

Computational Modeling of Retrograde (Vakri) Motion and *Ceṣṭā-bala* in Parāśarī Jyotiṣa: An Astronomical Formalization and Knowledge-Engineering Treatment

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Abstract

Retrograde (*vakri*) motion is one of the most interpretively significant — and most frequently misapplied — constructs in Vedic astrology, yet consumer astrology software typically reduces it to a boolean flag. This paper gives a precise, reproducible treatment. We (i) formalize apparent retrograde motion in the geocentric ecliptic frame, deriving the station condition and the synodic timing of the retrograde arc for the classical *grahas*; (ii) formalize the classical quantification of motional strength — *ceṣṭā-bala* — within Parāśara's *ṣaḍbala* scheme, and relate it to the eight-fold *gati* taxonomy; (iii) present algorithms that determine retrograde state and compute *ceṣṭā-bala* directly from an ephemeris; and (iv) describe how these primitives are operationalized within a knowledge-grounded, multi-agent question-answering system (RetroGrade). We are explicit about scope: the scientific claims of this work concern the correctness of astronomical computation and the faithful, auditable operationalization of documented classical rules. We make no empirical claim regarding the predictive validity of astrological interpretation itself. The contribution is therefore one of computational modeling, reproducibility, and knowledge engineering.

Keywords: *Vedic astrology; retrograde motion; vakri; ceṣṭā-bala; ṣaḍbala; gati; computational Jyotiṣa; ephemeris; knowledge engineering; multi-agent systems.*

1. Introduction

In classical Parāśarī Jyotiṣa, the apparent backward motion of a planet — *vakra* or *vakri gati* — is not treated as a defect but as a distinct dynamical state carrying substantial interpretive weight. A retrograde planet is held to be unusually strong in motional terms, and its significations are read as intensified and inward-turned. Despite this, the vast majority of astrology applications available today expose retrograde status, at best, as a single yes/no attribute, discarding both the underlying astronomy and the quantitative machinery that classical texts actually specify.

This paper addresses that gap by treating *vakri* motion as a first-class computational object. Our aim is twofold: to state the astronomy precisely enough to be reproducible, and to operationalize the classical quantification of motional strength faithfully enough to be audited against reference implementations. The name of the platform in which this model is embedded — RetroGrade — reflects the centrality of this single construct.

This work makes four contributions:

- (1) A compact astronomical formalization of apparent retrograde motion in the geocentric ecliptic frame, including the station condition and the synodic timing of the retrograde arc for the five *tāra grahas* and the lunar nodes (Section 2).
- (2) A formalization of *ceṣṭā-bala* within the six-fold *ṣaḍbala* strength scheme, and its relation to the eight-fold *gati* taxonomy (Section 3).

- (3) Reproducible algorithms that (a) determine retrograde state from an ephemeris and (b) compute ceṣṭā-bala from the ceṣṭā-kendra, together with a worked example (Section 4).
- (4) A description of how these primitives are consumed by a knowledge-grounded, multi-agent question-answering system, and an explicit statement of epistemological scope (Sections 5–7).

2. Astronomical Background: Apparent Retrograde Motion

2.1 Reference frames

Retrograde motion is a frame-dependent appearance, not a physical reversal. In the heliocentric frame every planet revolves about the Sun in the same direction without exception; there is no retrograde motion at all. In the geocentric frame — the frame in which every horoscope is cast — a planet's apparent ecliptic longitude λ can decrease over an interval, producing the appearance of backward motion across the fixed stars. Because the natal chart records the sky as seen from the Earth, this apparent motion is the physically correct object of astrological analysis, even though it does not correspond to any reversal in the heliocentric frame.

Let $\lambda(t)$ denote the apparent (geocentric, sidereally referenced) ecliptic longitude of a planet. The planet is prograde (*mārgī*) when $\lambda' = d\lambda/dt > 0$ and retrograde (*vakri*) when $\lambda' < 0$. The instants at which $\lambda' = 0$ are the stations (*vikala*); they bound the retrograde arc.

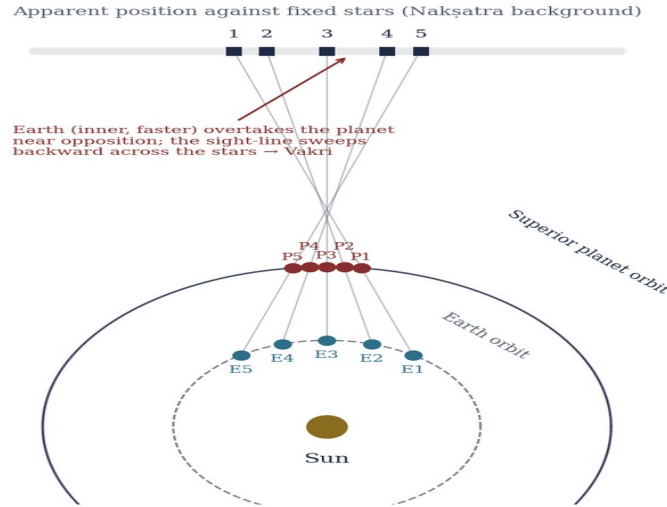


Figure 1. Geometry of apparent retrograde motion for a superior planet. As the inner, faster Earth (E1–E5) overtakes the planet (P1–P5) near opposition, the Earth–planet sight-line sweeps backward across the fixed-star background (positions 1–5), producing vakri motion.

2.2 Synodic configuration and timing

Retrograde episodes are governed by the synodic period S , the mean interval between successive identical Sun–Earth–planet configurations. For a superior planet of sidereal period P (with Earth's period $P_\oplus$), $1/S = 1/P_\oplus - 1/P$; for an inferior planet, $1/S = 1/P - 1/P_\oplus$. Superior planets (Mars, Jupiter, Saturn) turn retrograde around opposition, when the Earth passes between the Sun and the planet; inferior planets (Mercury, Venus) turn retrograde around inferior conjunction. The Sun and Moon never retrograde. The mean lunar nodes (Rāhu and Ketu) move retrograde continuously, completing a cycle in ≈ 18.6 years. Table 2 summarizes the timing.

Graha	Config. of retro	Synodic period (d)	Retro duration (d)	Retro / cycle
Budha (Mercury)	Inferior conj.	≈ 116	≈ 21–24	≈ 3×/yr
Śukra (Venus)	Inferior conj.	≈ 584	≈ 40–43	once/cycle
Maṅgala (Mars)	Opposition	≈ 780	≈ 60–80	once/cycle
Guru (Jupiter)	Opposition	≈ 399	≈ 120–123	once/cycle
Śani (Saturn)	Opposition	≈ 378	≈ 135–140	once/cycle
Rāhu / Ketu	Mean nodes	—	always	continuous

Table 2. Approximate synodic and retrograde parameters of the classical grahas. Durations vary with orbital eccentricity and the planet's ecliptic latitude at the episode.

2.3 Stations and the retrograde arc

Figure 2 shows $\lambda(t)$ for a superior planet computed under a coplanar circular-orbit model centred on opposition. The curve rises (prograde), flattens at the first station S_1 where $\dot{\lambda} = 0$, decreases through the retrograde arc ($\dot{\lambda} < 0$), flattens again at the second station S_2 , and resumes its rise. The two stations are the roots of $\lambda(t) = 0$ bounding the interval on which the planet is vakri. This condition is what an implementation must detect; it is exact and frame-defined, independent of any interpretive commitment.

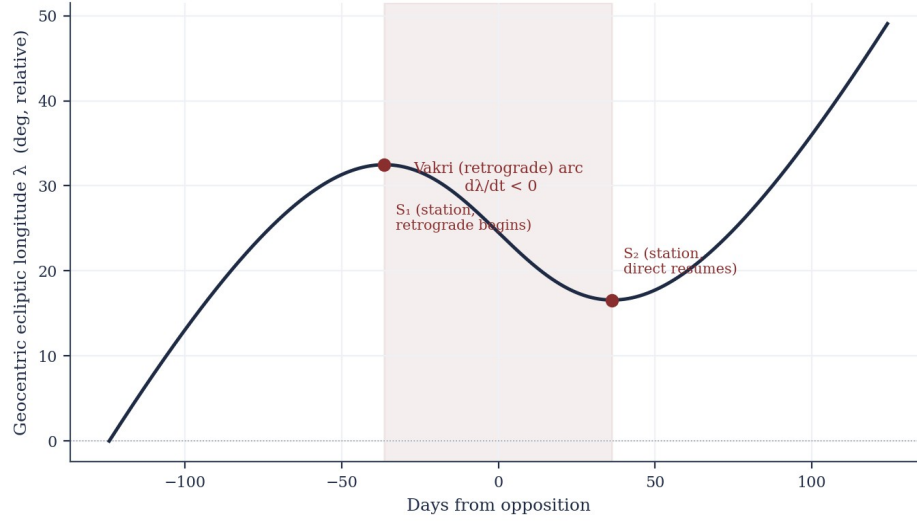


Figure 2. Geocentric ecliptic longitude $\lambda(t)$ of a superior (Mars-like) planet across an opposition, coplanar circular-orbit model. The shaded arc, bounded by the stations S_1 and S_2 ($\dot{\lambda} = 0$), is the vakri interval.

3. The Classical Treatment of Vakra Gati

3.1 The eight-fold gati taxonomy

Parāśara and later authorities classify a planet's motion into eight states (*aṣṭa-gati*), ranging from deep retrograde to very swift direct motion. Table 1 states these together with their kinematic characterization in terms of $\dot{\lambda}$. The taxonomy is a qualitative discretization of a continuous quantity (the geocentric rate) and is the classical counterpart of the velocity profile in Figure 2.

Gati (Sanskrit)	Sense	Kinematic characterization (geocentric ecliptic rate $\dot{\lambda}$)
Vakra	Retrograde	$\dot{\lambda} < 0$; apparent backward motion (deep, near opposition / inferior conjunction)
Anuvakra	Retro into prior sign	Retrograde motion that carries the planet back across a rāśi boundary

Gati (Sanskrit)	Sense	Kinematic characterization (geocentric ecliptic rate λ)
Vikala	Stationary	$\lambda \approx 0$; a station (S_n), the instantaneous turning point
Mandatarā	Very slow direct	$0 < \lambda \ll \text{mean}$; just after a direct station
Manda	Slow direct	λ below the planet's mean daily motion
Sama	Mean motion	$\lambda \approx \text{mean daily motion}$
Cara	Swift direct	λ above mean daily motion
Aticara	Very swift direct	$\lambda \gg \text{mean}$; maximal prograde speed

Table 1. The eight-fold gati taxonomy mapped to the geocentric ecliptic rate λ . Qualitative thresholds are relative to the planet's mean daily motion; virūpa allotments for a categorical scheme vary across texts and are therefore not fixed here.

3.2 Ceṣṭā-bala within ṣaḍbala

The *ṣaḍbala* (six-fold strength) framework aggregates six sources of planetary strength: *sthāna-bala* (positional), *dig-bala* (directional), *kāla-bala* (temporal), *ceṣṭā-bala* (motional), *naisargika-bala* (natural), and *dr̥k-bala* (aspectual). Strength is measured in *virūpa*, with 60 *virūpa* = 1 *rūpa*.

Ceṣṭā-bala is the component that rewards motional state, and it is precisely here that retrogression enters the strength calculus. In Parāśara's quantitative method it is derived from the *ceṣṭā-kendra* — an angle obtained from the planet's relationship to its *śīghrocca* (the fast apogee governing synodic motion). Reduced to the range $[0^\circ, 360^\circ]$, the strength is

$$\text{ceṣṭā-bala} = \kappa/3 \text{ for } \kappa \leq 180^\circ, \text{ and } (360 - \kappa)/3 \text{ for } \kappa > 180^\circ,$$

where κ is the *ceṣṭā-kendra* in degrees. The function peaks at $\kappa = 180^\circ$ — the configuration of opposition and deepest retrograde — yielding the maximal 60 *virūpa* (Figure 3). This is the formal sense in which classical Jyotiṣa treats a deeply retrograde planet as motionally strongest. For the Sun and Moon, which do not retrograde, Parāśara substitutes *ayana-bala* and *pakṣa-bala* respectively in place of a synodic *ceṣṭā* term.

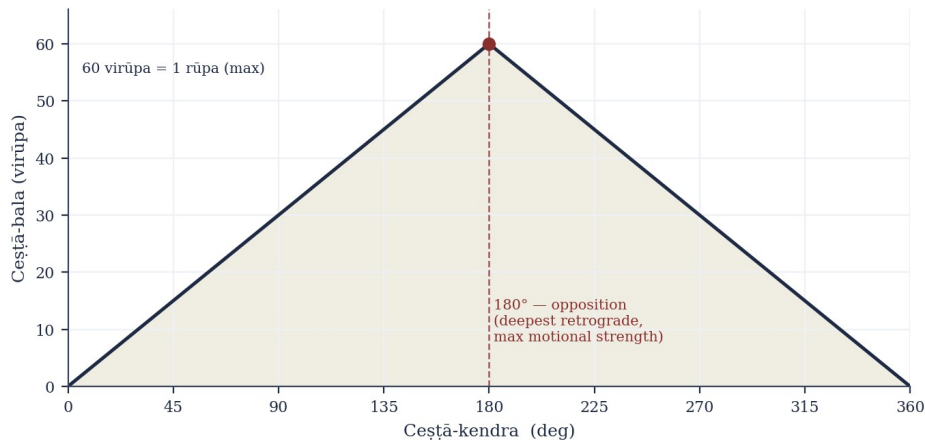


Figure 3. Ceṣṭā-bala as a function of the *ceṣṭā-kendra* κ under Parāśara's quantitative method. Motional strength is maximal (60 *virūpa*) at opposition / deepest retrograde ($\kappa = 180^\circ$).

3.3 An interpretive śakti schema

Beyond the quantitative *bala*, the platform employs an interpretive schema that aligns three *śaktis* — *icchā* (will/desire), *jñāna* (knowledge), and *kriyā* (action) — with regimes of gati (Table 3). Under this schema a deeply vakri planet is read under the sign of *icchā*: an intensified, inward-turned desire attached to the planet's significations, whose concrete expression is modulated by the *bhāva* (house) it occupies and the *nakṣatra* in which it is placed. We present this mapping as an explicit, interpretive design choice of the

system, not as a uniquely canonical classical doctrine; the classical corpus records several, sometimes divergent, interpretive stances (Section 3.4).

Śakti	Associated gati regime	Interpretive signature used by the system
<i>Icchā</i> (will/desire)	Deep vakra (near opposition; high ceṣṭā-bala)	Intensified, inward-turned desire in the significations of the planet, its bhāva and nakṣatra
<i>Jñāna</i> (knowledge)	Vikala / near-stationary	Reflective, deliberative, 'held' quality; re-examination of the planet's themes
<i>Kriyā</i> (action)	Cara / aticara (swift direct)	Outward, executed, forward-moving expression of the planet's significations

Table 3. The interpretive śakti schema adopted by the system, aligning *icchā* / *jñāna* / *kriyā* with *gati* regimes. Presented as a documented design choice, not an empirical claim.

3.4 The dignity debate

Classical authorities disagree on how retrogression interacts with dignity. One influential position holds that a retrograde planet in debilitation behaves as if exalted and vice versa (the *nīcābhilāṣī* / *uccābhilāṣī* principle); others, including strands of Sārāvalī and Phalaḍīpikā, weight the interaction differently. A faithful computational system must therefore treat the dignity–retrogression interaction as a parameterized, source-attributed rule rather than a single hard-coded verdict, so that the interpretive lineage of any given output remains explicit and auditable.

4. A Reproducible Computational Model

4.1 Retrograde-state detection

Given an ephemeris returning the apparent geocentric sidereal longitude $\lambda(t)$ of a graha, retrograde state is determined by the sign of the longitudinal rate. In discrete form, for a small step h (e.g., one hour):

Algorithm 1 — Vakri state. (i) sample $\lambda(t-h)$, $\lambda(t+h)$; (ii) compute $\dot{\lambda} \approx [\lambda(t+h) - \lambda(t-h)] / 2h$ with 360°-wrap correction; (iii) return VAKRI if $\dot{\lambda} < 0$, MĀRGĪ if $\dot{\lambda} > 0$, VIKALA (station) if $|\dot{\lambda}| < \epsilon$. Stations are refined by bracketing the sign change of $\dot{\lambda}$ and applying a root-finder (bisection or Brent) to $\dot{\lambda}(t) = 0$.

4.2 Ceṣṭā-bala computation

Algorithm 2 — Ceṣṭā-bala. (i) obtain the ceṣṭā-kendra κ from the planet's synodic relation to its śighrocca; (ii) reduce κ to $[0^\circ, 360^\circ)$; (iii) return $\kappa/3$ if $\kappa \leq 180^\circ$, else $(360 - \kappa)/3$, in virūpa. The result feeds the ṣaḍbala aggregate. Because both κ and the reduction are deterministic functions of ephemeris quantities, the output is exactly reproducible and can be diffed against a reference ṣaḍbala implementation.

4.3 Gati classification and śakti mapping

The continuous rate $\dot{\lambda}$ from Algorithm 1, normalized by the planet's mean daily motion, is discretized into the eight gati of Table 1 by threshold; the resulting gati is then mapped to a dominant śakti via Table 3. This yields, for any planet at any epoch, a triple (vakri-state, ceṣṭā-bala, dominant-śakti) that downstream interpretation consumes.

4.4 Worked example

Consider a natal Saturn whose ephemeris sampling yields $\dot{\lambda} < 0$ with a ceṣṭā-kendra near 180°. Algorithm 1 returns VAKRI; Algorithm 2 returns a ceṣṭā-bala approaching 60 virūpa; the gati classifier returns deep vakra, mapped to the icchā regime. The interpretive layer then reads this Saturn as motionally strong with an

intensified, inward-turned expression of its significations, refined by the house and nakṣatra it occupies and by the dignity rule selected in Section 3.4 — with every step attributable to a documented source.

5. Operationalization in a Multi-Agent System

These primitives are embedded within a knowledge-grounded, multi-agent question-answering platform whose broader architecture — a semantic router dispatching across specialized agents grounded in classical texts — is described in a companion paper. For present purposes, the relevant points are three. First, vakri-state and ceṣṭā-bala are computed deterministically by a Jyotiṣa engine and supplied to agents as structured evidence, so that motional strength is never hallucinated by a language model. Second, queries whose correct answer depends on retrogression are routed to agents that explicitly consult this evidence. Third, interpretive claims are generated under retrieval grounding with source attribution, and are constrained by guardrails that keep motional-strength statements consistent with the computed ṣaḍbala. The astronomy is thus computed, not learned, and the interpretation is grounded, not free-form.

6. Evaluation Protocol

Because the substantive claims of this work are computational, the evaluation targets computation. The astronomical layer admits an objective gold standard: agreement of the computed vakri-state and station timings against an independent ephemeris (e.g., Swiss Ephemeris) over a multi-decade span for all five tāra grahas. The strength layer admits a second objective check: agreement of computed ceṣṭā-bala against a reference ṣaḍbala implementation. The interpretive layer is assessed by expert audit of rule-faithfulness rather than by any measure of predictive accuracy. Table 4 states the protocol; measured values are reported from a production run and are marked pending here rather than asserted.

Axis	Metric	Target / status
Astronomical correctness	Vakri-state agreement vs Swiss Ephemeris (per-day, 5 grahas, 50-yr span)	$\geq 99.9\%$ [to be measured]
Station timing	Mean $ \Delta t $ of computed stations vs reference	$< 6\text{ h}$ [to be measured]
Ceṣṭā-bala fidelity	Mean $ \Delta $ virūpa vs reference ṣaḍbala implementation	$< 1\text{ virūpa}$ [to be measured]
Rule faithfulness	Expert audit of gati → interpretation mappings	[to be measured]
Routing	Correct dispatch of vakri-sensitive queries to the engine	[to be measured]

Table 4. Evaluation protocol. The astronomical and strength axes have objective gold standards; the interpretive axis is assessed for source-faithfulness, not predictive validity. Values marked pending are to be filled from a production run.

7. Discussion and Epistemological Positioning

We wish to be unambiguous about what is and is not claimed. The astronomy in Sections 2 and 4 is standard positional astronomy and is verifiable to arc-second precision. The strength computation in Sections 3 and 4 is a faithful operationalization of documented classical rules, and its correctness is defined relative to those rules and to reference implementations — not relative to any external outcome. Nothing in this paper constitutes a claim that retrograde planets exert measurable causal influence on human affairs, nor that astrological interpretation is empirically predictive. Those are questions this work neither tests nor asserts.

The contribution is instead one of computational modeling and knowledge engineering: taking a construct that software usually flattens to a boolean, restoring its astronomical content and its classical quantitative

machinery, and making the whole pipeline reproducible and auditable. This framing is also the ethically responsible one for a consumer-facing system: outputs are presented as tradition-grounded interpretation with transparent provenance, not as scientific prediction, and users are not misled about the epistemic status of what they receive.

8. Conclusion

Retrograde motion is a frame-dependent appearance with a precise astronomical definition and a well-specified classical treatment through *ceṣṭā-bala* and the *gati* taxonomy. We have formalized both, given reproducible algorithms that compute *vakri*-state and motional strength from an ephemeris, related them to an explicit interpretive schema, and situated them within a grounded multi-agent system — while drawing a clear line between the computational claims we make and the empirical claims we do not. Treating *vakri* as a first-class computational object, rather than a boolean flag, is what allows an automated system to reason about it with the depth the tradition actually specifies.

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