

The 1.11 Million Year Cycle in the Outer Solar System

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October 2026

Abstract

A companion paper establishes, from the standard 0–30 Ma geomagnetic polarity timescale, a clear periodicity in Earth's prevailing magnetic polarity near 1.1101 million years. This paper sets that figure aside and asks an independent question: does a period of similar length appear anywhere in the dynamics of the solar system itself, arrived at without any reference to Earth's magnetic field? Two such periods are identified, from two distinct physical mechanisms. The Uranus–Neptune orbital energy exchange, established via numerical integration of the outer planets (the LONGSTOP project), gives 1.119 Myr — a drifting, near-resonant beat. The Jupiter–Uranus perihelion anti-alignment, a stable secular frequency difference computable directly from measured planetary precession rates, gives 1.107 Myr — a fixed period. Both sit within a fraction of a percent of the geomagnetic figure. The paper also records the recovery, after a decades-long search, of the original source for a long-held personal note of "1.108 Myr" for this cycle. The explanation for why these independent timescales agree so closely is left for a future paper.

Introduction

A companion paper (*The 1.11 Million Year Cycle in Earth's Magnetic Field Polarity* [6]) shows that the geomagnetic reversal record, examined as a prevailing polarity through time rather than as a sequence of reversal timings, displays a clear periodicity at 1.1101 Ma. That result stands on its own, from Earth data alone. This paper asks a separate question, using entirely different data and methods: is there a period of similar length in the solar system itself?

Two candidates are examined below, each derived from outer-planet orbital dynamics with no reference to terrestrial geomagnetism. Their proximity to the geomagnetic figure is noted, but not explained, in this paper - that connection is left for later work.

The Uranus–Neptune Orbital Energy Exchange

Bertotti & Farinella [1] state that Uranus and Neptune exchange orbital energy over a 1.1 million year cycle. Uranus and Neptune sit near — but never lock into — a 2:1 mean-motion resonance. Their mutual gravitational perturbation produces a slow, cyclic exchange of orbital energy: Neptune's semi-major axis and eccentricity grow while Uranus's shrink, then the exchange reverses.

This result traces to the LONGSTOP project (Milani, Nobili, Carpino, and collaborators — a numerical integration of the outer planets over timescales up to 100 million years) and a later, independent 200-million-year integration [3]. The more precise figure, from the primary source [2], based on the LONGSTOP 1B integration, gives this period as:

1.119 Myr

Bertotti & Farinella simply rounded this to "1.1 Myr" in their text.

This is a near-resonant beat, not a fixed secular period, and it drifts: the underlying orbital-element

periods can shift by more than 1% over 1–20 million year intervals, so 1.119 Myr should be treated as the present-epoch value of a slowly wandering timescale, not a constant. For reference, the Uranus–Neptune synodic (conjunction) period is 171.42 years, so the 1.119 Myr modulation spans roughly 6,458 conjunctions.

The scale and possible cause of the drift

The same LONGSTOP 1B integration that established the 1.119 Myr period also identified a second, much longer term in the same semi-major-axis variations: a "small divisor" with a period of approximately 31 Myr [4]. In perturbation theory, a small-divisor term arises when a particular combination of orbital frequencies happens to sum close to zero, producing a slow, large-amplitude modulation superimposed on a faster signal. This is a specific, documented longer periodicity in the same dynamical system that produces the 1.119 Myr line — a plausible candidate for a genuine longer wave modulating the shorter cycle, rather than the shorter cycle's period wandering without structure.

The mainstream dynamical-astronomy literature offers a separate, and more commonly cited, explanation for why the outer planets' orbital elements are difficult to pin to a single fixed period over long baselines: the giant-planet system (Jupiter through Neptune) has been characterised as chaotic, with a Lyapunov time reported in the range of roughly 4 to 19 million years depending on integration method, often summarised as approximately 10 Myr [5] — meaning, on the standard interpretation, that the system's exact trajectory becomes progressively unpredictable from any finite-precision starting data beyond a few multiples of that timescale.

The present author is not persuaded that chaos is the operative explanation here. The pattern found across this paper and its companion is one of large-amplitude, well-defined waves — at 1.107 Myr, 1.119 Myr, 1.1101 Myr, and now the 31 Myr term identified above — rather than the featureless, unpredictable divergence chaos implies. A system genuinely dominated by such large periodic waves would be expected to resist, rather than produce, chaotic behaviour: the waves impose structure and constrain the system's evolution, rather than leaving it free to wander. On this view, the apparent "drift" in the 1.119 Myr figure is better read as the signature of the 31 Myr wave (and possibly others not yet identified) modulating it in a regular way, not as evidence of underlying chaos.

The Jupiter–Uranus Perihelion Lock

A second, independent, and — unlike the above — genuinely fixed period arises from a different mechanism: the angle between Jupiter's and Uranus's perihelion directions ($\Delta\varpi = \varpi_{\text{Jupiter}} - \varpi_{\text{Uranus}}$) librates around 180°, staying anti-aligned within roughly $\pm 70^\circ$. The period of this libration is set purely by the difference between the two planets' secular perihelion precession frequencies, conventionally labelled g_5 (Jupiter) and g_7 (Uranus):

$$\text{Period} = 360^\circ \div (g_5 - g_7)$$

Using modern catalogue values ($g_5 = 4.2575''/\text{yr}$, $g_7 = 3.0868''/\text{yr}$):

$$\Delta g = 1.1707''/\text{yr} \rightarrow \text{Period} = 1,296,000'' \div 1.1707''/\text{yr} = 1,107,030 \text{ years} \approx \mathbf{1.107 \text{ Myr}}$$

Unlike the Uranus–Neptune beat, this is a stable, directly computable secular frequency difference — not an epoch-dependent estimate, and not subject to the same drift.

A 35-Year Search, Resolved

This second figure has a personal history worth recording. A note of "1.108 Myr" for an outer-planet energy-exchange cycle had sat in the author's (Ray Tomes') records for decades, its original source untraceable — repeated searches over many years consistently failed to locate where the figure had come from. The source was finally recovered from an old personal notebook, which allowed the calculation described above under "The Jupiter–Uranus Perihelion Lock" to be reconstructed and checked. The recovered figure — 1.108 Myr — and the freshly computed value from modern catalogue g5/g7 data — 1.107 Myr — agree to within one part in a thousand, confirming the note was correct all along; what had been missing was not the number but its derivation.

Two Neighbouring Timescales, and Their Relation to the Geomagnetic Figure

The solar system offers two genuinely independent periods, both close to 1.11 Myr, arising from two different physical mechanisms:

Period (Myr)	Mechanism	Character
1.107	Jupiter–Uranus perihelion anti-alignment (g5 – g7)	Fixed secular frequency
1.119	Uranus–Neptune orbital energy exchange (LONGSTOP)	Drifting near-resonant beat

For comparison, the companion paper's independently derived geomagnetic figure is 1.1101 Myr — within a fraction of a percent of both astronomical values, despite coming from entirely unrelated data (Earth's reversal record) and an entirely unrelated method (spectral analysis of a ± 1 polarity signal, with no planetary input of any kind).

Conclusion

Two distinct mechanisms in outer solar system dynamics — one a drifting resonant beat, one a fixed secular frequency — both produce periods within a fraction of a percent of 1.11 million years, and within a similar margin of the independently derived geomagnetic figure reported in the companion paper. Why three unrelated determinations, from three unrelated physical systems, should agree this closely is not addressed here. That explanation is left for a future paper.

References

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