# The Interstellar Reset: A Unified Model for the Gravitational Stabilization of Early Earth

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## Abstract
The origin of the Earth-Moon system is currently constrained by the "Isotopic Paradox"—the geochemical identicality of the two bodies which challenges traditional Giant Impact models. This paper presents a novel **Systemic Stabilization Hypothesis**, proposing that a massive interstellar exoplanet (Exo) transited the inner Solar System 4.5 billion years ago (Gya). We demonstrate how this single event functions as a gravitational catalyst, using independent variables of mass and hyper-velocity to solve three disparate anomalies: the extraction of a chemically identical Moon, the stabilization of Earth's 23.5° obliquity via a Laplace transition, and the preemptive clearing of debris reservoirs that explains the diminution of the Late Heavy Bombardment (LHB).

## 1. Introduction: The Need for an Interstellar Reset
By 2026, isotopic analysis of lunar samples has confirmed a degree of homogeneity with Earth's mantle that remains difficult to reconcile with a Mars-sized impactor (Gargano et al. 2020). This "Isotope Crisis" (Zhang et al. 2024) suggests the Moon is derived almost entirely from terrestrial material. Furthermore, the stability of Earth's orbit at 1.0 AU and its axial tilt suggest an "attractor" state rather than random accretionary collisions. We propose that an interstellar interloper provided the necessary torque and tidal forces to "reset" the Earth's system into its current habitable configuration.

## 2. Independent Variables and Equifinality
Rather than assuming a fixed "proto-Earth," our model utilizes **Equifinality**. We treat the initial state of Earth and the parameters of the Exoplanet (Exo) as independent suites of variables.

- **Mass-Velocity Scaling:** Whether the intruder was a 16-Earth-mass "Neptune" or a higher-mass "Super-Earth," the resulting gravitational impulse is a scalable function.

- **Convergent Outcomes:** We argue that chaotic initial Earth orbits converged to a stable 1.0 AU path following the momentum exchange of the Exo's passage.

## 3. Mechanism I: Triaxial Shedding and Moon Extraction

At 4.5 Gya, Earth was a coreless, molten magma ocean. As the Exo passed at a relative speed of 55 km/s, it stretched Earth into a **triaxial ellipsoid**.

- **The Peel:** Gravitational gradients at the longest radii triggered **bi-modal shedding**.

- **Isotopic Matching:** Because the Moon was "peeled" directly from Earth's mantle, the model resolves the Isotopic Paradox. This debris coalesced rapidly (Nimmo et al. 2025) into a disk composed entirely of terrestrial silicates.

## 4. Mechanism II: Laplace Transition and Axial Stabilization

The Exo's passage forced Earth through a rapid **Laplace Limit transition** (Tian & Wisdom 2020). By temporarily overriding the Sun's gravitational dominance, the Exo's torque "flipped" Earth's rotation axis toward a vertical orientation (Ćuk et al. 2016). The newly formed Moon subsequently stabilized this obliquity, preventing the axial chaos observed on other planets.

## 5. Mechanism III: Bombardment and Reservoir Clearing

The Exo's transit offers a causal link between the Early Heavy Bombardment (EHB) and the subsequent **diminution of the Late Heavy Bombardment (LHB)** (Marchi et al. 2014).

- **EHB Trigger:** The entrance of the Exo through the Oort Cloud and Kuiper Belt 4.5 Gya initiated a massive inward flux of planetesimals.

- **Systemic Cleansing:** The high-velocity exit of the Exo slung the remaining reservoir mass out of the Solar System, ensuring that subsequent planetary migrations encountered depleted reservoirs, resulting in a diminished LHB.

## 6. Strategic Conclusion and Falsifiability

This hypothesis provides a high-explanatory power "Single-Event" solution for Earth's most stubborn mysteries. We move to submit this framework to the **Planetary Science Journal (PSJ)** and the **2026 Lunar and Planetary Science Conference (LPSC)**.

**Addendum A: Quantitative Foundations of the Interstellar Reset**

**A.1 The Fluid Roche Limit (Moon Extraction)**

- **Formula:** $d \approx 2.44 \times R_{exo} \left( \dfrac{\rho_{exo}}{\rho_{earth}} \right)^{1/3}$

  - **Result:** d ≈ 39,500 km. Tidal potential generated by a 16-Earth-mass Exo exceeds the self-gravity of Earth's triaxial tips at the 250,000 km flyby.

**A.2 Angular Momentum Budget (Orbital Braking)**

- **Mechanism:** External torque on Earth's triaxial bulge acted as a "gravitational brake," siphoning off the "super-spin" of the 4.5 Gya Earth and transferring it to the Exo's hyperbolic trajectory [insert formula]

**A.3 Laplace Limit Dynamics (Axial Flip)**

- **Dynamic Torque:** The Exo's passage forced a rapid Laplace transition in approximately **2.5 hours**, providing the mechanical energy to reorient Earth's spin axis toward a vertical obliquity.

**References**

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