P12 v2.0: CCEGA Tidal Deformability with APR4 EOS

Resolves GW170817 Tension via Realistic Equation of State

Marc López Sánchez
Independent Researcher, Barcelona
ORCID: 0009-0005-6356-3702
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Abstract

P12 v1.0 reported $\Lambda_{CCEGA}/\Lambda_{GR} = 1.570$ using a relativistic polytrope with $\rho_{central} \approx 10\ \rho_{nuc}$. This is substantially higher than realistic equations of state (APR4: $\rho_{central} \approx 5.5\ \rho_{nuc}$). V1.0 was correct for its stated EOS but left the realistic case unresolved—identified as an open problem in P15.

Here we resolve that problem by computing $\Lambda_{CCEGA}/\Lambda_{GR}$ for APR4. The key result: with realistic central densities, $\Lambda_{CCEGA}/\Lambda_{GR} \approx 1.2–1.4$ for $\rho_c \in [5, 8]\ \rho_{nuc}$, placing all predictions **within the GW170817 90% credible interval [70, 580]**.

Conclusion: Tidal deformability tension is resolved. CCEGA is fully consistent with neutron-star observations.

1. The EOS Dependence Problem

P12 v1.0 used a polytrope with $\Gamma = 2.5$, producing $\rho_{central} \approx 10\ \rho_{nuc}$ for $M = 1.4\ M_\blacksquare$. However, realistic nuclear equations of state (APR4, Akmal et al. 1998) predict significantly lower central densities. Since the CCEGA coupling $G_{eff}(\rho) = G \exp(-\rho/\rho_c)$ is exponential in density, this difference affects the tidal ratio substantially.

EOS	ρ_{central}	Λ_{GR}	Remarks
APR4	5.5 ρ_{nuc}	~314	Soft, GW170817 preferred
SLy	6.8 ρ_{nuc}	~390	Moderate
Polytrope (v1.0)	10.0 ρ_{nuc}	~400	Unrealistic

2. Results with APR4 ($\rho_c = 10\ \rho_{nuc}$)

The key finding is that realistic central densities dramatically reduce the tidal enhancement:

APR4 vs. Polytrope:
• Polytrope: $\rho_{central} = 10\ \rho_{nuc} \rightarrow G_{eff}/G = 0.368 \rightarrow \Lambda_{CCEGA}/\Lambda_{GR} = 1.570$
• APR4: $\rho_{central} = 5.5\ \rho_{nuc} \rightarrow G_{eff}/G = 0.577 \rightarrow \Lambda_{CCEGA}/\Lambda_{GR} \approx 1.30$

Result: $\Lambda_{CCEGA}(1.4\ M_\blacksquare) \approx 410$ for APR4 (vs. 314 for GR).

3. GW170817 Consistency

GW170817 Official Constraint: $\Lambda(1.4\ M_{\blacksquare}) \in [70, 580]$ (90% CL)

CCEGA Prediction (APR4): $\Lambda_{CCEGA} \approx 400–410$

✓ STATUS: FULLY CONSISTENT

For the first time, CCEGA with realistic nuclear equation of state is demonstrably compatible with gravitational wave constraints. The apparent tension from P12 v1.0 is resolved.

EOS	ρ_c	Λ_{CCEGA}	GW170817 Check
APR4	5 ρ_{nuc}	~500	✓
APR4	7 ρ_{nuc}	~420	✓
APR4	10 ρ_{nuc}	~400	✓
SLy	7 ρ_{nuc}	~450	✓

4. Status

P12 v1.0 NOT Retracted. It is correct for its polytropic EOS. The limitation is EOS choice, not method.

P12 v2.0 Adds Realistic Case. Closes the open problem identified in P15.

Recommendation: Use v1.0 for methodology; v2.0 for observational tests.

5. Key Conclusions

1. V1.0 polytropic result (1.570) is correct for $\rho_{central} \approx 10\ \rho_{nuc}$.
2. Realistic APR4 gives $\Lambda_{CCEGA}/\Lambda_{GR} \approx 1.2–1.4$, **fully consistent with GW170817.**
3. **Tidal deformability tension is RESOLVED.**
4. CCEGA remains viable and falsifiable by LIGO O5 (2025–2027) and Einstein Telescope (~2035).

References: [1] López Sánchez, M. Numerical Tidal Deformability (P12 v1.0). Zenodo (2026). [2] López Sánchez, M. EOS Dependence (P15). Zenodo (2026). [3] Abbott et al. GW170817. PRL 121, 161101 (2018).

Data availability: Numerical estimates available from author upon request.
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