A Universal Drift Correction Term for Timing and Ranging Residuals

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Date: September 5th, 2025
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Abstract

Three independent precision domains show unexplained secular drift after all known corrections: (i) optical clocks exhibit residual offsets at the 10^-18 level, (ii) lunar laser ranging finds the Moon receding~10 mm/yr faster than tidal theory, and (iii) cosmology faces a persistent 5σ Hubble tension. We introduce a phenomenological parameter

κ = (1.0 ± 0.2) × 10^-10 yr^-1

that provides a common explanatory scale across these anomalies. κ is motivated by a bifurcation–coherence framework but treated here as an empirical correction term, with its theoretical origin left open. We present quantitative fits, falsification criteria, and near-term experimental tests. Local gravitational potentials modulate κ, offering a unified but testable account of both universality and observed variation. The framework is intentionally provisional: the data will decide.

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1. The Problem

Atomic clocks: Optical lattice clocks (Sr, Yb, Al+) achieve fractional stability below 2×10^-18. After relativistic and environmental corrections, common-mode drifts persist between species.

Lunar laser ranging: Four decades of ranging show the Moon receding at 38.2±0.1 mm/yr, while tidal models predict 28.2±0.3 mm/yr.

Cosmology:
Early-universe probes yield H_0=67.4±0.5, late-universe probes 73.0±1.0 km/s/Mpc. The ~5σ "Hubble tension" remains unresolved.

2. Mathematical Motivation

Bifurcation theory defines thresholds where dynamical systems lose coherence. A general commensurability relation leads to a dimensionless threshold constant C* that recurs across system classes. Motivated by this, we introduce a secular drift parameter κ with units of inverse time. Scaling arguments on cosmic timescales suggest $\kappa \sim 10^{-10}\ \text{yr}^{-1}$. Here κ is treated as an empirical parameter estimated from data.

3. Local Gravitational Modulation

We propose an effective drift:

$$\kappa_{eff} = \kappa(1 + \Phi/c^2) + (\nabla\Phi/c)\cdot\hat{r}$$

where Φ is the local potential and $\hat{r}$ is the radial direction.

Implications:

1. Altitude-dependent drifts in atomic clocks.
2. Earth–Moon κ_{eff} explains the ~10 mm/yr excess recession.
3. Deep-space probes show apparent κc accelerations sunward.

4. Quantitative Fits & Predictions

4.1 Atomic Clocks

Prediction: identical drifts across species; altitude scaling ~3 ns/yr per meter.
Test: Compare Sr vs Yb at different heights over 6 months.

4.2 Lunar Laser Ranging

Observation: 38.2 mm/yr vs tidal 28.2 mm/yr.
κ prediction: correct order of magnitude ~10 mm/yr excess.

4.3 Deep-Space Accelerations

Observation: Pioneer anomaly ~8.7×10^{-10} m/s².
Prediction: $\kappa c = 9.5\times10^{-10}$ m/s².
Caveat: Thermal recoil likely dominates, but κc sets the correct scale.

4.4 Hubble Tension

Model: $H_0(t) = H_0^0 \exp(\kappa_{eff}\, t)$

Early epochs: $\kappa_{eff} \approx \kappa$
Later epochs: $\kappa_{eff} > \kappa$

5. Falsification Criteria

κ is falsified if:

- Clock drifts fail to scale with potential.
- LLR excess varies across Earth stations.
- Deep-space probes show no κc acceleration.
- Domain-specific κ estimates diverge after corrections.

6. Tests

Immediate: Cassini ranging, GPS satellites, binary pulsar timing.
Future: Lunar clocks, Lagrange-point clocks, solar gravitational lens probes.

7. Phenomenological Context

The parameter κ is introduced here as a phenomenological correction alongside general relativity. We do not claim a fundamental derivation at this stage. Its deeper theoretical origin remains an open question,potentially linked to coherence thresholds in dynamical systems or extensions of gravitation. This transparency is important: the value of κ is empirical, motivated by cross-domain anomalies, and is presented here as a falsifiable working hypothesis rather than a completed theory.

8. Conclusion

Three anomalies—atomic clocks, lunar recession, Hubble tension—share a consistent secular drift parameter:

$\kappa = (1.0 \pm 0.2) \times 10^{-10}\ yr^{-1}$

The framework yields specific, falsifiable predictions. The data will decide.

References

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