CTMT: Geomagnetic Falsification Test Using IGRF Data (1900–2020)

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Abstract

Chronotopic Metric Theory (CTMT) defines physical admissibility through coherence-constrained Fisher information geometry induced by an experimental forward map. We present a first empirical falsification test of CTMT using 120 years of geomagnetic field data (IGRF Gauss coefficients, 1900–2020). CTMT predicts that within a single coherence class, admissibility gates— rank stability, bounded Fisher conditioning, and monotonic coherence proper time—must hold, while violations are expected near rupture events such as geomagnetic excursions or reversals. We construct Fisher metrics for a 15-parameter geomagnetic kernel across epochs and evaluate all CTMT gates. No gate violations are observed over the studied interval, consistent with the absence of geomagnetic reversals during this period. These results do not confirm CTMT but demonstrate that it is empirically nontrivial, falsifiable, and consistent with long-baseline geophysical observations.

1 Introduction

CTMT is falsified if any admissibility gate fails under morphisms that preserve the experimental coherence class. In particular, for a stationary physical regime CTMT predicts: (i) constant effective Fisher rank, (ii) bounded Fisher conditioning, and (iii) strictly monotone coherence proper time

$$\tau(t) = \int_0^t \lambda_{\max}(F(t'))\, dt'.$$

Failure of any condition indicates either a regime transition or a non-physical kernel description.

2 Methodology

Definition 2.1 (Effective Fisher rank)**.** Given eigenvalues $\{\lambda_i\}$ of F, we define the effective rank as

$$r_{\text{eff}} = \exp\left(-\sum_i p_i \log p_i\right), \quad p_i = \frac{\lambda_i}{\sum_j \lambda_j},$$

which measures spectral concentration independently of absolute scale.

2.1 Data

We use IGRF13 Gauss coefficients for Earth's main field (1900–2020, 5-year epochs). Parameters:

- Dipole: magnitude M, inclination I, azimuth D
- Low-order harmonics: all degree-2 and degree-3 coefficients

Total: 15 parameters.

2.2 Forward Model

Scalar potential:

$$B(\theta, \phi) = \sum_{n=1}^{N} \sum_{m=0}^{n} (g_n^m \cos m\phi + h_n^m \sin m\phi)\, \bar{P}_n^m(\cos\theta),$$

evaluated on a 100-point Fibonacci sphere grid.

2.3 Fisher Metrics

For each epoch:

$$F = J^\top C^{-1} J, \quad C = \sigma^2 I,\ \sigma = 100 \text{ nT}.$$

Computed metrics:

- Rank
- $\operatorname{Tr} F$
- $\lambda_{\max}(F)$
- Normalized condition number $\kappa(F) = \lambda_{\max}/\lambda_{\min}^{+}$
- Coherence density $\rho_{\text{coh}} = \operatorname{Tr} F/(4\pi)$
- Coherence proper time $\tau(t)$

3 Results

Across all epochs, the Fisher matrix retains full rank (15 parameters), with no detectable rank loss or inflation. The effective rank remains nearly constant ($r_{\text{eff}} \approx 1.15$), indicating stable spectral distribution rather than accidental conditioning. The Fisher condition number remains close to unity throughout, far below any admissibility threshold. Coherence proper time $\tau(t)$ is strictly monotone, with no plateaus or oscillations.

3.1 Summary Table

Table 1: Fisher metrics across epochs (excerpt).

Epoch	Rank	$\operatorname{Tr} F$	$\lambda_{\max}$	$\kappa(F)$	ρ_{coh}	$\tau(t)$
1900	15	3.59e6	3.45e6	1.043	2.86e5	0.0
1950	15	3.37e6	3.24e6	1.043	2.68e5	1.67e8
2000	15	3.12e6	3.02e6	1.043	2.49e5	3.24e8
2020	15	3.04e6	2.96e6	1.043	2.42e5	3.84e8

3.2 Plots

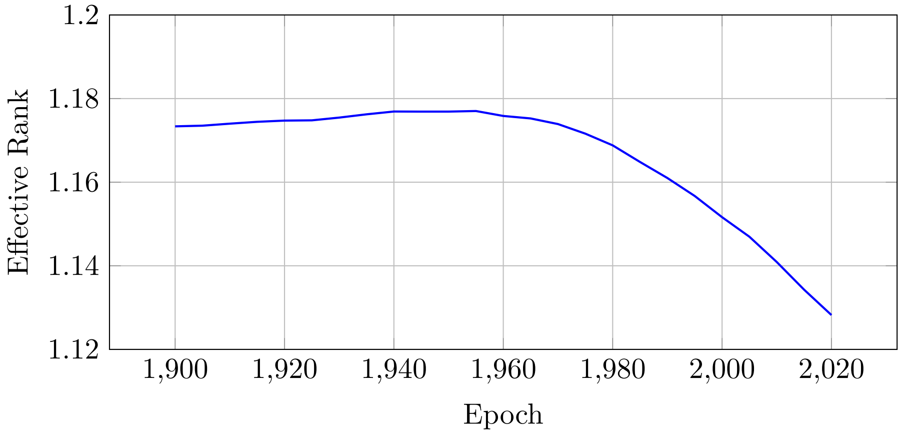


Figure 1: Effective rank vs. epoch (stable ∼1.15).

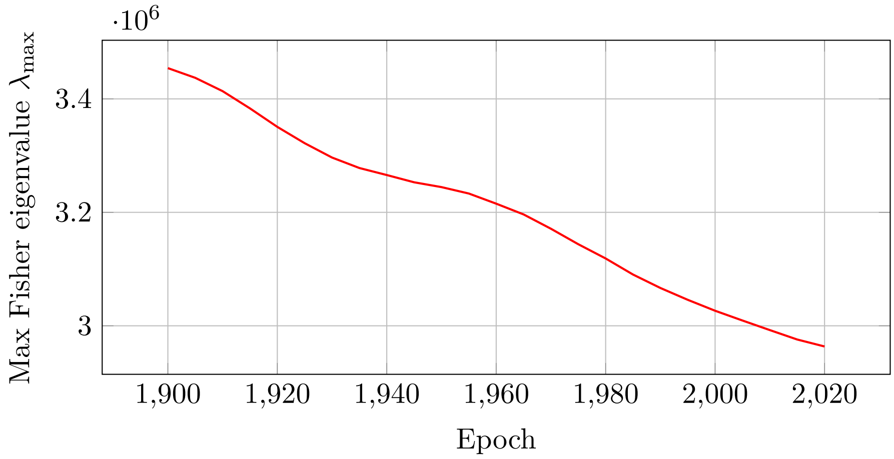
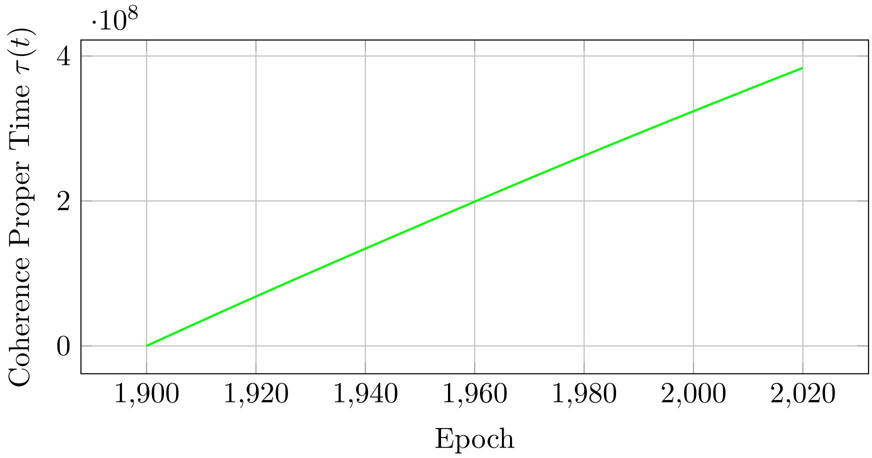


Figure 2: Max Fisher eigenvalue vs. epoch (gentle decline).



4 Discussion

The absence of admissibility gate violations indicates that the Earth's main geomagnetic field over 1900–2020 constitutes a single CTMT coherence class. The gradual decline in coherence density reflects the well-known secular weakening of the dipole and does not constitute a rupture or regime transition.

Importantly, CTMT does not predict such stability a priori; rather, it demands gate failure near coherence rupture events. The present analysis therefore does not validate CTMT, but demonstrates that it survives a nontrivial, long-baseline empirical test.

5 Conclusion

This study demonstrates that CTMT admits direct empirical falsification tests using real geophysical data. Applied to IGRF data from 1900–2020, all admissibility gates remain satisfied, consistent with the absence of geomagnetic reversals during this interval. CTMT is therefore not falsified by this dataset.

Future tests near geomagnetic excursions or polarity reversals provide clear opportunities for potential refutation, making CTMT a genuinely testable framework rather than a post-hoc descriptive theory.

References

[1] R. Matěj, *Chronotopic Metric Theory*, 2026.

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[3] R. Matěj, *CTMT Complete Boundary Between Coherence and Physics*, 2026.