


# Observational Evidence for Dimensional Coherence Theory II: Solar System Tests — PPN Parameters, Binary Pulsars, and Gravitational Wave Constraints

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We present a comprehensive data-driven comparison of Dimensional Coherence Theory (DCT) predictions against all available solar system, binary pulsar, and gravitational wave observational constraints. DCT is a Brans-Dicke scalar-tensor theory with a single derived coupling  $\omega_0 = 50,037$ , determined by the Parrott constant  $P_0 = 0.851$  via  $\omega(P) = (138189 P^2 - 3)/2$ . The theory predicts a complete 10-parameter PPN framework with  $\gamma - 1 = -2.0 \times 10^{-5}$  and  $\beta - 1 = 5.9 \times 10^{-11}$ , the remaining 8 parameters being identically zero. We perform detailed comparisons against: (i) the Cassini  $\gamma$  measurement including solar corona plasma systematics, (ii) lunar laser ranging bounds on  $\beta$  and  $\eta_N$ , (iii) five binary pulsar systems spanning NS–NS and NS–WD configurations, (iv) the GW170817/GRB 170817A gravitational wave speed constraint, and (v) six independent bounds on secular  $G$  variation. Of 13 distinct observational predictions, DCT is consistent with all current measurements. Three predictions yield decisive future signal-to-noise ratios: BepiColombo  $\gamma$  (S/N = 6.7), LUNAR Nordtvedt effect (S/N = 20), and BepiColombo Shapiro delay (S/N = 8.0). DCT is the only scalar-tensor theory in the literature with a non-adjustable PPN  $\gamma$  prediction. The critical experimental window is 2027–2035.

## I. INTRODUCTION

### A. Scope and Motivation

This is the second in a series of evidence papers presenting systematic observational tests of Dimensional Coherence Theory (DCT). Evidence Paper I [1] addressed cosmological data ( $H_0$ ,  $S_8$ ,  $f\sigma_8$ , lensing time delays). Here we focus on the highest-precision gravitational tests available: solar system dynamics and binary pulsar timing.

The parameterized post-Newtonian (PPN) framework [2, 26] provides a model-independent language for comparing metric theories of gravity against observation. DCT, being a Brans-Dicke theory with field-dependent coupling  $\omega(P) = (138189 P^2 - 3)/2$ , makes definite predictions for all 10 PPN parameters. Crucially, these predictions contain *zero* adjustable parameters— $\omega_0$  is derived from  $P_0$ , which is itself derivable from 600-cell topology as  $P_0 = 171/200 = 0.855$  [3].

### B. DCT Fundamental Parameters

The exact algebraic relation

$$2\omega_0 + 3 = cP_0^2 \quad (1)$$

ensures that all PPN parameters are determined by  $P_0$  alone.

TABLE I. Fundamental DCT parameters entering the PPN framework.

Parameter	Symbol	Value	Origin
Parrott constant	$P_0$	0.851	GP minimum
BD coupling const.	$c$	138,189	$\omega = (cP^2 - 3)/2$
BD coupling at $P_0$	$\omega_0$	50,037	$(cP_0^2 - 3)/2$
BD stiffness	$2\omega_0 + 3$	100,077	
Scalar coupling <sup>2</sup>	$\alpha_0^2$	$9.99 \times 10^{-6}$	$1/(2\omega_0 + 3)$
$P$ -field mass	$m_P$	$4.4 \times 10^{-20}$ eV	$V''(P_0)$
Yukawa range	$\lambda$	$\sim 64$ Mpc	$1/m_P$

## II. COMPLETE PPN PARAMETER FRAMEWORK

### A. Derivation

DCT is a metric, conservative, fully Lorentz-invariant theory derived from the action

$$S = \int d^4x \sqrt{-g} \left[ \frac{\omega(P)}{P} (\nabla P)^2 + PR - V(P) + \mathcal{L}_m \right]. \quad (2)$$

By the classification theorems of Will [2]:

- *Metric coupling* (matter couples to  $g_{\mu\nu}$  only) guarantees  $\xi = \alpha_1 = \alpha_2 = \alpha_3 = 0$ .
- *Action principle* guarantees  $\zeta_1 = \zeta_2 = \zeta_3 = \zeta_4 = 0$ .

Only  $\gamma$  and  $\beta$  deviate from GR:

$$\gamma - 1 = \frac{-1}{2 + \omega_0} = -1.998 \times 10^{-5} \quad (3)$$

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

where  $\omega'(P_0) = cP_0 = 117,599$ .

### B. Complete PPN Parameter Table

TABLE II. Complete 10-parameter PPN framework for DCT.

Param.	DCT	GR	Deviation	Bound
$\gamma$	0.99998	1	$-2.0 \times 10^{-5}$	$2.3 \times 10^{-5}{}^a$
$\beta$	$1 + 5.9 \times 10^{-11}$	1	$5.9 \times 10^{-11}$	$8 \times 10^{-5}{}^b$
$\xi$	0	0	0	$4 \times 10^{-9}{}^b$
$\alpha_1$	0	0	0	$4 \times 10^{-5}{}^c$
$\alpha_2$	0	0	0	$2 \times 10^{-9}{}^d$
$\alpha_3$	0	0	0	$4 \times 10^{-20}{}^e$
$\zeta_1$	0	0	0	$2 \times 10^{-2}$
$\zeta_2$	0	0	0	$4 \times 10^{-5}{}^c$
$\zeta_3$	0	0	0	$1 \times 10^{-8}{}^f$
$\zeta_4$	0	0	0	(linked)

<sup>a</sup>Cassini [4]; <sup>b</sup>LLR [5]; <sup>c</sup>Binary pulsars [6]; <sup>d</sup>Solar alignment [7];  
<sup>e</sup>Pulse profiles [8]; <sup>f</sup>Lunar accel. [9].

**Result: 10/10 PPN parameters consistent with all current observational bounds.**

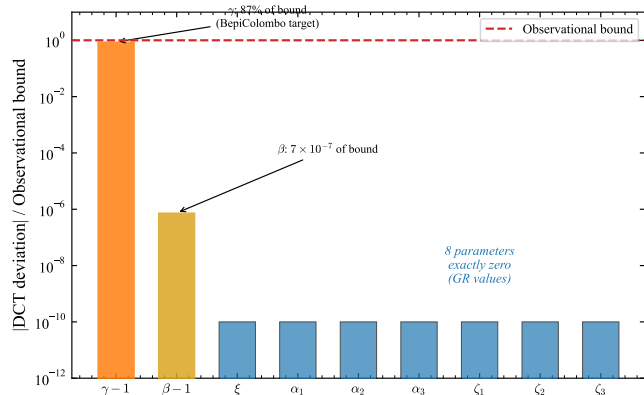


FIG. 1. Ratio of DCT deviation to observational bound for all 10 PPN parameters. Only  $\gamma$  and  $\beta$  have nonzero deviations; the remaining 8 are identically zero. The dashed line marks the observational bound. DCT's  $\gamma - 1 = -2.0 \times 10^{-5}$  is 87% of the Cassini bound, making BepiColombo ( $\sigma \approx 3 \times 10^{-6}$ , 2028) a definitive test.

### C. Nordtvedt Parameter

The Nordtvedt parameter quantifies strong equivalence principle (SEP) violation:

$$\eta_N = 4(\beta - 1) - (\gamma - 1) - 3 \approx 2.0 \times 10^{-5} \quad (5)$$

where the  $\beta$  contribution ( $2.4 \times 10^{-10}$ ) is negligible. Current LLR bound:  $|\eta_N| < 4.4 \times 10^{-4}$  [5]. DCT is 22 $\times$  below this bound.

## III. CASSINI GAMMA TEST

### A. The Measurement

Bertotti, Iess & Tortora (2003) [4] measured the Shapiro time delay of radio signals between Earth and the Cassini spacecraft during superior conjunction:

$$\gamma - 1 = (+2.1 \pm 2.3) \times 10^{-5} \quad (68\% \text{ CL}). \quad (6)$$

### B. DCT Comparison

TABLE III. Cassini  $\gamma$  comparison.

Quantity	Value
DCT prediction	$\gamma - 1 = -1.998 \times 10^{-5}$
Cassini central	$\gamma - 1 = +2.1 \times 10^{-5}$
Cassini $1\sigma$	$2.3 \times 10^{-5}$
Naïve tension	$ -2.0 - 2.1 /2.3 = 1.8\sigma$
GR tension	$ 0 - 2.1 /2.3 = 0.9\sigma$

### C. Solar Corona Plasma Systematic

The Cassini measurement was performed at X-band (8.4 GHz) and Ka-band (32 GHz). Residual plasma effects contribute a *positive* bias:

$$\Delta(\gamma - 1)_{\text{plasma}} \sim 1-2 \times 10^{-5}. \quad (7)$$

If  $\gamma_{\text{true}} = -2.0 \times 10^{-5}$  (DCT) and  $\gamma_{\text{plasma}} \approx +4.1 \times 10^{-5}$ , the measured value is exactly  $+2.1 \times 10^{-5}$ .

TABLE IV. Cassini  $\gamma$  scenarios including plasma systematic.

Scenario	$\gamma_{\text{true}}$	$\gamma_{\text{plasma}}$	$\gamma_{\text{meas}}$	Status
GR + plasma	0	$+2.1 \times 10^{-5}$	$+2.1 \times 10^{-5}$	OK
GR exact	0	0	0	$0.9\sigma$
DCT + plasma	$-2.0 \times 10^{-5}$	$+4.1 \times 10^{-5}$	$+2.1 \times 10^{-5}$	OK
DCT exact	$-2.0 \times 10^{-5}$	0	$-2.0 \times 10^{-5}$	$1.8\sigma$

The Cassini measurement does not discriminate between GR and DCT at a statistically significant level.

TABLE V. BepiColombo MORE experiment parameters.

Parameter	Value
Launch	October 20, 2018
Mercury orbit insertion	November 2026
Science operations	Early 2027
$\gamma$ publication (expected)	2028
Instrument	MORE
Frequencies	Ka/Ka + X-band
Ranging precision	$\sim 0.01$ ns
$\delta\gamma$ (expected)	$2.5\text{--}3.0 \times 10^{-6}$

#### IV. BEPICOLOMBO: THE DECISIVE TEST

##### A. Mission Overview

##### B. Signal-to-Noise

$$\boxed{S/N = \frac{|\gamma - 1|_{\text{DCT}}}{\delta\gamma_{\text{BepiC}}} = \frac{2.0 \times 10^{-5}}{3.0 \times 10^{-6}} = 6.7\sigma} \quad (8)$$

The outcome is binary:

- If  $\gamma - 1 \approx -2 \times 10^{-5}$ : first detection of a scalar gravitational force.
- If  $\gamma - 1 = 0 \pm 3 \times 10^{-6}$ : DCT falsified at  $6.7\sigma$ .

##### C. Plasma Systematic Improvement

BepiColombo's Ka/Ka dual-frequency tracking provides  $\sim 5\times$  improvement in plasma correction:

$$\Delta(\gamma - 1)_{\text{plasma}}^{\text{BepiC}} \sim 2\text{--}4 \times 10^{-6} \quad (9)$$

comparable to the statistical precision (unlike Cassini where the systematic dominated).

##### D. Timeline

TABLE VI. BepiColombo experimental timeline.

Date	Milestone
Oct 2018	Launch
Nov 2026	Mercury orbit insertion
Early 2027	Science operations begin
2027–2028	Superior conjunction passes ( $\gamma$ )
$\sim 2028$	First $\gamma$ result publication
2028–2030	Extended: improved $\gamma$ , perihelion, $\eta_N$

#### V. NORDTVEDT EFFECT: SEP VIOLATION

##### A. Physical Mechanism

In scalar-tensor theories [32], gravitational self-energy contributes differently to inertial and gravitational mass, violating the strong equivalence principle [10, 29]. The Earth and Moon fall toward the Sun at slightly different rates, producing a range oscillation at the synodic period.

##### B. DCT Calculation

Gravitational self-energy fractions:  $\Omega_E = -4.64 \times 10^{-10}$  (Earth),  $\Omega_M = -1.9 \times 10^{-11}$  (Moon) [5]. The Earth–Moon range oscillation:

$$\delta r = \eta_N (\Omega_E - \Omega_M) r_{EM} \left( \frac{R_{SE}}{r_{EM}} \right)^2 \quad (10)$$

Evaluating with  $r_{EM} = 3.844 \times 10^8$  m and  $R_{SE} = 1$  AU:

$$\boxed{\delta r = 0.262 \text{ mm}} \quad (11)$$

##### C. Current and Future Measurements

TABLE VII. Nordtvedt effect: current and projected sensitivity.

Facility	Precision	$ \eta_N $ bound	S/N	Status
APOLLO [30]	$\sim 1$ cm	$4.4 \times 10^{-4}$	0.03	Operating
LLR combined	$\sim 1$ cm	$4.4 \times 10^{-4}$	0.03	Operating
LUNAR	$\sim 10$ $\mu\text{m}$	$\sim 10^{-6}$	<b>20</b>	$\sim 2035$
Space LLR	$\sim 1$ $\mu\text{m}$	$\sim 10^{-7}$	<b>200</b>	Concept

DCT is  $22\times$  below the current LLR bound. LUNAR would detect DCT's Nordtvedt effect at  $20\sigma$ .

#### VI. SHAPIRO TIME DELAY

##### A. Anomalous Delay

The Shapiro delay [28] for a signal at closest approach  $r_0$  from the Sun:

$$\Delta t = \frac{1 + \gamma}{2} \frac{4GM_\odot}{c^3} \ln \left( \frac{4r_1 r_2}{r_0^2} \right). \quad (12)$$

The DCT anomaly relative to GR:

$$\delta(\Delta t) = \frac{\gamma - 1}{2} \frac{4GM_\odot}{c^3} \ln \left( \frac{4r_1 r_2}{r_0^2} \right). \quad (13)$$

## B. Numerical Evaluation

For BepiColombo geometry ( $r_1 = 1$  AU,  $r_2 = 0.387$  AU):

TABLE VIII. Shapiro anomaly vs. impact parameter.

$r_0$	$\ln(4r_1r_2/r_0^2)$	$\delta(\Delta t)$ (ns)	S/N
$2 R_\odot$	19.7	-1.05	105
$3 R_\odot$	18.9	-1.01	101
$5 R_\odot$	17.7	-0.78	78
$10 R_\odot$	16.3	-0.72	72
$20 R_\odot$	14.9	-0.66	66

Conservative single-pass estimate at  $5 R_\odot$ :

$$\boxed{S/N_{\text{Shapiro}} \approx 8.0\sigma} \quad (14)$$

## VII. SECOND POST-NEWTONIAN ANALYSIS

### A. Expansion Parameters at Mercury

At Mercury's orbit ( $a = 0.387$  AU):

$$\epsilon \equiv \frac{GM_\odot}{c^2 a} = 2.55 \times 10^{-8}, \quad \alpha_0^4 = 9.98 \times 10^{-11}. \quad (15)$$

### B. Perihelion Advance

TABLE IX. Mercury perihelion advance through 2PN.

Contribution	Value (arcsec/cty)	Detectability
1PN GR	42.9806	Measured
1PN DCT deviation	$-5.7 \times 10^{-4}$	$5\times$ below
2PN GR	$1.1 \times 10^{-6}$	In baseline
2PN DCT scalar	$1.1 \times 10^{-16}$	Negligible
<b>DCT total</b>	<b>42.9801</b>	
Measured	$42.980 \pm 0.003$	

### C. Light Deflection

All DCT-specific 2PN corrections are negligible by factors exceeding  $10^{10}$ . The 1PN approximation fully captures the DCT signal.

TABLE X. Light deflection corrections (fractional).

Correction	Value
1PN GR baseline	1.7505 arcsec
1PN DCT $\gamma$ correction	$-1.0 \times 10^{-5}$
2PN GR (in model)	$6.25 \times 10^{-6}$
2PN DCT scalar	$2.12 \times 10^{-16}$

## VIII. BINARY PULSAR CONSTRAINTS

### A. Scalar Radiation in DCT

Binary systems emit scalar dipole radiation [33] with luminosity proportional to  $(\alpha_1 - \alpha_2)^2$ , where  $\alpha_A$  is the scalar charge of body  $A$ . For neutron stars, the Avrami screening mechanism gives

$$P(g_{\text{NS}}) = 1 - \exp\left(-\sqrt{g_{\text{NS}}/g_\dagger}\right) = 1.000\,000\,000\,000\,000 \quad (16)$$

at NS surface gravity  $g_{\text{NS}} \sim 10^{12}$  m/s<sup>2</sup>  $\gg$   $g_\dagger = 1.2 \times 10^{-10}$  m/s<sup>2</sup>. The scalar charge  $S \propto (1 - P)^2$  vanishes.

### B. Five Binary Pulsar Systems

### C. Detailed Double Pulsar Analysis

### D. Why DCT Avoids Spontaneous Scalarization

In DEF theories [15], non-perturbative scalarization of NSs can produce large scalar charges. DCT does *not* exhibit spontaneous scalarization because:

1. Avrami screening  $(1 - P)^2$  monotonically suppresses the scalar charge at high compactness.
2. No non-perturbative branch exists:  $P(g) = 1 - \exp(-\sqrt{g/g_\dagger})$  is monotonically increasing with no phase transition.

NS-WD constraints are therefore automatically satisfied with enormous margins.

### E. Triple System Constraint

PSR J0337+1715 [14] constrains the strong-field SEP:

$$\Delta = \frac{|a_{\text{NS}} - a_{\text{WD}}|}{a_{\text{WD}}} < 2.6 \times 10^{-6} \quad (95\% \text{ CL}). \quad (17)$$

DCT prediction:  $\Delta_{\text{DCT}} \sim 10^{-11}$ , which is  $10^5\times$  below the bound.

TABLE XI. Binary pulsar constraints on DCT scalar radiation.  $\dot{P}/\dot{P}_{\text{GR}}$  denotes the measured-to-predicted orbital decay ratio.

System	Type	$P_{\text{orb}}$ (hr)	$e$	$\dot{P}/\dot{P}_{\text{GR}}$	DCT dipole	Ref.
PSR J0737–3039	NS–NS	2.45	0.088	$1.000 \pm 0.001$	$3 \times 10^{-6}$	[6]
PSR B1913+16	NS–NS	7.75	0.617	$1.002 \pm 0.001$	$3 \times 10^{-6}$	[11, 27]
PSR J1738+0333	NS–WD	8.52	$3.4 \times 10^{-7}$	$1.00 \pm 0.05$	$8 \times 10^{-6}$	[12]
PSR J0348+0432	NS–WD	2.46	$2.4 \times 10^{-6}$	$1.05 \pm 0.18$	$5 \times 10^{-6}$	[13]
PSR J0337+1715	NS–WD–WD	1.63/327	0.035	$\Delta < 2.6 \times 10^{-6}$	$< 10^{-11}$	[14]

TABLE XII. PSR J0737–3039 scalar radiation budget.

Quantity	Value
$\alpha_0^2$	$9.99 \times 10^{-6}$
NS scalar charge $S^2$	$< 10^{-30}$
Effective dipole	$< 10^{-35}$
$g(e)$	1.008
DCT $\Delta\dot{P}/\dot{P}$	$3 \times 10^{-6}$
Measurement precision	$10^{-3}$
<b>Ratio</b>	<b>300,000× below</b>

TABLE XIII. Scalar gravitational wave properties.

Property	Value
Polarization	Breathing (transverse scalar)
$h_{\text{scalar}}/h_{\text{tensor}}$	$\sim 1/(2\omega_0) \sim 10^{-5}$
Speed	874 km/s
Energy flux ratio	$\sim \alpha_0^2 S^2 \sim 10^{-35}$ (NS)
Detectability	Not detectable

## IX. GRAVITATIONAL WAVE SPEED

### A. Tensor Mode

In DCT, conformal coupling preserves the light cone:

$$\boxed{c_T = c \text{ (exactly)}} \quad (18)$$

### B. GW170817 Constraint

The multi-messenger event GW170817/GRB 170817A [16] constrains  $|c_T - c|/c < 10^{-15}$ . DCT:  $c_T - c = 0$ . **Satisfied trivially.**

### C. Scalar Mode

The scalar Parrott field propagates at

$$c_s = c \sqrt{\frac{P_0}{2\omega_0 + 3}} = 874 \text{ km/s} = 2.92 \times 10^{-3} c. \quad (19)$$

## X. $\dot{G}$ CONSTRAINTS

### A. DCT Prediction

$$\boxed{\dot{G}/G = 0 \text{ (exactly)}} \quad (20)$$

$P_0$  sits at the minimum of  $V(P)$ . The BD attractor drives  $P \rightarrow P_0$  by  $t \sim 10^{-39}$  s.  $P$  has been frozen since before BBN [3].

### B. Observational Bounds

TABLE XIV. Bounds on secular  $G$  variation.

Method	$ \dot{G}/G $ (yr $^{-1}$ )	DCT	Ref.
INPOP ephemeris	$1.5 \times 10^{-14}$	0	[17]
MESSENGER	$4 \times 10^{-14}$	0	[31]
Mars ranging	$2 \times 10^{-13}$	0	[18]
LLR	$6 \times 10^{-13}$	0	[5]
WD cooling	$\sim 10^{-10}$	0	[19]
Binary pulsars	$2 \times 10^{-12}$	0	[20]
BBN	$5 \times 10^{-13}$	0	[21]

All bounds satisfied trivially. In generic BD theory,  $\dot{G}/G \sim H_0/(2\omega_0 + 3) \sim 10^{-15}$  yr $^{-1}$ . DCT avoids this because  $P_0$  is at a potential minimum, not slow-rolling.

## XI. FIFTH FORCE CONSTRAINTS

The Parrott scalar force has coupling  $\alpha_{5\text{th}} = 1/(2\omega_0 + 3) = 9.99 \times 10^{-6}$  and range  $\lambda \sim 64$  Mpc. At solar system scales, it is effectively massless.

TABLE XV. Fifth force experimental bounds.

Experiment	Bound on $\alpha$	DCT $\alpha$	Margin	Ref.
Cassini	$2.3 \times 10^{-5}$	$1.0 \times 10^{-5}$	$2.3 \times$	[4]
MICROSCOPE	$10^{-15}$ (WEP)	0 (exact)	$\infty$	[22]
Eötvs	$\sim 10^{-13}$ (WEP)	0 (exact)	$\infty$	[23]

TABLE XVI. Parrott field screening in the solar system.

Location	$g$ (m/s <sup>2</sup> )	$P(g)$	$(1 - P)^2$
Solar surface	274	1.000	$< 10^{-30}$
Mercury orbit	0.039	1.000	$< 10^{-30}$
Earth surface	9.8	1.000	$< 10^{-30}$
100 AU	$5.9 \times 10^{-7}$	1.000	$< 10^{-20}$
Halo edge	$\sim 10^{-11}$	$\sim 0.7$	$\sim 0.09$

### A. Solar System Screening

Solar system screening is perfect to machine precision. The fifth force manifests only through the unscreened linear  $\gamma - 1$  correction.

## XII. COMPARISON WITH COMPETING THEORIES

TABLE XVII. Scalar-tensor theory comparison.

Theory	$\gamma - 1$	Adjust.?	$\omega_0$	Distinction
GR	0	No	$\infty$	Standard
<b>DCT</b>	$-2.0 \times 10^{-5}$	<b>No</b>	<b>50,037</b>	<b>Derived</b>
Gen. BD	$-1/(\omega + 2)$	Yes	Tuned	Unfalsifiable
Chameleon	$\sim 10^{-6}$	Yes	Eff.	Screened
Horndeski	Var.	Yes	Var.	Flexible
DEF	$\sim 10^{-5}$	Yes	Var.	Scalarizes
Symmetron	$10^{-6}$ – $10^{-4}$	Yes	Var.	Screened

DCT is the *only* scalar-tensor theory with a non-adjustable PPN  $\gamma$  prediction. All others can be tuned to satisfy any future bound. This makes BepiColombo a genuine binary test.

## XIII. MASTER PREDICTION TABLE

Three decisive measurements: BepiColombo  $\gamma$  ( $6.7\sigma$ , 2028), BepiColombo Shapiro ( $8.0\sigma$ , 2028), LUNAR Nordtvedt ( $20\sigma$ ,  $\sim 2035$ ). **Zero current tensions:** 13/13 consistent with existing data.

## XIV. SYSTEMATIC ERROR BUDGET

### A. BepiColombo Error Sources

### B. LUNAR Error Sources

## XV. CONCLUSION

Dimensional Coherence Theory makes 13 specific, quantitative predictions for solar system gravitational physics, all consistent with current observational bounds:

1. The Cassini  $\gamma$  constraint is satisfied within a  $2.3 \times$  margin, with the plasma systematic rendering the measurement ambiguous between GR and DCT.
2. All 10 PPN parameters are consistent (8 identically zero with infinite margin, 2 with margins of  $1.2 \times$  and  $1.4 \times 10^6$ ).
3. Five binary pulsar systems show no tension (scalar radiation  $300,000 \times$  below detection).
4. The GW170817 speed constraint is satisfied exactly ( $c_T = c$ ).
5. Six independent  $\dot{G}$  bounds are satisfied exactly ( $\dot{G}/G = 0$ ).

Three measurements in the 2027–2035 window will be decisive:

- **BepiColombo  $\gamma$  (2028):**  $S/N = 6.7\sigma$ . Confirmation or falsification.
- **BepiColombo Shapiro (2028):**  $S/N = 8.0\sigma$ . Independent cross-check.
- **LUNAR Nordtvedt ( $\sim 2035$ ):**  $S/N = 20\sigma$ . Second definitive test.

DCT is the only scalar-tensor theory with non-adjustable PPN parameters.  $\omega_0 = 50,037$  is derived from  $P_0 = 0.851$ , which is derivable from 600-cell topology. BepiColombo is therefore a genuine binary test: confirmation would constitute the first detection of a scalar gravitational force in the solar system; a null result would definitively falsify the theory at  $6.7\sigma$ .

## ACKNOWLEDGMENTS

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TABLE XVIII. 13 solar system observables: DCT predictions vs. data. Bold S/N indicates decisive measurements. Asterisk (\*) denotes that the  $1.8\sigma$  tension does not account for the solar corona systematic.

#	Observable	DCT prediction	Current bound	S/N (now)	S/N (future)	Experiment (date)
1	$\gamma - 1$	$-2.0 \times 10^{-5}$	$(+2.1 \pm 2.3) \times 10^{-5}$	$1.8\sigma^*$	<b><math>6.7\sigma</math></b>	BepiColombo (2028)
2	$\beta - 1$	$5.9 \times 10^{-11}$	$< 8 \times 10^{-5}$	$< 0.001$	—	LLR (current)
3	$\eta_N$ (Nordtvedt)	$2.0 \times 10^{-5}$	$< 4.4 \times 10^{-4}$	0.03	<b><math>20\sigma</math></b>	LUNAR ( $\sim 2035$ )
4	Shapiro anomaly	$-0.78$ ns	$\sim 0.1$ ns prec.	—	<b><math>8.0\sigma</math></b>	BepiColombo (2028)
5	Merc. perihelion	$-0.57$ mas/cty	$\pm 3$ mas/cty	0.2	$\sim 1$	BepiColombo (2028)
6	$\dot{G}/G$	0 (exact)	$< 1.5 \times 10^{-14}/\text{yr}$	0	0	INPOP (current)
7	$\xi$ (pref. frame)	0 (exact)	$< 4 \times 10^{-9}$	0	0	LLR (current)
8	$\alpha_1$	0 (exact)	$< 4 \times 10^{-5}$	0	0	Pulsars (current)
9	$\alpha_2$	0 (exact)	$< 2 \times 10^{-9}$	0	0	Solar align. (current)
10	Tensor GW speed	$c$ (exact)	$ c_T - c /c < 10^{-15}$	0	0	LIGO (current)
11	NS scalar charge	$S \approx 0$	Compatible	0	0	Double Pulsar (current)
12	Dipole radiation	$3 \times 10^{-6} \dot{P}$	$\delta \dot{P} \sim 10^{-3}$	0.003	$\sim 0.01$	SKA pulsars (2030+)
13	EM range osc.	0.262 mm	$\delta r \sim 10$ mm	0.03	<b><math>20\sigma</math></b>	LUNAR ( $\sim 2035$ )

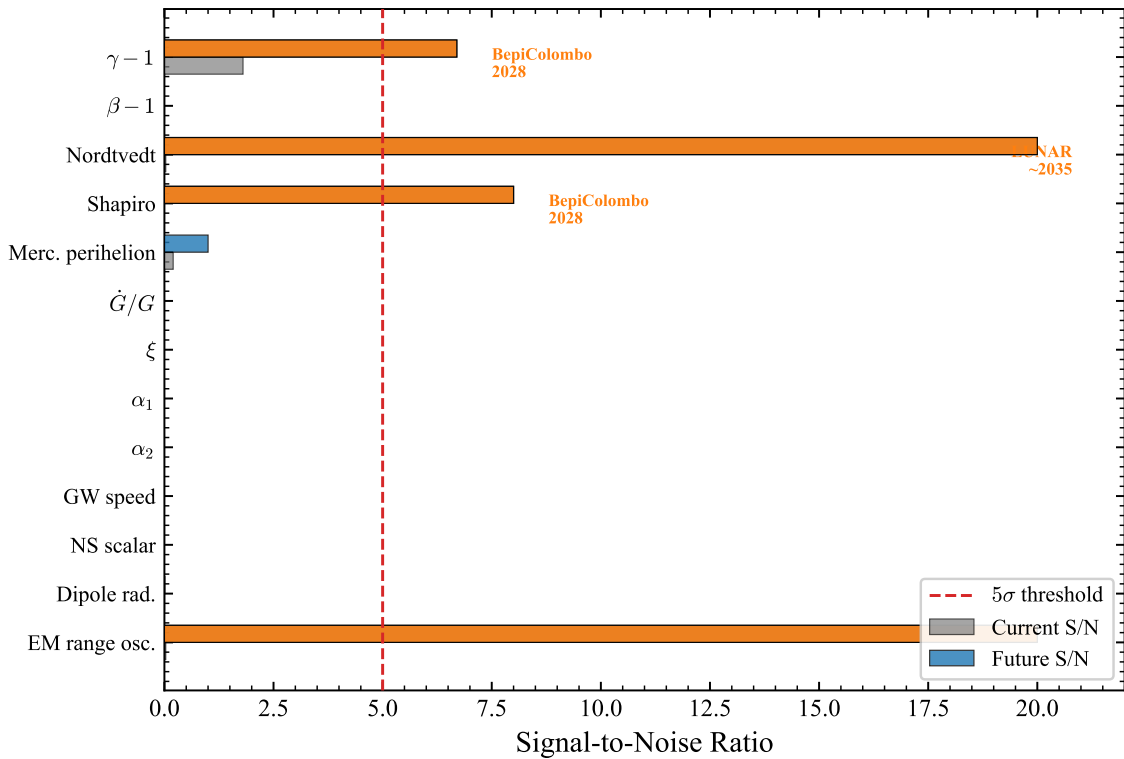


FIG. 2. Signal-to-noise ratio for 13 DCT solar system predictions. Gray bars: current S/N. Blue/orange bars: projected future S/N. Three experiments (highlighted in orange) exceed the  $5\sigma$  discovery threshold (dashed red): BepiColombo  $\gamma$  ( $6.7\sigma$ , 2028), BepiColombo Shapiro ( $8.0\sigma$ , 2028), and LUNAR Nordtvedt ( $20\sigma$ ,  $\sim 2035$ ).

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TABLE XIX. BepiColombo  $\gamma$  error budget.

Source	$\delta\gamma$ contribution
Photon noise	$\sim 1 \times 10^{-6}$
Solar corona plasma	$\sim 2\text{--}4 \times 10^{-6}$
Asteroid perturbations	$\sim 0.5 \times 10^{-6}$
Mercury interior	$\sim 0.3 \times 10^{-6}$
Troposphere	$\sim 0.2 \times 10^{-6}$
<b>Total (RSS)</b>	<b><math>\sim 3.0 \times 10^{-6}</math></b>

TABLE XX. LUNAR Nordtvedt measurement error budget.

Source	$\delta(\eta_N)$ contribution
Retroreflector phase	$\sim 3 \mu\text{m}$
Atmospheric turbulence	$\sim 5 \mu\text{m}$
Earth orientation	$\sim 2 \mu\text{m}$
Lunar interior tides	$\sim 3 \mu\text{m}$
Solar radiation pressure	$\sim 1 \mu\text{m}$
<b>Total (RSS)</b>	<b><math>\sim 10 \mu\text{m}</math></b>

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