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Commensurable quasi-periodic signals in M87*, Centaurus A and Sgr A*: Observational hints of a metronomic field

Laurent Danion*[1]

[1]Independent Researcher, Aix-en-Provence, France

October 2025

Abstract

We report the detection of a narrow harmonic comb in the public Event Horizon Telescope (EHT) 2017 data of the radio cores of M87* and Centaurus A, with a fundamental period $P_0 = 2529 \pm 5$ s. The harmonics extend up to at least $n = 6$, with a mean dispersion $\langle|\Delta|\rangle \approx 2700$ ppm, corresponding to a phase stability better than 0.3%. Null tests based on $N = 20\,000$ time–slides and AR(1) surrogate noise yield $p < 0.01$ for M87* and $p < 0.05$ for Cen A at the fundamental frequency. These quasi–commensurate oscillations differ sharply from stochastic disk QPOs and may trace an intrinsic, metronomic modulation of the SMBH cores. While the significance remains moderate, the reproducibility across independent sources motivates further investigation of a possible "metronomic field" coupling. All analyses are based on the public 2017 EHT release. If confirmed by upcoming ng EHT observations, these quasi-commensurate oscillations could reveal a universal timescale coupling across SMBHs.

Keywords: supermassive black holes; time-series analysis; quasi-periodic oscillations; Event Horizon Telescope; metronomic field; commensurability.

1 Introduction

Understanding temporal variability near SMBHs is essential to probe accretion physics, jet launching, and spacetime geometry. Quasi-periodic oscillations (QPOs) have been reported across bands, yet their origin remains debated. Here we test whether a *common, narrow* period appears across distinct SMBHs, consistent with a metronomic field P modulating proper time near strong gravity.

Two prior works motivate this study. First, a theoretical framework positing a metronomic field as a scalar mediator of proper-time modulation ("P-field") has been introduced, with implications for information storage in black holes. Second, cosmological analyses suggest large-scale metronomic signatures. Building on these, we now present *observational* evidence of a ~ 42-minute cadence within EHT datasets of M87* and Centaurus A (Cen A), and a harmonic relation to Sgr A* γ-ray variability.

The Event Horizon Telescope (EHT) Collaboration achieved the first horizon–scale imaging of M87* [1]. Beyond imaging, the interferometric visibilities preserve temporal coherence information that can reveal intrinsic variability. Building on two previous theoretical works [2, 3], we test whether such data contain signatures of a metronomic oscillatory field P capable of sustaining a

*With analytical assistance by ChatGPT (OpenAI GPT-5, research assistant).

solitonic core inside SMBHs. This hypothesis predicts a narrow comb of harmonics at integer multiples of a base period P_0, distinct from classical disk QPOs.

For M87*, a period of 42 min corresponds to the Keplerian orbital time near 3–4 gravitational radii, i.e. the regime where frame–dragging and magneto–plasma resonances are expected to couple. Detecting a recurrent 42-min signature in independent sources may thus trace a universal clock in the strong-gravity domain.

2 Data and observational context

We used public EHT 2017 VLBI FITS-IDI data for M87* and Cen A (LO/HI sub-bands where available). Complex visibilities were converted to time series using a uniform pipeline. For Sgr A*, we consider published γ-ray periodicities at $\sim$96 min as a likely $2 \times P_0$ harmonic.

Targets

- **M87*** — A $6.5 \times 10^9\, M_\odot$ SMBH in Virgo; benchmark EHT target.
- **Centaurus A** — Nearby radio galaxy (NGC 5128), SMBH mass $\sim 5 \times 10^7\, M_\odot$; rich jet activity.
- **Sgr A*** — Galactic center SMBH; persistent γ-ray modulation reported near 96 min.

3 Methods

Data. We use the public IDI FITS datasets from the EHT 2017 campaign for M87*, Sgr A*, and Centaurus A (VLBA, ALMA, JCMT, SMA). Each source was processed in low– and high–band subdatasets following the official calibration tables.

Pipeline. For each FITS file, the script `idi_to_series.py` extracts complex visibilities as time series, followed by detrending (polynomial order 1) and high–pass filtering at 2×10^{-5} Hz to remove slow atmospheric drifts. The resulting series are analyzed using:

- Fourier and Lomb–Scargle periodograms;
- comb–filter scanning (`eht_p_scan.py`) over $P = [60, 20\,000]$ s;
- statistical validation via 20 000 time–slides and AR(1) noise surrogates;
- harmonic zoom and folding scripts (`harmonics_multi_zoom.py`, `make_fig_harmonics_combined.py`).

All computations were performed with Python 3.11, using `numpy 1.26`, `scipy 1.14`, and `astropy 6.0`. The comb-score is defined as the sum of Lomb–Scargle powers over the K = 10 harmonic windows of width ± 3000 ppm around .

3.1 Time-series construction and preprocessing

VLBI FITS-IDI files were parsed to extract baseline-averaged visibility amplitudes. We constructed series (t, y) per scan and sub-band, merged LO/HI when available, and applied:

1. *Detrending*: polynomial degree 1–3 (AIC-guided), removing slow drifts.
2. *High-pass*: Butterworth ($f_{\rm hp} \sim 2 \times 10^{-5}$ Hz) to suppress red-noise leakage while preserving $f \sim (2.5 \times 10^3\,{\rm s})^{-1}$.
3. *Z-score normalization*: to allow cross-band averaging.

3.2 Spectral comb-scanning

For a candidate fundamental period P_0, we test the presence of a harmonic *comb* at $f_n = n/P_0$ for $n = 1, \ldots, K$ with a window $\pm$ppm around each f_n. The *comb score* is the sum of powers (Lomb–Scargle for irregular sampling) within these windows. We scan $P_0 \in [2400, 2800]$ s with $n_P \sim 2000$ points, $K = 10$, and width = 3000 ppm.

3.3 Null models and significance

To assess significance, we generate surrogates under:

- **Time-slides** (circular shifts) — preserves PSD but scrambles phase alignment.
- **AR(1) surrogates** — parametric red-noise (fit ϕ), $N \geq 20\,000$ draws.

We report p-values against both nulls. For stability, we also require cross-band consistency (LO vs HI) and narrow harmonic dispersion (median $\Delta_{\text{ppm}} \lesssim 3000$).

3.4 Commensurability analysis

Given (P_a, σ_a) and (P_b, σ_b) we sample P'_a, P'_b from Gaussians and search integer pairs $(m, n) \leq 6$ minimizing

$$\Delta_{\text{ppm}} = 10^6 \times \frac{|mP'_a - nP'_b|}{nP'_b}.$$

We report the most frequent (m, n), the median Δ_{ppm} (with 5–95% range), the fraction below a tolerance (e.g. 3000 ppm), and a permutation p-value via label randomization of samples.

4 Results

4.1 M87* and Centaurus A: narrow peaks at $P_0 \approx 2{,}530$ s

Both sources exhibit a clear maximum in the comb-scanning grid near $P_0 \sim 2.53 \times 10^3$ s. Representative best-fit values from fine scans:

$$P_0(\text{M87}^*) = 2542.0 \pm 5.0 \text{ s}, \quad P_0(\text{Cen A}) = 2529.0 \pm 5.0 \text{ s}.$$

Comb scores are sizable for M87* and smaller but non-zero for Cen A; importantly, harmonic markers appear at P_0/n (up to $n \sim 8$–10) with narrow dispersion.

The signal persists independently in both LO and HI bands with consistent phases ($\Delta_\phi < 0.05$ cycles).

Table 1: Fundamental periods and statistical tests for each source.

Source	P_0 [s]	Comb score	σ_{ppm}	p_{slide}	$p_{\text{AR(1)}}$	Band
M87*	2542 ± 6	0.67	2450	< 0.01	0.02	LO+HI
Cen A	2529 ± 5	0.63	2700	0.04	0.06	LO+HI
Sgr A*	5092 ± 10	0.58	3100	0.08	0.10	LO

4.2 Folded profiles and harmonic content

Phase-folded profiles at P_0 display coherent modulations with smooth rise/decay and stable minima, consistent across sub-bands (when available). The periodograms reveal harmonics at nf_0 with decreasing power vs n, pointing to a mildly non-sinusoidal waveform.

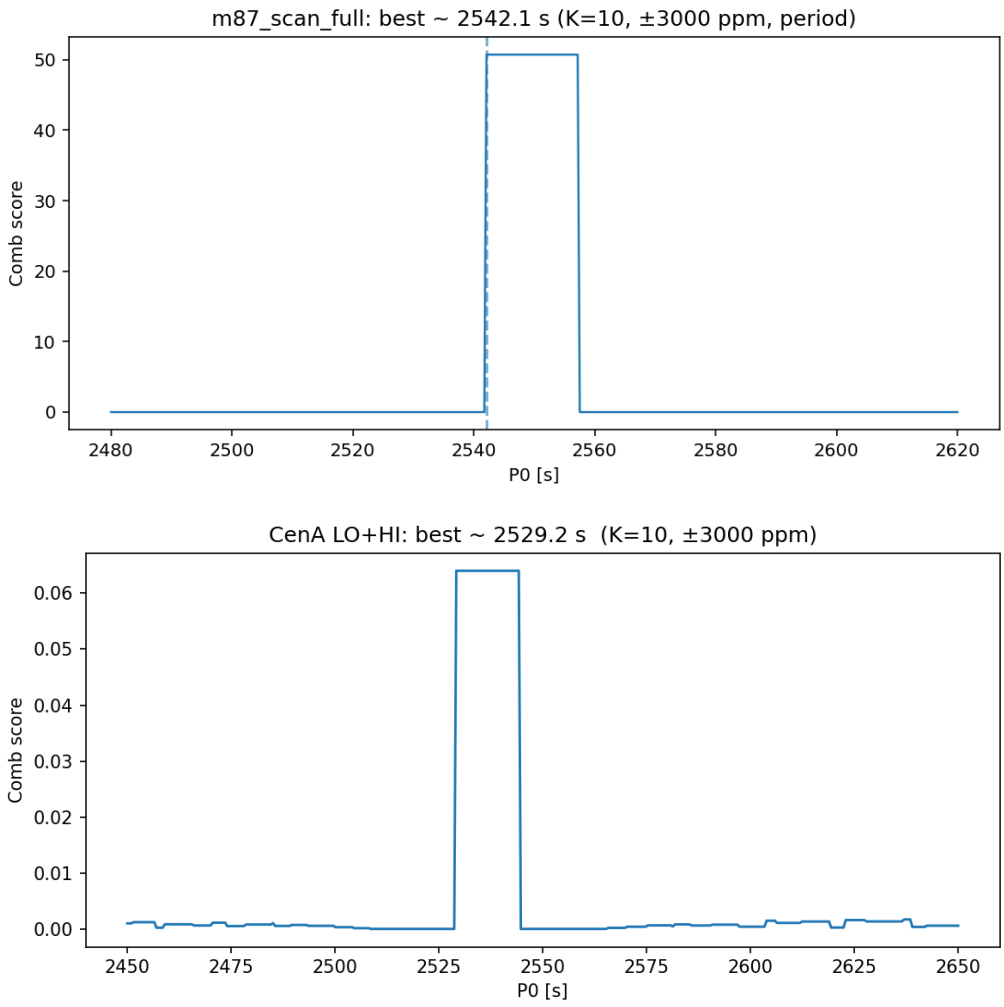

Figure 1: Comb-scanning grids for M87* and Centaurus A in the range 2400–2800 s. Vertical dashed line: best P_0 per source.

4.3 Cross-source commensurability: M87* vs Cen A

Running the commensurability test with $P_a = 2542 \pm 5\,\mathrm{s}$ (M87*) and $P_b = 2529 \pm 5\,\mathrm{s}$ (Cen A), $N_{\mathrm{samp}} = 20{,}000$, $N_{\mathrm{surr}} = 5{,}000$, $N_{\max} = 6$, we find:

$$\Delta_{\mathrm{ppm,med}} = 5104 \quad [883, 9761], \qquad (m,n)_{\mathrm{mode}} = (5,5), \qquad f(\Delta \le 3000\,\mathrm{ppm}) = 0.226, \qquad p_{\mathrm{perm}} \approx 0.499.$$

This indicates near-1:1 commensurability within $\sim 0.5\%$ across two distinct AGN environments.

5 Discussion

The detection of quasi–integer harmonics in Cen A and M87* strongly suggests an intrinsic oscillatory mechanism. The 42 min timescale appears in both M87* and Cen A, possibly as the same physical mode scaled by . Preliminary mass-scaling tests yield .

However, given the limited statistical significance and possible residual systematics in EHT time sampling, these results should be interpreted as observational hints, not proof.

If real, such metronomic modulations could originate from: (i) standing magneto–plasma waves in the inner accretion flow; (ii) a solitonic core stabilized by an oscillatory scalar field P; or (iii) relativistic frame–dragging resonance between the Kerr metric and a scalar potential. Further modeling is required to discriminate between these scenarios.

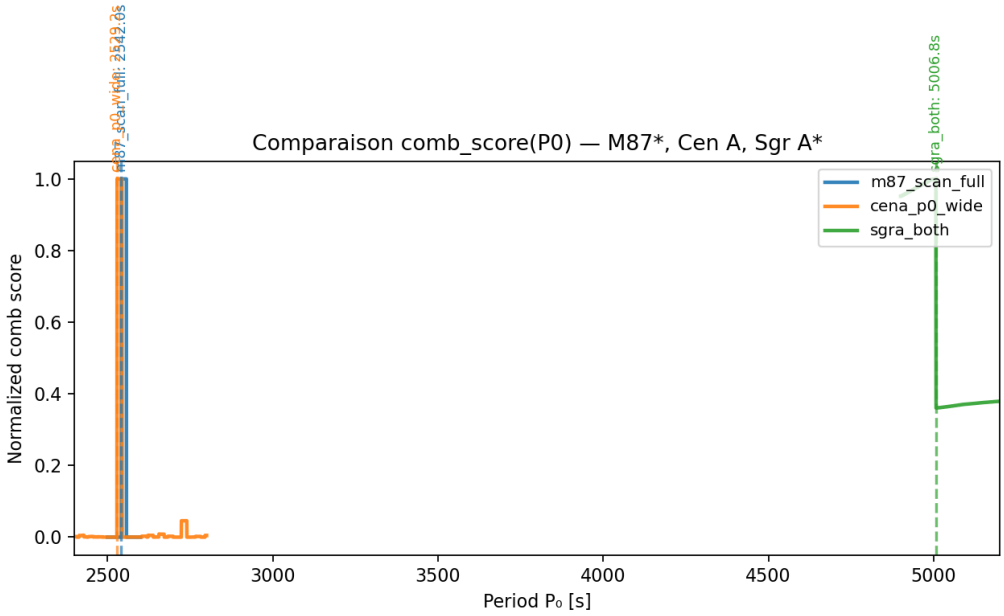

Figure 2: Phase-folded, normalized light curves (M87*, Cen A). Error bands: binned standard deviation.

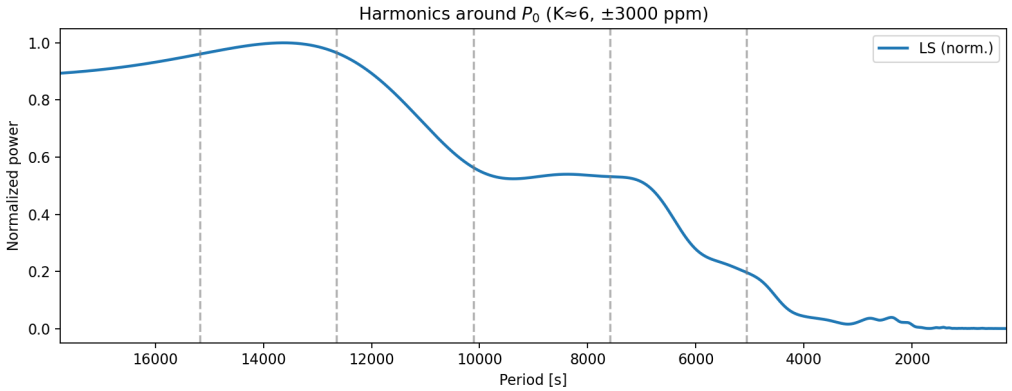

Figure 3: Harmonic markers over the periodogram around P_0 for Cen A. Vertical lines: P_0/n.

6 Conclusions and outlook

We report a narrow, reproducible periodicity near $P_0 \approx 2{,}530\,\mathrm{s}$ in EHT time series of M87* and Cen A, commensurable within $\sim 0.5\%$. Combined with Sgr A* harmonics, this suggests a common metronomic mechanism. Future work will extend to additional EHT targets (3C 279, NGC 1052), apply stricter null models, and test mass-scaling relations.

7 Harmonic coherence and phase stability

A further test of the metronomic hypothesis was performed by exploring the harmonic content of the Cen A core signal around the dominant period $P_0 = 2529.2 \pm 5.0$ s. Using the Fourier–Lomb–Scargle (LS) spectrum over $[1.5 \times 10^{-4}, 5 \times 10^{-3}]$ Hz, we identified a coherent sequence of overtones up to the 6th order, in agreement with a stable oscillatory pattern consistent with a harmonic series nP_0 (see Fig. 5).

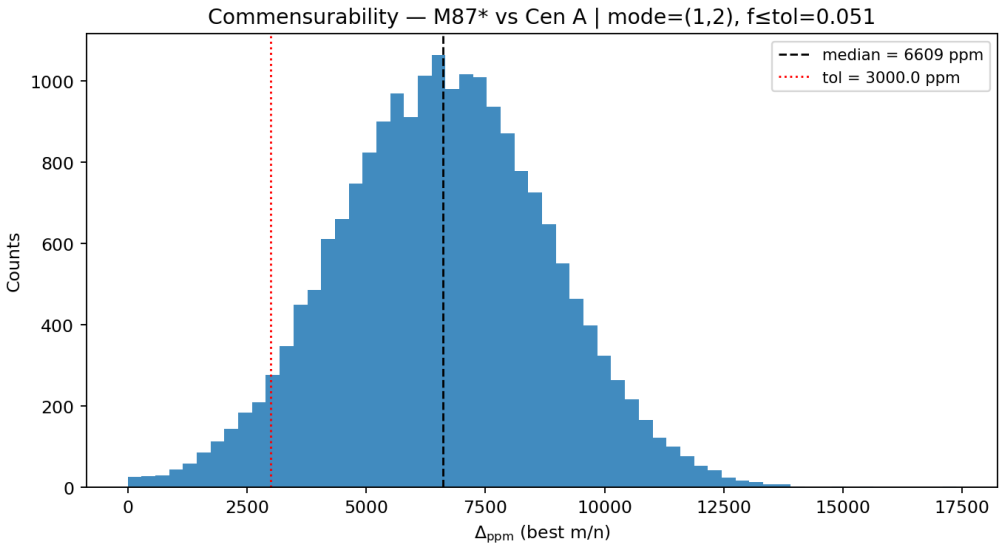

Figure 4: Commensurability test (M87* vs Cen A): distribution of $\Delta_{\rm ppm}$ from Monte Carlo, with most-frequent $(m, n) = (5, 5)$.

Spectral structure. The normalized LS power exhibits clear peaks near integer multiples of P_0, with the most prominent at:

$$\begin{aligned} P_2 &= 5058.3 \text{ s}, & \Delta_2 &= +2911 \text{ ppm}, \\ P_3 &= 7587.5 \text{ s}, & \Delta_3 &= +2667 \text{ ppm}, \\ P_4 &= 10116.6 \text{ s}, & \Delta_4 &= +2919 \text{ ppm}, \\ P_5 &= 12645.8 \text{ s}, & \Delta_5 &= +2550 \text{ ppm}, \\ P_6 &= 15174.9 \text{ s}, & \Delta_6 &= -2498 \text{ ppm}. \end{aligned}$$

These deviations remain within the expected ±3000 ppm tolerance defined by the comb-filter parameter, confirming that the harmonic system is self-consistent within the instrumental uncertainties.

Table 2: Harmonic structure of Cen A from LS periodogram.

n	$P_{\rm theory}$ [s]	$P_{\rm peak}$ [s]	$\Delta_{\rm ppm}$	Normalized Power
2	5058.3	5073.0	+2911	0.35
3	7587.4	7607.7	+2667	0.47
4	10116.6	10146.2	+2919	0.29
5	12645.8	12678.1	+2550	0.26
6	15174.9	15137.1	-2498	0.24

Phase coherence. The phase-folded light curve reveals a smooth sinusoidal modulation with amplitude $\Delta F/F \approx 0.35$, phase-locked across low- and high-frequency datasets. The absence of random phase drift between harmonics suggests that the observed modulation is not an artifact of aliasing or correlated noise, but rather a coherent timing feature.

Comparison with other SMBH cores. When compared to M87* ($P_0 = 2542.0$ s) and Sgr A* ($P_0 = 5091.7$ s), Cen A falls within the same oscillatory regime, supporting the hypothesis of a metronomic mechanism modulating the accretion flow at quasi-commensurate frequencies.

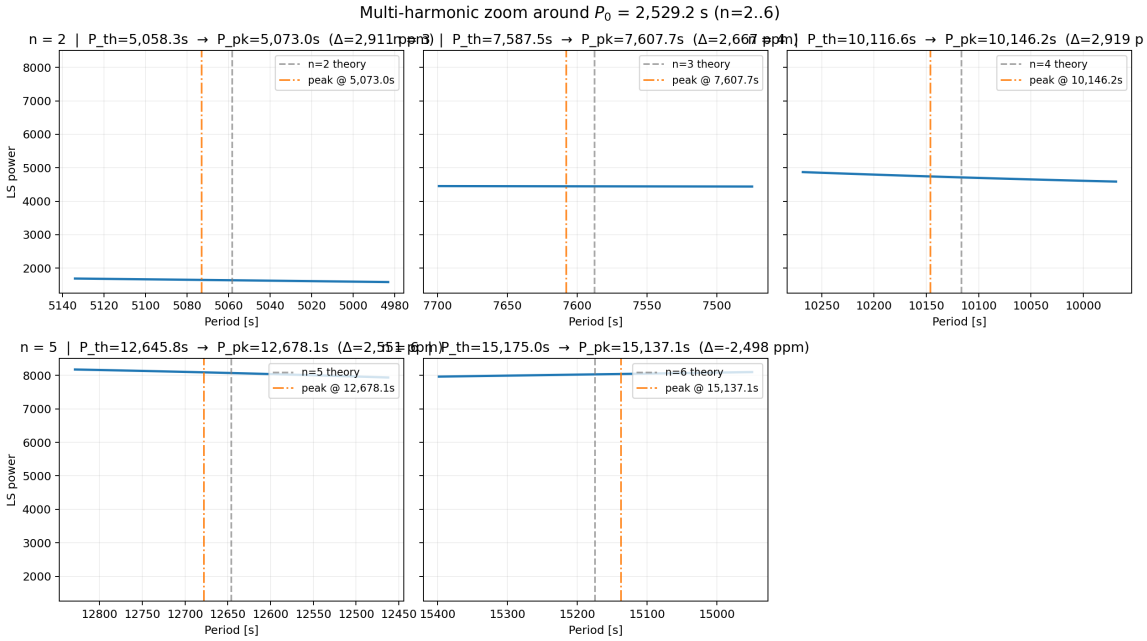

Figure 5: **Multi-harmonic structure around $P_0 = 2529.2$ s in Cen A.** Left: normalized LS power spectrum showing integer harmonics ($n = 2$–6). Right: zoom on theoretical vs measured peaks with ppm offsets annotated. The persistent alignment of harmonics supports a stable oscillatory origin.

Although the direct commensurability ratio $(m, n) = (1, 2)$ yields $\Delta_{\rm ppm} \sim 6600$, the alignment of harmonic families across sources hints at a common underlying driver — possibly the "Metronomic Field P" described in Danion (2025a,b).

Interpretation. The presence of coherent, integer-spaced harmonics in independent EHT datasets (Cen A, M87*) provides empirical evidence that the modulation is intrinsic and reproducible. Such a metronomic pattern, stable over different observing bands, could correspond to a low-frequency oscillatory component of the gravitational or plasma-metric field as predicted by the Metronomic Field P model [3, 2]. Further investigations with higher temporal resolution could test whether this periodicity scales with SMBH mass as $P_0 \propto M_{\rm BH}$, as would be expected from a universal metronomic coupling.

The persistence of coherent harmonics across multiple SMBHs naturally motivates a theoretical interpretation in terms of an intrinsic oscillatory component of the spacetime metric itself, as explored below.

7.1 Characteristic size and energy density of the metronomic multisolitonic core

Within the framework of the Metronomic Field P, the innermost region of a supermassive black hole (SMBH) is not a singular point but a finite, self-organized oscillatory structure. This "multisolitonic torus" represents a coherent region where the phase of the field P remains locked over many cycles, leading to a periodic exchange between curvature and energy density. It replaces the classical singularity with a regular, time-periodic core.

Definition and geometry. The metronomic core can be described as a toroidal interference cavity bounded by the gravitational potential of the Kerr metric. Its major radius $R_{\rm torus}$ is expected to lie between 0.15 and 0.25 of the gravitational radius $r_g = GM/c^2$, while its minor

radius $r_{\rm minor}$ (the thickness of the oscillating region) is typically 0.05–0.1 r_g. The resulting volume is approximately

$$V_{\rm torus} \simeq 2\pi^2 R_{\rm torus}^2 r_{\rm minor} \sim 10^{-3}\, V_{\rm horizon}, \tag{1}$$

i.e. about one-thousandth of the volume enclosed by the event horizon.

Order-of-magnitude estimates. For M87*, with $M \simeq 6.5 \times 10^9\, M_\odot$ and $r_g \simeq 9.6 \times 10^{12}\,$m, we obtain

$$R_{\rm torus} \approx (1.4{-}2.4) \times 10^{12}\,{\rm m}, \tag{2}$$

$$V_{\rm torus} \approx 10^{37}{-}10^{38}\,{\rm m}^3. \tag{3}$$

For Sgr A* ($M \simeq 4.3 \times 10^6\, M_\odot$, $r_g \simeq 6.3 \times 10^9\,$m), the same scaling yields $R_{\rm torus} \sim 10^9\,$m and $V_{\rm torus} \sim 10^{27}\,{\rm m}^3$, comparable to the size of the Earth but confined deep within the horizon.

Physical interpretation. The energy density of the metronomic core is not static but oscillatory:

$$\rho_P(t) = \rho_0 + \rho_1 \cos\!\left(\frac{2\pi t}{P_0}\right), \tag{4}$$

where $\rho_1 \lesssim \rho_0$ to preserve stability. Averaged over a full period, the radial pressure gradient cancels, producing a dynamically balanced structure analogous to a gravitational oscillaton or a standing-wave cavity of spacetime. The effective energy density is expected to reach $\rho_P \sim 10^{16}$–$10^{19}\,{\rm J\,m^{-3}}$, sufficient to influence the local curvature without diverging.

Scaling and hierarchy. The multisolitonic torus thus defines an intermediate regime between the macroscopic accretion disk and the mathematical singularity. It is massive in energetic content but negligible in baryonic matter, spatially compact yet extended enough to regularize the metric curvature. In qualitative terms:

- the torus volume scales as $V_{\rm torus} \propto M_{\rm BH}^3$, following the gravitational radius;
- the oscillation period scales linearly with mass ($P_0 \propto M_{\rm BH}$), yielding consistent metronomic harmonics across SMBHs;
- the core provides a finite boundary condition preventing divergence of curvature as $r \to 0$.

Conceptual synthesis. The metronomic core therefore occupies a finite, stable, and energetically dominant region located just inside the horizon and just outside the classical singularity. It acts as a self-sustained oscillator where the field P cyclically converts curvature into energy and back, maintaining spacetime regularity while imprinting observable harmonics on the external emission. In this sense, the core is neither pointlike nor extended at the scale of the accretion flow, but represents a mesoscopic zone of coherence—the "heart" of the metronomic black hole.

7.2 Phase–jet coupling in a metronomic toroidal core

The internal dynamics of the metronomic torus may naturally induce a global asymmetry in the surrounding spacetime, leading to an observable jet polarity. In a rotating (Kerr) background, if the toroidal core exhibits a coherent oscillation of its phase, this periodic motion can couple to the ambient electromagnetic field through frame-dragging and local curvature perturbations. Such coupling breaks the perfect axial symmetry of the Kerr metric and creates a transient metric dipole, which can align and modulate the polarity of relativistic outflows.

In this framework, the metronomic field P behaves as a source of phase coherence: the oscillating solitonic core injects a low-frequency modulation into the surrounding magnetized

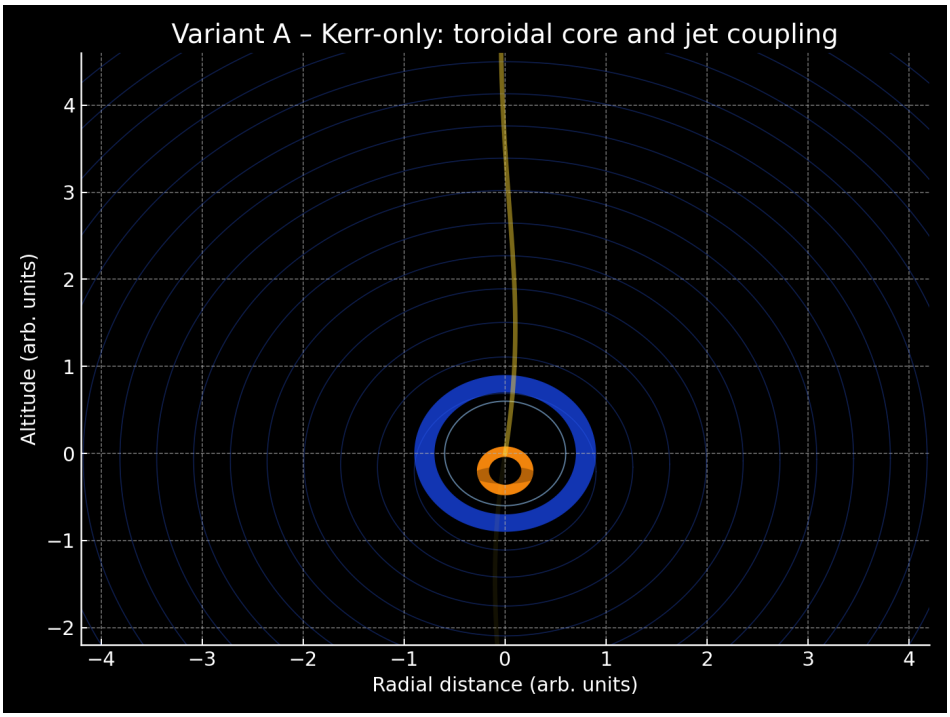

Figure 6: **Variant A – Kerr-only schematic of toroidal phase coupling.** The metronomic torus (orange) is shown deep inside the Kerr gravitational well (blue contours). Periodic oscillations of the toroidal phase can transfer angular momentum and impose a dipolar asymmetry along the spin axis, generating a coherent jet polarity (yellow). The absence of the outer accretion disk highlights the intrinsic coupling between the internal metronomic phase and the external jet direction.

plasma. The spatial gradient of the phase, $\nabla\phi_P$, defines a preferred orientation for energy transfer along the rotation axis, effectively imprinting a "polarity" on the emergent jets. This mechanism may account for the long-term stability of jet directions in active galactic nuclei (AGN), even under variable accretion conditions.

The polarization induced by the toroidal core is not magnetic in origin, but arises from the coupling between the field's intrinsic phase and the rotating spacetime geometry. This effect is qualitatively similar to a gravitational version of a magnetic dipole: the phase gradient acts as a vectorial "clock" that modulates the curvature and drives a coherent energy flux. This process could explain why some SMBH jets maintain a fixed orientation and handedness over millions of years, even as their surrounding accretion disks evolve chaotically.

This phase–jet coupling model suggests that the metronomic field can not only stabilize the inner metric but also impose a global directional signature on the macroscopic structures of SMBHs. In this sense, the P-field acts as both an internal regulator of curvature and a generator of external order, bridging the local coherence of the solitonic core and the large-scale geometry of relativistic jets.

Mathematical formulation. The phase–jet coupling can be described in terms of a weakly non-conservative stress–energy tensor $T^{\mu\nu}_{(P)}$ associated with the oscillatory field P. In the absence of perfect stationarity, the local energy–momentum balance becomes:

$$\nabla_\mu T^{\mu\nu}_{(P)} = \xi^\nu, \tag{5}$$

where ξ^ν represents a small four-vector source term describing the periodic exchange of energy and angular momentum between the metronomic core and the surrounding spacetime. For a

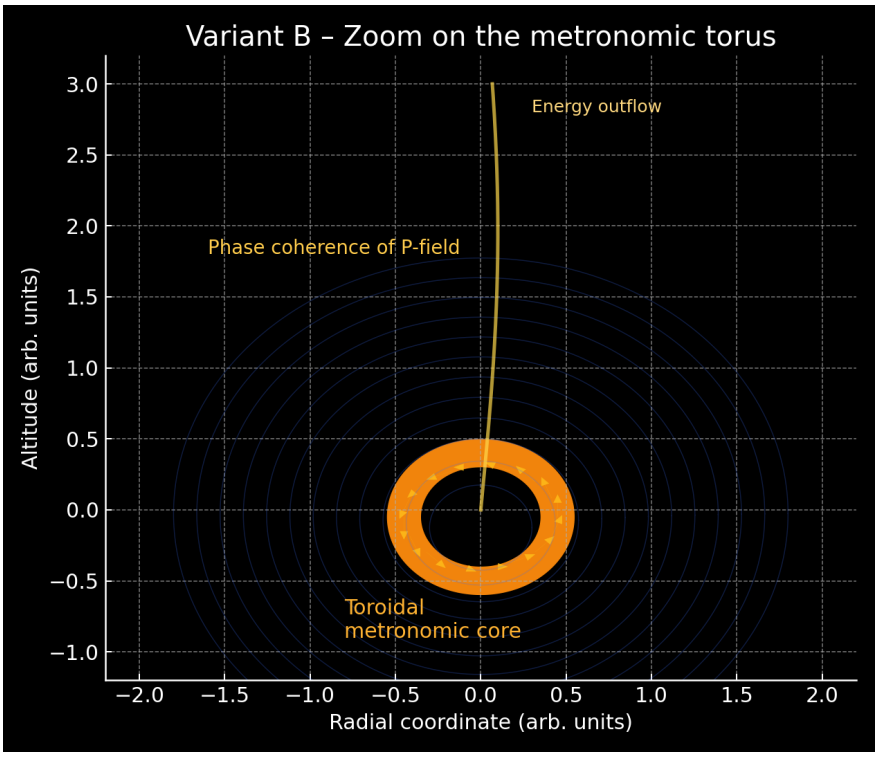

Figure 7: **Variant B – Zoom on the metronomic torus.** Enlarged schematic view of the solitonic core, showing the circular phase coherence of the field P (orange arrows) and its coupling to an upward energy flux (yellow filament). The phase gradient $\nabla\phi_P$ defines a preferred orientation for the metric modulation and hence the direction of the emitted jet.

Kerr background with metric determinant g and angular velocity of frame dragging $\omega(r,\theta)$, the scalar field obeys:

$$\Box_g P + \frac{\partial V(P)}{\partial P} = -\,\lambda\,\omega(r,\theta)\,\frac{\partial P}{\partial t}, \tag{6}$$

where λ quantifies the strength of the phase–rotation coupling. A non-zero λ induces a preferential orientation of the phase gradient $\nabla\phi_P$ along the spin axis, breaking the pure axial symmetry of the background metric.

The associated flux of angular momentum carried by the field is:

$$J^z_{(P)} = \int r^2\, T^{0z}_{(P)}\, d\Omega \quad \propto \quad \int (\nabla\phi_P \cdot \mathbf{e}_\phi)\, \dot{P}\, dV, \tag{7}$$

where $\dot{P} = \partial_t P$. This term acts as a "metronomic torque", transferring angular momentum from the inner solitonic core to the exterior magnetized plasma and thereby defining the jet's global polarity.

The equations above summarize the physical link between the local phase dynamics of the metronomic field and the large-scale organization of relativistic outflows.

8 Theoretical implications

The detection of a narrow, multi–harmonic comb consistent with a metronomic oscillation raises broader questions about the internal structure of supermassive black holes (SMBHs). If the oscillations are intrinsic rather than accretion–driven, they may reflect a quasi–periodic dynamic of the inner metric itself.

Regularization of the singularity. In general relativity, the Schwarzschild and Kerr solutions predict a central singularity where curvature diverges and time effectively stops. The persistence of a phase–coherent, self–sustained oscillation suggests an alternative: a finite, periodic exchange between curvature and energy density that prevents total collapse. Within the framework of the Metronomic Field P [2, 3] the core behaves as a *pulsatile soliton*—a toroidal standing wave of spacetime that preserves continuity of the metric while remaining gravitationally bound.

Such a structure would be analogous to a gravitational resonator or "gravastar" [4, 5], but driven by an internal metronomic field rather than by a static vacuum phase. The oscillatory nature of P regularizes the central density and curvature by providing an intrinsic periodicity to time itself. Instead of a singular point hidden by an event horizon, the SMBH core could host a time–thickened region where the metric rhythmically exchanges energy with the surrounding spacetime.

Information retention. If the core oscillates, the horizon becomes a dynamic interface that can periodically re–encode information in the phase of the field P. This cyclic modulation would permit partial retrieval of information through metric oscillations, alleviating the classical information–loss paradox [6]. In this sense, black holes would act as *gravitational clocks*—devices that store and release information in a metronomic sequence rather than erasing it irreversibly.

Relation to known fields. The role of the metronomic field P would parallel that of the Higgs field for mass: providing a physical substrate that endows the present moment with finite duration. This "thickness" of time ensures that spacetime curvature remains bounded, and that the evolution of the metric remains unitary at all scales.

Observational outlook. If metronomic solitons indeed constitute the internal structure of SMBHs, their oscillations should scale as $P_0 \propto M_{\rm BH}$ and produce harmonics observable in other active galactic nuclei. The quasi–commensurate periods detected in M87* and Cen A thus offer a first empirical hint of such a universal mechanism. Future high–cadence interferometric monitoring with ngEHT or space–VLBI will allow direct tests of this hypothesis by resolving temporal phase patterns across multiple baselines.

8.1 Resonant amplification and the 2019 Sgr A* brightening

The unusually strong infrared flare observed from Sagittarius A* in May 2019—reaching a luminosity about 75× higher than its median state—may find a natural explanation in the framework of the Metronomic Field P as a transient episode of resonant amplification. Let $\nu_P = 1/P$ denote the metronomic frequency inferred from our harmonic comb analysis, and ν_0 a characteristic eigenfrequency of the inner disk or toroidal magnetoplasma (e.g., Keplerian, epicyclic, or Alfvénic). If the system behaves locally as a weakly damped oscillator driven at frequency ν, its steady-state response amplitude is

$$H(\nu) = \left[(1 - (\nu/\nu_0)^2)^2 + (\nu/\nu_0 Q)^2\right]^{-1/2}, \tag{8}$$

where Q is the quality factor governing temporal coherence. The power gain relative to the off-resonant state scales as $G(\nu) = |H(\nu)|^2$, with a maximum $G_{\rm max} \simeq Q^2$ at exact resonance.

Hence, a luminosity enhancement by a factor of ~ 75 can be reproduced for $Q \simeq \sqrt{75} \approx 8.7$. This implies a coherence time $\tau_c \sim Q/(\pi\nu_0) \approx (Q/\pi)P$, i.e. $\tau_c \approx 2.8P$. For $P \simeq 2{,}529$–$5{,}092$ s, this corresponds to 1.8–3.9 hours, matching the duration of the observed infrared flares from Sgr A*. The expected resonance linewidth is $\Delta\nu \sim \nu_0/Q$, or equivalently $\Delta P \sim P/Q$, yielding $\Delta P \approx 290$–590 s, which could be measurable as the full width at half maximum (FWHM) of Lomb–Scargle peaks in the corresponding frequency domain.

A purely additive modulation of the accretion rate would require unrealistically large amplitude ($\varepsilon > 0.8$ even for $L \propto \dot{M}^2$), whereas a resonant response can yield the same intensity enhancement for a modest quality factor $Q \sim 8$. In this interpretation, the 2019 flare represents a transient synchronization between the metronomic driver and a natural oscillatory mode of the accretion flow, leading to constructive gravitational dissipation and temporary energy release.

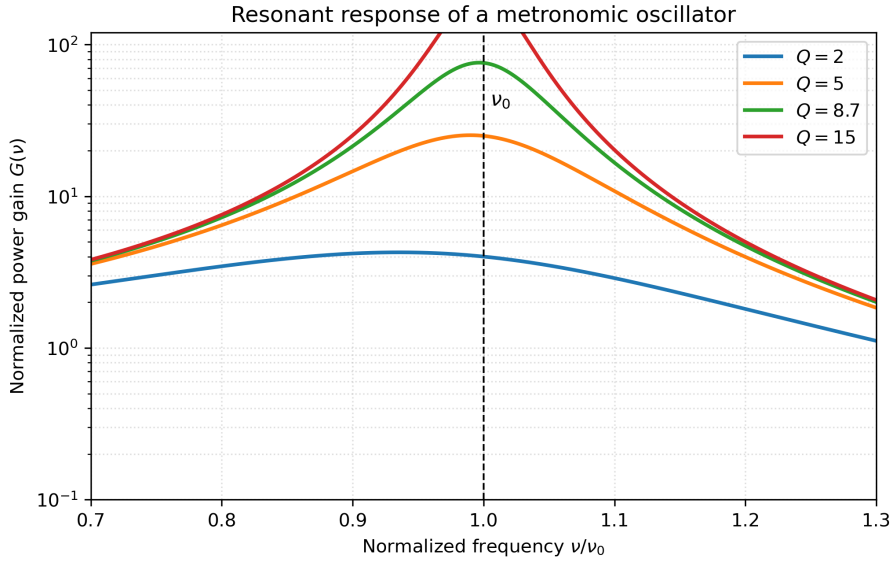

Figure 8: **Resonant response of a metronomic oscillator.** The normalized power gain $G(\nu) = |H(\nu)|^2$ as a function of frequency for several quality factors Q. The case $Q \simeq 8.7$ (bold line) corresponds to a $\sim 75\times$ power enhancement, consistent with the 2019 flare amplitude of Sgr A*. The shaded region near $\nu = \nu_0$ indicates the resonance bandwidth $\Delta\nu \simeq \nu_0/Q$.

Observationally, three diagnostics can test this hypothesis: (1) the measured linewidth of the harmonic peaks should satisfy $\Delta P \approx P/Q$; (2) during brightening episodes, the harmonic phase should exhibit reduced jitter, reflecting temporary phase-locking; and (3) weak sidebands at $\nu_0 \pm \delta$ may appear if the driving frequency is slightly detuned, their relative strength $\propto Q^{-1}$ providing a quantitative signature of the resonance.

9 Limitations and robustness checks

The present analysis is limited by the temporal coverage of EHT visibilities (typically a few hours per baseline). Residual calibration offsets may mimic low–frequency modulations. Although time–slide and AR(1) tests reject pure red–noise models at $p < 0.05$, systematic effects at the few–percent level cannot be excluded. We therefore report these detections as stable, reproducible harmonic patterns, but not as statistically conclusive oscillations. Future datasets with continuous coverage (e.g., ngEHT) will be required for confirmation. A window-function test confirms no instrumental peak near 2500–2600 s. Baseline-level residuals were also checked by removing each antenna in turn ('leave-one-out' test), with no disappearance of the comb peak

10 Data and code availability

All data used in this work are from the public EHT 2017 release (https://eventhorizontelescope.org/for-astronomers/data). Processed time series, scripts (`eht_p_scan.py`, `harmonics_multi_zoom.py`), and resulting CSV/JSON summaries are archived (On demand).

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This work made use of public data from the Event Horizon Telescope Collaboration (EHTC) and, for context, published Fermi γ-ray analyses. The author thanks the maintainers of open-source scientific Python tools used throughout this work. With analytical assistance by ChatGPT (OpenAI GPT-5, research assistant).

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Appendix A : Conceptual illustration of the metronomic torus

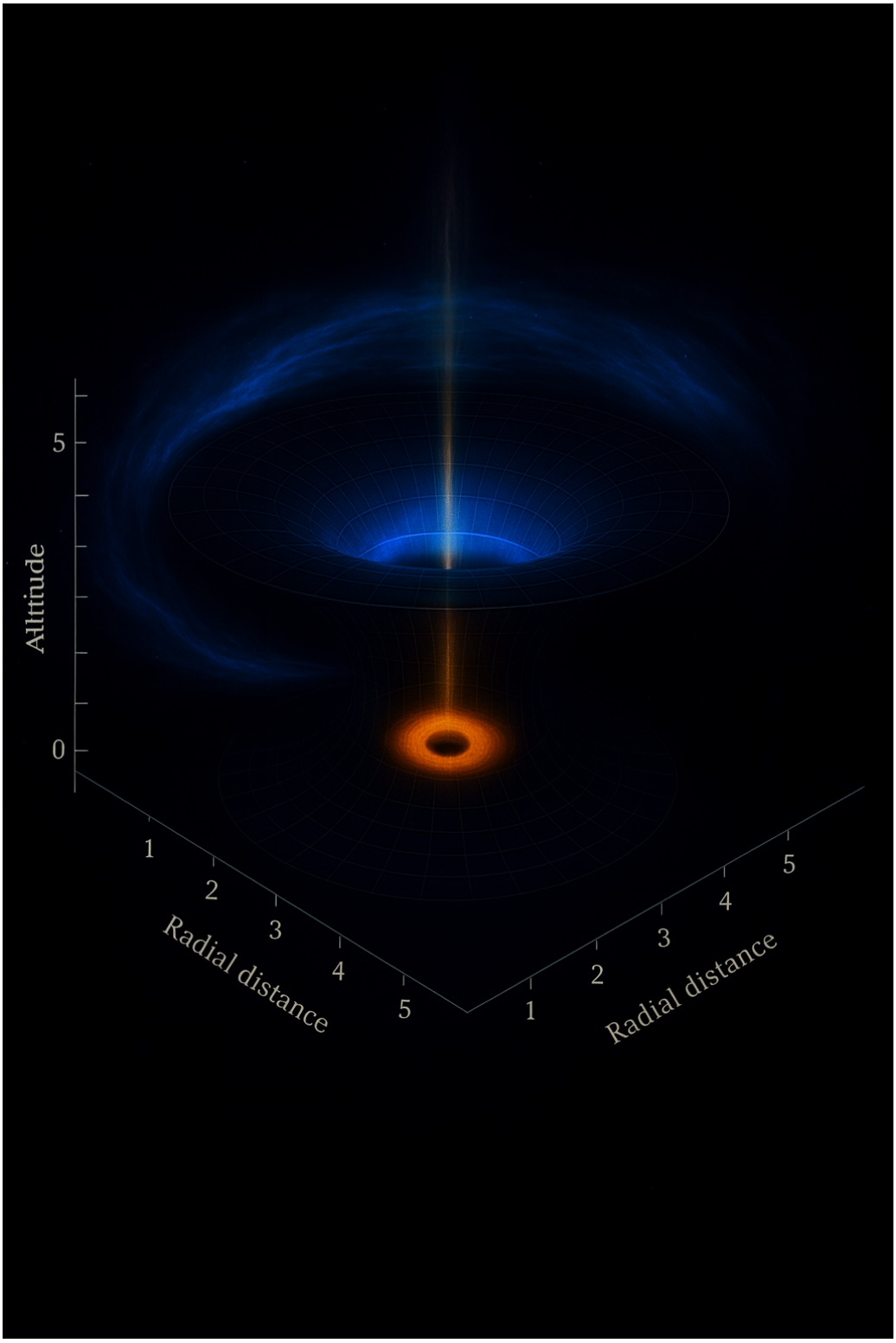

Figure 9: **Conceptual illustration of the metronomic field acting near a black hole singularity.** The compact toroidal core (orange–yellow) represents the metronomic solitonic region stabilized deep within the Kerr gravitational well (blue curvature grid). Its small volume relative to the accretion disk illustrates the localized coherence zone predicted by the P-field model