tension networks between adjacent vortex rings;
3. Multi-beam interlocking topology with mutual enhancement effects.

2.3 Stage 3: Eternal Companion of an Isolated Black Hole

1. Maintenance Mechanism of Immortal Circulation

The key lies in self-organization-derived self-cleaning, self-proliferation, and self-healing capabilities that resist non-destructive perturbations. Its existence timescale is limited only by the host galaxy's lifetime ($> 10^{10}$ years).

2. Observational Verification

EHT polarization observations of Sgr A* reveal:

Traditional Model Contradictions	Sgr A* Observations	This Theory's Explanation
Accretion disks should exhibit turbulence	Sgr A* bright ring shows ordered polarization [?]	Sheath-core ring structure (implicitly ordered)
No companion star, yet stable > 1 Myr	Viscous timescale only 0.1 Myr	Z's-Er continuously generates plasma soup

Traditional Model	Sgr A*	This Theory's
Contradictions	Observations	Explanation
mHz frequency fluctuations	—	Reflects self-organization perturbation frequency

3. Revolutionary Breakthrough Against Traditional Theory

Core Issues	Accretion Disk Model Dilemmas	This Theory's Solution
Material Source	Depends on continuous companion star supply	Black hole's own ingestion-ejection cycle (Z's-Er driven)
Radiation Mechanism	Thermal bremsstrahlung cannot explain high-energy flares	Sheath-core synchrotron-curvature radiation
Lifetime	Turbulence causes short lifetime ($\sim 10^5$ years)	Sheath-core magnetic stiffness maintenance ($> 10^{10}$ years)

4.3 Classical BZ Mechanism

The classical Blandford-Znajek mechanism [?] extracts energy through black hole rotation but does not address jet material sources. Section 4.2 resolves the source problem, while black hole rotational electromagnetic perturbations enable the plasma soup's self-organizing capability to construct an eternal sheath-core circulation.

4.4 New Observational Paradigm

We hope to verify sheath-core geometry through multi-band polarization interferometry. Future work will focus on:

- Quantifying the universal relationship between Z's-Er and black hole parameters;
- Reproducing sheath-core formation processes through GRMHD simulations;
- Investigating the hinge mechanism of multiple circulations, which requires further study.

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Author Contribution Statement: Beikai Zeng: Independently proposed the theoretical framework, developed the argumentation, and drafted the manuscript.

Note: Figure translations are in progress. See original paper for figures.

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