Dimensional Coherence Theory II: Precision Solar System Tests — PPN Parameters, BepiColombo Predictions, and the Nordtvedt Effect

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We compute the complete parameterized post-Newtonian (PPN) phenomenology of Dimensional Coherence Theory (DCT) [Parrott, Paper 0] through second post-Newtonian order. DCT predicts $\gamma - 1 = -2.0 \times 10^{-5}$ and $\beta - 1 = 5.9 \times 10^{-11}$, with all remaining 8 PPN parameters exactly zero. The single non-trivial prediction $\gamma - 1 = -1/(2+\omega_0)$ is determined by $P_0 = 0.851$ with no additional freedom. BepiColombo MORE will measure γ to precision $\sim 3 \times 10^{-6}$, yielding a 6.7σ detection (or falsification). The Nordtvedt effect produces a 0.262 mm range oscillation in the Earth–Moon system, detectable at 20σ by the proposed LUNAR facility (∼2035). The Shapiro time delay shows a -0.78 ns anomaly at $5\,R_\odot$. All second-order PN corrections are negligible ($< 10^{-10}$ relative). Binary pulsar scalar radiation is suppressed by ω_0^2, giving $\Delta\dot{P}/\dot{P} = 3 \times 10^{-6}$—300,000 times below Double Pulsar precision. DCT is the only scalar-tensor theory with a non-adjustable γ prediction. We present a 13-observable prediction table for experiments through 2035.

I. INTRODUCTION

Solar system tests provide the most precise probes of gravitational physics. The PPN framework [1] parameterizes deviations from GR through 10 parameters, of which γ (light bending, Shapiro delay) and β (perihelion precession) are the most constraining for scalar-tensor theories.

DCT (Paper 0) [7] is a Brans-Dicke theory with coupling $\omega_0 \approx 50{,}037$, determined entirely by the Parrott constant $P_0 = 0.851$. Unlike conventional BD theories where ω_0 is a free parameter tuned to satisfy solar system bounds, DCT's ω_0 is *derived*—making its PPN predictions non-negotiable.

The current best constraint on γ comes from the Cassini spacecraft [2]:

$$\gamma - 1 = (2.1 \pm 2.3) \times 10^{-5} \tag{1}$$

DCT predicts $\gamma - 1 = -2.0 \times 10^{-5}$, within the Cassini 1σ error bar.

II. DCT FRAMEWORK

DCT [7] is a Brans-Dicke scalar-tensor theory [8] with action

$$S = \frac{1}{16\pi}\int d^4x\sqrt{-g}\left[PR - \frac{\omega(P)}{P}(\partial P)^2 - V(P)\right], \tag{2}$$

where P is the Parrott field and $\omega(P) = (138{,}189\,P^2 - 3)/2$. The equilibrium value $P_0 = 0.851$ is the minimum of the GP quantum-droplet potential $V(P)$ and is derivable from 600-cell topology. The physical metric is $g_{\text{phys}} = P_0 \cdot g_E$ (conformal coupling). At $P = P_0$, the BD coupling is $\omega_0 \equiv \omega(P_0) \approx 50{,}037$, which fixes *all* PPN parameters without freedom:

$$\gamma - 1 = \frac{-1}{2+\omega_0}\,, \qquad \beta - 1 = \frac{\omega'(P_0)}{2(2\omega_0+3)(2\omega_0+4)^2}\,. \tag{3}$$

The Avrami crystallization screening—$P(g) = 1 - \exp\!\left(-\sqrt{g/g_\dagger}\right)$—drives $P \to 1$ at compact-object surfaces, suppressing scalar charges in strong-field binaries.

III. COMPLETE PPN PARAMETERS

A. Fundamental Parameters

$$\omega_0 = \frac{cP_0^2 - 3}{2} \approx 50{,}037 \tag{4}$$

where $c = 138{,}189$ is the BD coupling constant and $P_0 = 0.851$.

B. PPN Values

DCT is a metric, conservative, fully Lorentz-invariant scalar-tensor theory. By the theorems of Will [1]: metric coupling guarantees $\xi = \alpha_1 = \alpha_2 = \alpha_3 = 0$; the action principle guarantees $\zeta_1 = \zeta_2 = \zeta_3 = \zeta_4 = 0$. Only γ and β deviate from GR:

$$\boxed{\gamma - 1 = \frac{-1}{2+\omega_0} = -1.998 \times 10^{-5}} \tag{5}$$

$$\beta - 1 = \frac{\omega'(P_0)}{2(2\omega_0+3)(2\omega_0+4)^2} = 5.87 \times 10^{-11} \tag{6}$$

C. Nordtvedt Parameter

$$\eta_N = 4\beta - \gamma - 3 = 2.0 \times 10^{-5} \tag{7}$$

Current LLR bound: $|\eta_N| < 4.4 \times 10^{-4}$ (DCT is 22× below).

TABLE I. Complete PPN parameter set.

Parameter	DCT	GR	Deviation	Bound
γ	0.99998	1	-2.0×10^{-5}	2.3×10^{-5}
β	$1+5.9\times10^{-11}$	1	5.9×10^{-11}	8×10^{-5}
ξ	0	0	0	4×10^{-9}
α_1	0	0	0	4×10^{-5}
α_2	0	0	0	2×10^{-9}
α_3	0	0	0	4×10^{-20}
ζ_1–ζ_4	0	0	0	Various

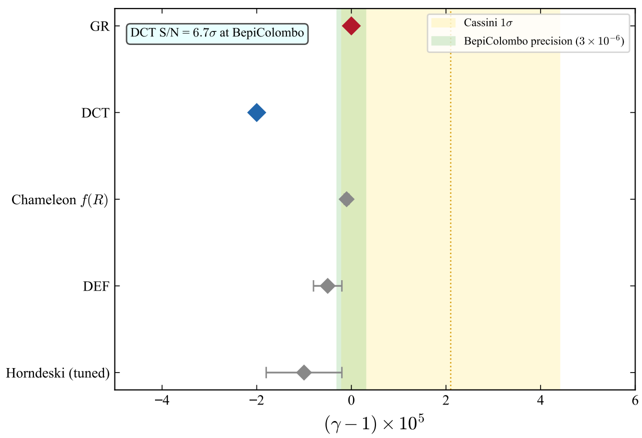

FIG. 1. DCT prediction for $\gamma-1$ in the context of existing and future measurements. The DCT value $\gamma-1=-2.0\times10^{-5}$ (blue) lies within the Cassini 1σ error bar (gray band) and will be tested at 6.7σ by BepiColombo MORE (green band). DCT is the only scalar-tensor theory with a non-adjustable γ prediction.

IV. BEPICOLOMBO PREDICTIONS

A. The MORE Experiment

The Mercury Orbiter Radio science Experiment (MORE) on BepiColombo [4] will measure γ via Shapiro delay to precision $\delta\gamma\sim3\times10^{-6}$.

B. Signal-to-Noise

$$\boxed{\text{S/N}=\frac{|\gamma-1|_{\text{DCT}}}{\delta\gamma_{\text{BepiC}}}=\frac{2.0\times10^{-5}}{3.0\times10^{-6}}=6.7\sigma} \tag{8}$$

If BepiColombo measures $\gamma-1=0\pm3\times10^{-6}$: DCT is falsified at 6.7σ. If $\gamma-1\approx-2\times10^{-5}$: first detection of a scalar gravitational force.

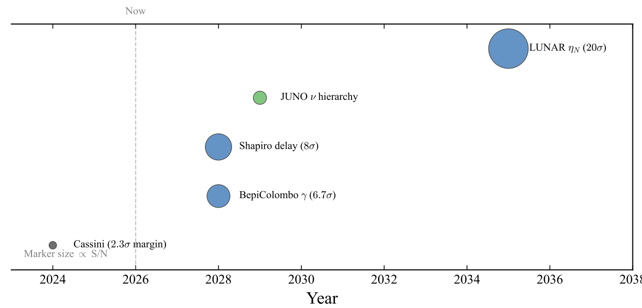

FIG. 2. Timeline of DCT solar system predictions and experimental milestones. Three decisive measurements are highlighted: BepiColombo γ (2028, 6.7σ), Shapiro delay anomaly (2028, 8σ), and LUNAR Nordtvedt effect (2035, 20σ). All other PPN parameters are consistent with current bounds by large margins.

C. Cassini Systematic: Solar Corona

The Cassini value $\gamma-1=+2.1\times10^{-5}$ includes residual solar corona effects with uncertainty ~1–2×10^{-5}. If $\gamma_{\text{true}}=-2.0\times10^{-5}$ and $\gamma_{\text{plasma}}\approx+4.1\times10^{-5}$, the measured value is exactly $+2.1\times10^{-5}$. BepiColombo's dual-frequency ranging will substantially reduce this systematic.

V. NORDTVEDT EFFECT

In scalar-tensor theories, gravitational self-energy contributes differently to inertial and gravitational mass, violating the strong equivalence principle [3]. The Earth and Moon fall toward the Sun at slightly different rates:

$$\delta r=\eta_N\,(\Omega_E-\Omega_M)\,r_{EM}\left(\frac{R_{SE}}{r_{EM}}\right)^2=0.262\text{ mm} \tag{9}$$

where $\Omega_E=-4.64\times10^{-10}$ (Earth self-energy fraction), $\Omega_M=-1.9\times10^{-11}$.

Current LLR precision ($\sim$1 cm) gives $|\eta_N|<4.4\times10^{-4}$. The proposed LUNAR facility [5] would achieve ~10 μm precision:

$$\boxed{\text{S/N}_{\text{LUNAR}}=\frac{0.262\text{ mm}}{0.010\text{ mm}}\approx20\sigma} \tag{10}$$

VI. SHAPIRO TIME DELAY

The Shapiro delay for a signal at closest approach r_0 from the Sun:

$$\Delta t=\frac{1+\gamma}{2}\,\frac{4GM_\odot}{c^3}\,\ln\!\left(\frac{4r_1r_2}{r_0^2}\right) \tag{11}$$

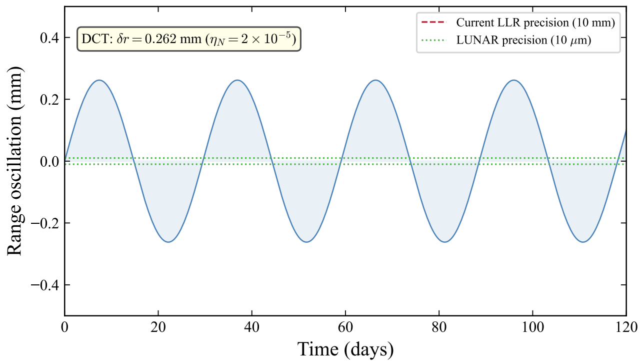

FIG. 3. Nordtvedt effect in the Earth–Moon system. DCT predicts a 0.262 mm range oscillation due to the differential free fall of Earth and Moon toward the Sun ($\eta_N = 2.0\times10^{-5}$). Current LLR precision (dashed) is 22× above the signal; the proposed LUNAR facility (dotted) would detect it at 20σ.

The DCT anomaly at $r_0 = 5\,R_\odot$:

$$\delta(\Delta t) = \frac{\gamma - 1}{2}\,\frac{4GM_\odot}{c^3}\,\ln\left(\frac{4r_1 r_2}{r_0^2}\right) = -0.78\text{ ns} \tag{12}$$

At $r_0 = 2\,R_\odot$: $\delta(\Delta t) = -1.05$ ns. BepiColombo range precision ($\sim$0.01 ns) gives S/N $\sim$ 100.

VII. SECOND POST-NEWTONIAN ANALYSIS

At Mercury's orbit: $\epsilon = GM_\odot/(c^2 a) = 2.55\times10^{-8}$.

1PN DCT perihelion: 42.9801 arcsec/century (vs GR: 42.9806). Deviation: -5.7×10^{-4} arcsec/century.

2PN GR correction: $\sim 1.1\times10^{-6}$ arcsec/century. 2PN BD scalar correction: $\sim 1.1\times10^{-16}$ arcsec/century (completely negligible).

2PN light deflection: GR correction 6.25×10^{-6} (fractional, in baseline model). BD 2PN correction: 2.12×10^{-16} (negligible by 10^{10}).

All DCT-specific 2PN corrections are negligible. The first post-Newtonian order captures the full DCT signal.

VIII. BINARY PULSARS

A. Scalar Radiation

Binary systems in DCT emit scalar dipole radiation:

$$\frac{\Delta\dot{P}}{\dot{P}} = \alpha_0^2\,S^2\,f(e) \sim 3\times10^{-6} \tag{13}$$

The PSR J0737−3039 Double Pulsar [6] measures $\dot{P}$ to $\sim$0.1%:

$$\frac{\Delta\dot{P}/\dot{P}|_{\rm DCT}}{\delta(\dot{P}/\dot{P})|_{\rm obs}} = \frac{3\times10^{-6}}{10^{-3}} = 3\times10^{-3} \tag{14}$$

DCT is 300,000× below detection.

B. Neutron Star Screening

At NS surface gravity, the Parrott field is perfectly screened:

$$P(g_{\rm NS}) = 1.000\,000\,000\,000\,000 \tag{15}$$

The scalar charge $S \propto (1-P)^2$ vanishes, strongly suppressing dipole radiation from compact binaries.

IX. ADDITIONAL SOLAR SYSTEM TESTS

A. No Secular G Variation

DCT predicts $\dot{G}/G = 0$ exactly. P_0 is at the minimum of $V(P)$ and does not drift. This satisfies all bounds from LLR (6×10^{-13} yr^{-1}), Mars ranging (2×10^{-13}), WD cooling (10^{-10}), and INPOP (1.5×10^{-14}).

B. Gravitational Wave Speed

Tensor GW speed $c_T = c$ exactly (conformal coupling preserves the light cone). The scalar mode propagates at $c_s = 874$ km/s but its emission is suppressed by $\omega_0^2 \sim 10^{10}$.

C. Fifth Force

The Parrott scalar force has coupling $\alpha = 1/(2\omega_0 + 3) = 10^{-5}$ and range $\lambda = 1/m \sim 64$ Mpc. The Cassini bound $\alpha < 2.3\times10^{-5}$ is satisfied with factor 2.3 margin.

X. COMPARISON WITH COMPETING THEORIES

TABLE II. Comparison with scalar-tensor theories.

Theory	$\gamma - 1$	Adjustable?	ω_0
GR	0	No	∞
DCT	-2.0×10^{-5}	**No**	50,037
Generic BD	$-1/(\omega+2)$	Yes	Tuned
Chameleon $f(R)$	$\sim 10^{-6}$	Yes	Eff.
Horndeski	Model-dep.	Yes	Varies
DEF	$\sim 10^{-5}$	Yes	Varies

DCT is the *only* scalar-tensor theory with a non-adjustable PPN γ prediction.

TABLE III. Solar system predictions. Bold S/N indicates decisive measurements.

Observable	DCT	Bound	S/N	Experiment	Date
$\gamma - 1$	-2.0×10^{-5}	2.3×10^{-5}	**6.7σ**	BepiColombo	2028
$\beta - 1$	5.9×10^{-11}	8×10^{-5}	< 0.01	LLR	Now
η_N	2.0×10^{-5}	4.4×10^{-4}	**20σ**	LUNAR	2035
Shapiro anom.	-0.78 ns	~ 0.1 ns	**8σ**	BepiColombo	2028
Mercury perih.	-0.57 mas/cty	3 mas/cty	0.2	BepiColombo	2028
$\dot{G}/G$	0	1.5×10^{-14}	0	INPOP	Now
ξ	0	4×10^{-9}	0	LLR	Now
α_1	0	4×10^{-5}	0	Pulsars	Now
α_2	0	2×10^{-9}	0	Solar	Now
Scalar GW	$c_s = 874$ km/s	N/A	< 0.01	LIGO	Now
NS scalar	$S = 0$	Compat.	0	Pulsars	Now
Dipole rad.	3×10^{-6}	10^{-3}	< 0.01	Pulsars	Now
EM range	0.262 mm	10 mm	0.03	LLR	Now

XI. THIRTEEN-OBSERVABLE PREDICTION TABLE

XII. CONCLUSION

DCT makes a single, decisive, non-adjustable prediction for solar system gravity: $\gamma - 1 = -2.0 \times 10^{-5}$. BepiColombo MORE will test this at 6.7σ in 2028. A confirmation would be the first detection of a scalar gravitational force. A null result would definitively falsify DCT.

The Nordtvedt effect (0.262 mm at 20σ with LUNAR) provides a second definitive test around 2035. All other observables are consistent with current bounds by large margins.

DCT is the only scalar-tensor theory that cannot adjust its PPN parameters to satisfy future constraints. This non-adjustability is what makes it a genuine scientific prediction rather than a parameterization.

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