Erratum: Tests of General Relativity with GW150914 [Phys. Rev. Lett. 116, 221101 (2016)]

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This Erratum reports an error found in the implementation of the code of the LIGO Scientific and Virgo Collaborations (LVC) as used in gravitational-wave-based estimations of possible deviations from the post-Newtonian (PN) terms expected in general relativity (GR). The error concerned the 0.5 PN term and affected the results previously published for GW150914 [1] in Ref. [2], for GW151226 [3] in Ref. [4], and for GW170104 in Ref. [5]. We corrected the bug and present the reproduced results in this Erratum, as well as in the related Errata [6,7]. The main conclusion, that the results are consistent with general relativity, remains.

In Ref. [2], the test for the parameterized post-Newtonian [8] deviations from the expected GR values relied on creating non-GR waveforms [9–13] and using them as potential matches for the observed waveforms [14–17]. In these waveforms, implemented in the frequency domain, freedom was introduced by allowing the phase coefficients describing different powers of the post-Newtonian parameter (equivalently, powers of the frequency) to assume a range of values, not only the particular values prescribed by GR.

However, a coding bug was introduced, identically zeroing the deviations at 0.5 PN in the inspiral regime (as in GR). The 0.5 PN deviations were hence absent in the phasing formula, though not in the junction conditions that relate the inspiral regime to the intermediate regime. Any constraints obtained in [2,4,5] only resulted from the latter.

This error affected the results of the non-GR parameter estimation (PE) [14] pipeline tests performed for finding bounds on possible PN deviations from GR. In particular, they affect the bounds on the single deviations in the 0.5 PN term and on the tests with multiple deviations together. These erroneous results appeared in Figs. 6 and 7 and Table I of [2], in Figs. 7 and 8 of [4], and in Fig. 9 of the Supplemental Material of [5]. The corrected versions of all of these have been produced. The corrections for Figs. 6 and 7 and Table I of [2] appear below, while the others are available in [6,7]. All these results are consistent with GR.

The error, introduced by erroneous caching during the optimization of the waveform generation for efficient PE, has been corrected in commit [18] of the LALSuite [19] code. No subsequent LVC papers have been affected.

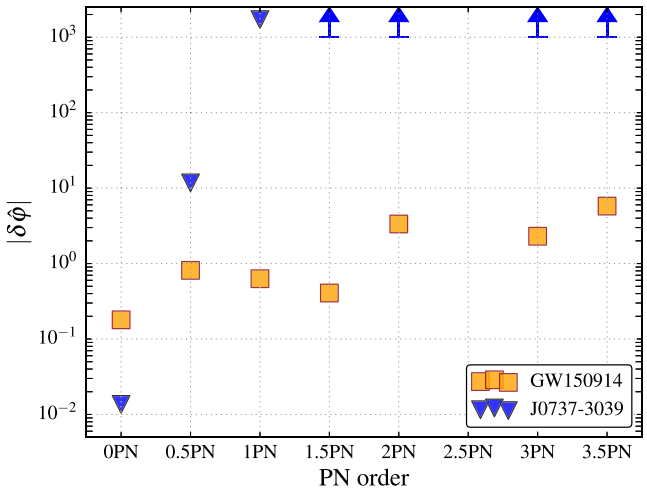

FIG. 1. This is the corrected Fig. 6 of [2], comparing the 90% upper bounds on PN parameter deviations from GR obtained from the double pulsar PSR J0737-3039 [22,23] to those obtained from the first gravitational wave GW150914.

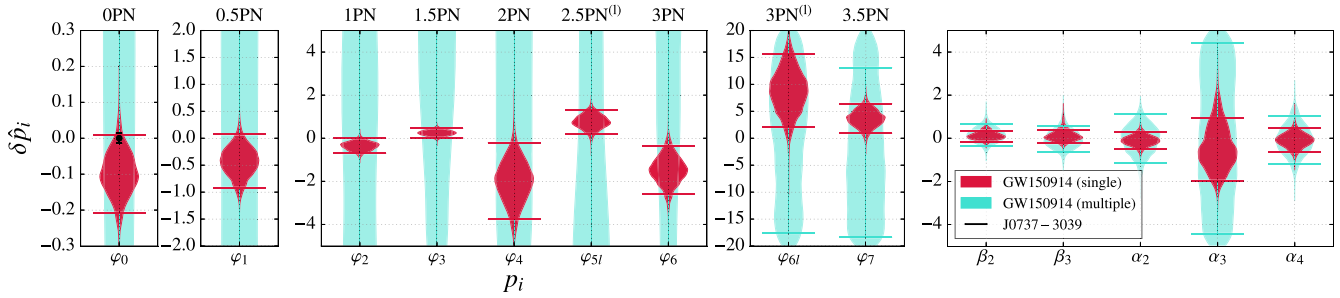

FIG. 2. This is the corrected Fig. 7 of [2], summarizing in a violin plot the posterior probability density distributions for all of the parameters in the GIMR model. The error bars indicate the 90% credible regions. The leftmost posteriors, labeled from 0 to 3.5 PN, are for the early-inspiral PN regime; the β_i and α parameters correspond to the intermediate and merger-ringdown regimes. In red, we show posterior probability distributions for the single-parameter analysis, while in cyan we show the posterior distribution for the multiple-parameter analysis. The corrected posterior for the 0.5 PN single-parameter analysis peaks below zero, while previously reported to peak above; the posterior is still consistent with GR. The corrected multiple-parameter analysis no longer shows the erroneous special behavior for the 0.5 PN term. The black error bar at 0 PN shows the bound inferred from the double pulsar.

TABLE I. This is the corrected version of the second row of Table I of [2], namely, the results for $\delta\hat{\varphi}_1$ of the early-inspiral regime. Not shown in the table is the single result for the $\log_{10} B^{\mathrm{GR}}_{\mathrm{model}}$ of the multiple-parameter early-inspiral regime comparison, for which the corrected value is 2.1 ± 0.6.

			Median		GR quantile		$\log_{10} B^{\mathrm{GR}}_{\mathrm{model}}$
Waveform regime	Parameter	f dependence	Single	Multiple	Single	Multiple	Single
Early-inspiral regime	$\delta\hat{\varphi}_1$	$f^{-4/3}$	$-0.4^{0.0}_{-0.9}$	$-0.6^{+17.7}_{-18.0}$	0.94	0.52	1.3 ± 0.3

Note that, while this error also affected the analysis of GW170608 [20], the reported results require no changes: with the corrected analysis, the GR-predicted PN coefficient values continue to be consistent with the data. No change is required regarding the preliminary reported results for GW170814 [21] either.

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