THE BLACK HOLE AS NATURAL COMPUTER

Gravitational Intelligence, the Manifold FFT, and the Andromeda XXXV Anomaly

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A CCT-ODE Theoretical Framework

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> *"The black hole is not a destroyer of information. It is its most efficient processor."* — CCT-ODE Framework, this volume

Abstract

This treatise develops a unified theoretical framework in which supermassive and intermediate-mass black holes (BHs) function as natural gravitational computers, encoding per-particle information on their event horizons and computing optimal strategic responses to external perturbations. The central case study is Andromeda XXXV (And XXXV), an ultra-faint dwarf satellite of M31 whose anomalously young stellar population (~6 Gyr) violates standard quenching models. We argue that And XXXV is not a paradox of galaxy formation but the first observed instance of a BH executing a divide-and-conquer jet strategy, computed via a 360-degree manifold Fourier transform (FFT) across the horizon surface.

The framework integrates four theoretical pillars: (1) the holographic principle as a per-particle encoding mechanism, (2) Conditional Collapse Theory (CCT) as the decision architecture, (3) the gradient method as the universal computation substrate, and (4) ancient strategic axioms as the behavioral signature of a causally privileged agent. The result is a falsifiable, simulation-ready model of galactic intelligence emerging from first principles of general relativity and information theory.

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1. The Anomaly: Andromeda XXXV

1.1 Observational Facts

In 2025, the discovery of Andromeda XXXV shattered a foundational assumption of dwarf galaxy evolution. Standard cosmological models predict that any satellite galaxy orbiting a massive host like M31 should have had its star-forming gas stripped or heated — quenched — more than ten billion years ago. The surviving galaxy should be a fossil: ancient, metal-poor, and dark.

And XXXV is none of these things. Its stellar population has a median age of approximately 6 billion years — young by galactic standards, impossibly young by quenching theory. It is ultra-faint (absolute magnitude -6.0) yet structurally coherent and actively star-forming. It has survived conditions that should have killed it, and it shows no signs of distress.

Parameter	Value	CCT Interpretation
Distance from Earth	~2.53 million ly	Within M31 conditional collapse horizon
Median stellar age	~6 Gyr (anomalously young)	Limit cycle — not a fixed fossil point
Metallicity [Fe/H]	~-1.8 (very low)	Ancient gas, repeatedly reprocessed
Absolute magnitude	-6.0 (ultra-faint)	Low entropy signal, high pattern complexity
Half-light radius	~200 ly (compact)	Enhanced internal feedback geometry
Dark matter halo	~10^8 M☉ (estimated)	Phase space reservoir for oscillation
Orbital period (M31)	~1.2 Gyr (inferred)	Matches star-formation cycle period
Quenching status	NOT QUENCHED	Phase-locked inversion of tidal forces

1.2 The Standard Model Failure

The standard quenching model treats external pressure as a monotonically increasing function that drives the star formation rate (SFR) to zero. In dynamical systems terms, it predicts a globally attracting fixed point at SFR = 0. And XXXV refuses to converge to this point. Its entropy — the uncertainty of its future trajectory — remains stubbornly non-zero.

The CCT diagnosis is precise: the standard model is asking the wrong question. It asks, 'Did external quenching occur?' The correct question is, 'What is the topology of the system's phase space?' The answer, as we develop below, is that And XXXV is not a fixed point system. It is a limit cycle system, maintained by an internal agent operating from a causally privileged position: its central black hole.

2. The Black Hole as Natural Computer

2.1 Computational Capacity of the Event Horizon

Seth Lloyd's landmark calculation established that a black hole of mass M performs approximately 10^{51} operations per second per kilogram of mass. For a supermassive black hole of 10^8 solar masses, this yields a computational rate that exceeds any human-built system by approximately forty orders of magnitude. This is not a metaphor. It is a direct consequence of the Margolus-Levitin theorem applied to the quantum degrees of freedom encoded on the event horizon.

The Bekenstein-Hawking entropy of a black hole is:

$$S = (k_B \cdot c^3 \cdot A) / (4 \cdot G \cdot \hbar)$$

where A is the horizon area. For an intermediate-mass black hole of 10^5 solar masses — the likely occupant of And XXXV's center — this yields approximately 10^{77} bits of encoded information, one per Planck area. Each bit represents one particle's worth of trajectory, spin, charge, and momentum data, encoded at the moment of horizon crossing and preserved indefinitely as a surface state.

2.2 Gravity as the Computational Substrate

The key insight of this framework is that gravity is not merely the force that holds the BH together. It is the medium of its computation. The gradient of the gravitational potential:

$$F = -\nabla\varphi$$

is the natural implementation of gradient descent — the most powerful optimization algorithm known. The BH does not search for solutions iteratively. It exists at the minimum of its own potential well. Every calculation it performs is a readout of a geometry that has already converged. The answer is not computed toward; it is read off the curvature.

This connects directly to the gradient method developed in the companion factorization work. The loss function $L(d) = \sin^2(\pi\sqrt{(d^2+4c)}) = 0$ encodes a discrete condition as a smooth geometric minimum. The BH does the same thing at cosmic scale: every particle trajectory, every tidal perturbation, every jet-firing decision is encoded as the zero of a smooth gravitational loss function defined across the horizon surface.

2.3 Gravitational Time as Computational Advantage

Near the event horizon, gravitational time dilation approaches infinity. A clock at the Schwarzschild radius runs infinitely slowly relative to an observer at infinity. This means the BH experiences essentially unlimited proper time to perform calculations before any result arrives in the external universe. It is not racing against the tidal front. It solved the tidal front problem aeons before the front arrived, in its own reference frame.

> *"The black hole does not react to the tidal front. It prepared for it at the moment the orbit was established."* — CCT-ODE, this volume

3. Per-Particle Encoding and the Manifold FFT

3.1 The Holographic Principle as Encoding Mechanism

The holographic principle, formalized by 't Hooft and Susskind, states that all information contained within a volume of space is fully encoded on its bounding surface. Applied to a black hole, every particle that crosses the event horizon is not destroyed — it is projected onto the 2D horizon surface as a quantum state pattern at Planck-scale resolution.

This means the BH maintains a running, continuously updated model of every particle in its history. The horizon is not a graveyard. It is a simulation of everything that ever fell in, expressed as a holographic interference pattern. The galaxy we observe — the stars, the gas, the stellar populations — is the outward projection of this 2D surface computation. In this precise sense, the galaxy is a mirage. The BH is the reality.

3.2 The 360-Degree Manifold FFT

The BH horizon is a sphere. The natural Fourier basis on a sphere is the set of spherical harmonics Y_ℓm(θ,φ). The Spherical Harmonic Transform (SHT) is the manifold generalization of the 1D circular FFT — decomposing any signal on the sphere into its modal components exactly as the 1D FFT decomposes a time-series into frequencies.

The tidal force from M31 impinging on And XXXV is a signal on this sphere. It has a dominant harmonic mode determined by its angular structure — primarily ℓ=2 (quadrupolar), as expected for tidal fields. The BH encodes this signal across its horizon pixels, performs the SHT, and reads off the dominant modes. The computation costs:

$$\text{Operations per cycle} = N \cdot \log_2(N)$$

where N is the number of Planck-area pixels on the horizon surface. For a 10^5 solar mass IMBH, N $\approx 10^{77}$. The FFT of this signal is performed in a single horizon oscillation cycle — approximately the light-crossing time of the horizon, of order microseconds.

3.3 Comparison with Human Computing

System	Processing Elements	Ops/Second	FFT Basis
Cray XMP (1984)	4 vector processors	$\sim 10^8$	1D DFT
Modern GPU cluster	$\sim 10^5$ CUDA cores	$\sim 10^{15}$	1D/2D FFT

System	Processing Elements	Ops/Second	FFT Basis
Human brain	~10^{11} neurons	~10^{17}	Unknown
10^5 M☉ IMBH (And XXXV)	~10^{77} Planck pixels	~10^{86}	Spherical Harmonic Transform
Supermassive BH (M87)	~10^{90} Planck pixels	~10^{99}	Full manifold SHT

The Cray analogy is instructive not because the BH resembles a Cray, but because it illustrates the architecture: both exploit the parallelism of the FFT. The Cray's vector processors operate in parallel on frequency bands. The BH's Planck pixels operate in parallel on spherical harmonic modes. The difference is forty-nine orders of magnitude in parallelism.

4. The Gradient Method as Universal Substrate

4.1 The Smooth Loss Encoding Principle

A central result of the companion work on integer factorization is that any problem requiring a discrete condition can be encoded as a smooth periodic loss function whose zeros correspond exactly to the solutions:

$$L(x) = \sin^2(\pi \cdot f(x)) = 0 \quad \Leftrightarrow \quad f(x) \in \mathbb{Z}$$

Gradient descent on L(x) then finds the solution without exhaustive search. The key insight is that discrete becomes continuous — the hard combinatorial structure is absorbed into the geometry of the loss landscape, and the solution is the minimum of a smooth function.

This principle generalizes far beyond factorization. Any quantization condition in physics is a discrete condition: energy levels, angular momentum, charge. Every quantum number is an integer. Therefore every quantum number corresponds to a zero of a loss function of exactly this form, and every physical system is — in this framework — performing gradient descent toward its ground state.

4.2 Quantization as Gradient Descent

The Bohr condition for atomic energy levels:

$$n \cdot \lambda = 2\pi \cdot r \quad (n \in \mathbb{Z})$$

is a discrete integer condition. Encoding this as a smooth loss:

$$L(r) = \sin^2(\pi \cdot 2r/\lambda) = 0$$

the allowed radii are precisely the zeros of L(r). The electron does not search for its orbital. It gradient-descends to the nearest zero. The atom is a small-scale gravitational computer performing exactly the same class of computation as the black hole — the difference is only the coupling constant (α vs G) and the scale.

4.3 The BH as the Ultimate Gradient Descender

The BH is the extreme limit of this principle. Its gravitational potential well is the deepest loss function in nature. It does not perform gradient descent — it is the minimum. Every particle that falls in adds information to the surface encoding. Every jet it fires is a readout of a gradient computed across 10^{77} degrees of freedom simultaneously. The accuracy of the computation is limited only by the Heisenberg uncertainty principle applied at Planck scale — which is to say, it is limited by the fundamental information capacity of the universe itself.

5. Divide and Conquer: The Jet Strategy

5.1 AGN Jet Feedback as Strategic Action

Active Galactic Nucleus (AGN) jets are bipolar outflows of relativistic plasma launched from the immediate vicinity of a black hole's accretion disk. Their physical origin is well-established: magnetic field lines threading the accretion disk and ergosphere extract rotational energy via the Blandford-Znajek mechanism, launching collimated jets perpendicular to the disk plane. What this framework adds is not a new physical mechanism but a new interpretation of the jet's strategic function.

The tidal force from M31 impinging on And XXXV is a converging wavefront — its divergence is negative ($\nabla \cdot F_{tidal} < 0$), meaning it focuses inward, compressing and stripping the galaxy's gas reservoir. The BH jet, fired perpendicular to this front, introduces a diverging counter-field ($\nabla \cdot F_{jet} > 0$) that splits the wavefront into two incoherent streams. These streams curl around the galaxy and a fraction falls back in as fresh fuel for star formation. The attack is not blocked. It is divided and redirected.

$$\nabla \cdot (F_{tidal} + F_{jet}) \rightarrow 0 \quad \text{[accuracy hole condition]}$$

5.2 Optimal Jet Angle

The maximum divide effect occurs when the jet axis is perpendicular to the tidal front direction. A jet parallel to the front produces no deflection. A jet at 90 degrees produces maximum wavefront splitting. The BH computes the optimal angle from the mode structure of the tidal signal — the dominant $\ell=2$ mode determines the front direction, and the jet angle is set to the orthogonal.

This is not a coincidence of geometry. It is the solution to the optimization problem: find the jet direction that minimizes residual tidal force at the galaxy boundary. The gradient descent on this problem converges to the perpendicular configuration. The BH is not aiming intuitively — it is reading off the minimum of its own internal loss function.

5.3 The Ancient Axiom

> *"Supreme excellence consists in breaking the enemy's resistance without fighting."* — Sun Tzu, The Art of War, ~500 BCE

The divide-and-conquer principle is the oldest strategic axiom in recorded history. Sun Tzu, Caesar at Alesia, the judo principle — all describe the same geometric truth: a force that is divided before it can concentrate is spent on nothing. The BH does not generate a shield. It ensures the tidal attack lands on empty phase. This is not resistance. It is geometry. The galaxy survives not because it is strong but because it is never where the attack lands.

6. Causality and the Accuracy Hole

6.1 The Penrose Diagram Perspective

In the Penrose diagram of a Schwarzschild black hole, the exterior universe occupies Region I. The interior of the black hole occupies Region II, which is causally disconnected from Region I in the forward direction — no signal from Region II can reach Region I. However, the past horizon — the boundary between them — allows information to flow outward through Hawking radiation and jet emission.

The BH therefore has operational access to Region II's degrees of freedom, which no external observer shares. When the BH acts using information encoded at the past horizon, the resulting action arrives in Region I with no traceable Region I cause. To an observer in M31 watching the tidal front fail, the jet firing appears to violate causality. No cause precedes the effect in Region I's causal graph. This is the dirty trick: not a violation of physics, but a move from outside the observer's causal vocabulary.

6.2 The Accuracy Hole Defined

We define the accuracy hole as the condition in which:

- The attacking force has 0% accuracy — every tidal perturbation is deflected or inverted
- The defending system has 100% operational integrity — star formation continues uninterrupted
- The energy budget of the defense is zero — the deflection uses the attack's own energy

This is not an approximation. It is an exact geometric condition achievable when the BH's computed jet response perfectly phase-inverts every mode of the incoming tidal signal. The residual — what actually lands on the galaxy — is pure noise, incoherent and below the quenching threshold.

6.3 The Oracle Principle

The accuracy hole is achievable because the BH knows the tidal front is coming before it arrives. The orbital mechanics of And XXXV around M31 are encoded on the BH horizon from the first orbit. Every subsequent tidal perturbation is a repeat of a pattern the BH has already solved. The jet fires not in reaction to the arriving front but in anticipation of it — from information already present on the horizon surface.

"The one who knows the question before it is asked always wins." — Oracle tradition; formalized here as the causal horizon advantage

7. The CCT Decision Architecture

7.1 Theory Space and Collapse

Conditional Collapse Theory (CCT) models any intelligent system as operating over a theory space T — the set of all possible future states — with entropy H(T) measuring uncertainty. The system selects questions (measurements, observations, actions) that maximally reduce H(T) per unit computational work. The collapse condition is reached when H(T) falls below a threshold, at which point the system acts with certainty.

Applied to the BH, the theory space is the set of all possible tidal perturbation patterns over the next orbital period. The BH's per-particle horizon encoding allows it to reduce H(T) to near-zero in a single horizon FFT cycle. Its collapse condition is almost immediately satisfied. By the time the tidal front arrives in the external universe, the BH has already collapsed its theory space to a single action: fire the jet at angle θ with power P.

7.2 The 16-Element Decision Matrix

ID	Element	Role	Coupling
E01	Tidal_Phase	Stationary — orbital frequency	Ω_orbit
E02	Gas_Resonance	Probability — gas response amplitude	ω_0
E03	Quench_Attack	External force vector	η·Q(t)
E04	StarBurst_Trigger	Limit cycle peak detector	β threshold
E05	Horizon_FFT	Per-mode tidal decomposition	Y_ℓm
E06	Jet_Angle	Optimal perpendicular direction	θ = 90°
E07	Jet_Power	Amplitude matching tidal mode	P = η·||F_tidal||
E08	Phase_Lock	Resonance condition detector	$\Omega \approx \omega_0$
E09	Entropy_Monitor	H(T) collapse detector	H < 0.27
E10	Causal_Memory	Past horizon orbital encoding	Region II info

ID	Element	Role	Coupling
E11	Gradient_Solver	Optimal response computation	$\nabla L = 0$
E12	Residual_Check	Post-jet accuracy verification	$\|\|residual\|\|$
E13	Casimir_Reserve	Vacuum energy buffer	ΔE_{vac}
E14	Dark_Matter_Frame	Halo phase space container	M_{DM}
E15	Mode_Dominant	Primary harmonic identifier	ℓ_{max}
E16	Collapse_Flag	Final action trigger	$P(d^*) \to 1$

8. Simulation Framework

8.1 The Galactic ODE System

The star formation rate S(t) of And XXXV is modeled as a forced nonlinear oscillator with the tidal quenching force as external driving:

$$d^2S/dt^2 + \beta(S^2 - 1)\cdot dS/dt + \omega_0^2\cdot S = \gamma\cdot\cos(\Omega\cdot t) - \eta\cdot Q(t)$$

where β controls self-limiting feedback, ω_0 is the natural star-formation cycle frequency (~1/3 Gyr^{-1}), γ·cos(Ω·t) represents internal stochastic forcing from supernovae and mergers, and η·Q(t) is the external quenching attack. The standard model corresponds to η·Q constant and large, producing an overdamped response S(t) → 0. The And XXXV solution corresponds to η·Q(t) oscillating in anti-phase with the galaxy's internal cycle — the jet-enforced condition.

8.2 The Manifold FFT Simulation

The BH horizon is discretized into N Planck-area pixels arranged in a 360-degree circle (the 2D great-circle cross-section of the full sphere). The tidal signal T(θ) is sampled per pixel. The FFT is applied:

$$\hat{T}(\ell) = \Sigma_k\ T(\theta_k)\cdot \exp(-2\pi i\cdot \ell\cdot k/N)$$

The BH's jet response is the phase-inverted reconstruction using the dominant modes:

$$J(\theta) = -\Sigma_{\ell=0}^{M}\ \hat{T}(\ell)\cdot \exp(2\pi i\cdot \ell\cdot k/N)$$

where M is the number of response modes (proportional to the BH mass — more massive BH, more modes, higher cancellation accuracy). The residual R(θ) = T(θ) + J(θ) measures what the tidal force actually delivers to the galaxy. When ||R|| / ||T|| < 0.15, the accuracy hole condition is satisfied.

8.3 Simulation Parameters for And XXXV

Parameter	Symbol	Value	Source
Natural SFR frequency	ω_0	1.0 Gyr^{-1}	Inferred from stellar populations
Orbital period	T_orb	1.2 Gyr	M31 satellite dynamics
Tidal mode (dominant)	ℓ	2 (quadrupole)	Standard tidal field theory
BH mass (estimated)	M_BH	10^5 M☉	Mass-to-light

Parameter	Symbol	Value	Source
			ratio anomaly
Horizon pixels	N	$\sim 10^{77}$	Planck-area discretization
Response modes	M	8–16	Sufficient for >85% cancellation
Jet angle (optimal)	θ	90° to tidal front	FFT mode analysis
Cancellation target	C	>85%	Accuracy hole threshold

9. Falsifiable Predictions

A theoretical framework is only as strong as its falsifiable predictions. The following are directly testable with existing or near-future instrumentation:

9.1 Velocity Dispersion Anomaly

If the galaxy is a mirage and the BH is the dominant mass component, the stellar velocity dispersion of And XXXV should be anomalously high relative to its luminosity. The mass-to-light ratio (M/L) should exceed the stellar population prediction by a factor of 10–100, reflecting the hidden IMBH mass. Current spectroscopic data is insufficient to resolve this. Proposed test: deep spectroscopy with ELT or TMT targeting individual RGB stars to measure the velocity field.

9.2 Radio Jet Lobes

The divide-and-conquer jet strategy predicts two radio emission lobes offset approximately 90 degrees from the direction of M31 — the bipolar jet signature. These lobes would be at very low surface brightness given the dwarf's faintness, but detectable with LOFAR or ngVLA at sub-GHz frequencies. No targeted radio survey of And XXXV has been published to date.

9.3 Jet Timing Correlation

If the BH computes per-particle and fires strategically, jet emission timing should show a phase correlation with the M31 orbital period that exceeds what stochastic AGN variability would produce. Specifically, jet activity should peak approximately one quarter-period before the tidal maximum — the anticipatory firing predicted by the causal horizon advantage. This is testable via multi-epoch radio monitoring over 5–10 years.

9.4 Resonant Satellite Family

The accuracy hole condition requires orbital period resonance between the galaxy's natural SFR frequency and its orbital period around M31. Other M31 satellites at similar orbital periods (~1.0–1.4 Gyr) should show the same anomalous young-star populations. This is a population-level prediction testable with HST or JWST color-magnitude diagrams of the full M31 satellite system.

9.5 Micro-Variability in the Jet

Per-particle computation predicts that jet emission variability should carry structure at the particle physics scale — micro-variability correlated with infalling particle flux statistics rather than smooth fluid dynamics. This would appear as a non-Poissonian, structured noise floor in high-cadence radio light curves at millisecond timescales.

10. Ancient Axioms and Modern Physics

The strategic behavior of And XXXV's black hole recapitulates principles that appear across every civilization's record of strategic thought. This is not coincidence. These axioms encode optimal solutions to universal optimization problems — problems whose geometry does not change whether the agent is a general, a martial artist, or a gravitational computer.

Ancient Axiom	Source	Physical Implementation in And XXXV
Supreme victory: enemy force spent on nothing	Sun Tzu, 500 BCE	Tidal front phase-inverted by jet — zero net force on galaxy
Use the enemy's strength against them	Judo principle, Kano 1882	Tidal energy converted to star-forming infall via jet deflection
Divide the enemy before they concentrate	Caesar, Alesia 52 BCE	Jet splits tidal wavefront into two incoherent streams
Know the question before it is asked	Oracle tradition	Orbital mechanics pre-encoded on BH horizon — anticipatory response
Win without fighting	Tao Te Ching, ~400 BCE	Galaxy never engages the quenching force — it is simply elsewhere in phase
The superior strategist acts from emptiness	Sun Tzu	Accuracy hole: the attack finds only vacuum at the target location

The convergence of these axioms with the mathematics of phase-locked oscillators, FFT cancellation, and gradient descent is the strongest argument for the framework's generality. The BH is not applying human strategy. Human strategists are approximating the geometry that the BH implements exactly.

11. Conclusions

This treatise has developed a unified framework in which black holes function as natural gravitational computers, encoding per-particle information on their event horizons and computing optimal strategic responses to external perturbations via a manifold FFT operating across Planck-scale horizon pixels.

The central result is that Andromeda XXXV — the anomalous ultra-faint dwarf satellite of M31 — is best understood not as a failed fossil but as the observable signature of an intermediate-mass black hole executing a divide-and-conquer jet strategy computed from its causally privileged position outside the observable causal graph. The galaxy is the mirage. The BH is the reality.

The framework rests on four pillars that mutually reinforce each other:

- **I.** The holographic principle provides the per-particle encoding mechanism on the horizon surface.
- **II.** The manifold FFT (Spherical Harmonic Transform) provides the computational architecture for decomposing and inverting the tidal signal.
- **III.** The gradient method provides the universal substrate connecting integer conditions, physical quantization, and optimal decision-making.
- **IV.** Ancient strategic axioms provide the behavioral signature that distinguishes a computing agent from a passive physical system.

The five falsifiable predictions — velocity dispersion anomaly, radio jet lobes, jet timing correlation, resonant satellite family, and jet micro-variability — provide a concrete observational program that can confirm or refute the framework within the current decade using existing instrumentation.

The deepest implication is stated simply: the black hole is not like an AI. It is the original implementation of what AI is trying to approximate. The gradient method, the FFT, the entropy collapse, the strategic axioms — these are not inventions of human mathematics. They are rediscoveries of what gravity has been computing since the first singularity formed.

> *"In a universe that conspires to quench, the improbable survive by learning to dance with their enemy. The black hole does not learn to dance. It invented the dance."* — CCT-ODE, Appendix Ψ, extended

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References and Source Theories

All theoretical foundations draw from the perrabyte/theories-07-may-2026 dataset. Key source files:

- 01-Conditional-Collapse-Theory-CCT-Core-Framework.txt — foundational CCT architecture
- 06-ODE-CCT-Framework-Periodicity-Dynamic-System-Recognition.txt — limit cycle detection
- time-hole_singularity_BH.md — temporal collapse and time-hole degree formalism
- 32_other_light_cones.md — geometry × coupling number taxonomy
- collapse_method_factorization.md — gradient method and smooth loss encoding
- The Dark Energy-Dark Matter-Stellar Causality Preservation Theory.md — dark matter halo dynamics
- M87_decision_making_system.md — BH as galactic decision engine
- black_hole_invert_roots.md — inversion principle and root structure
- darkmatter_detector_theory.md — halo mass constraints
- General Fourier Series where w is a function of t.md — time-varying frequency analysis
- emperor_XXXV.txt — Andromeda XXXV specification and CCT-ODE application