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A Gravitational-wave Measurement of the Hubble Constant Following the Second Observing Run of Advanced LIGO and Virgo (vol 908, 218, 2021)

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1. Introduction

This erratum reports two errors, found respectively in the gwcosmo codebase used for estimating the Hubble constant H_0 (Gray et al. 2020), and an associated galaxy catalog preprocessing script, both of which affect the results of the published article (Abbott et al. 2021).

The first of the two errors is the absence of a factor of $1/(1+z)$, where z is the galaxy redshift, in the in-catalog terms of the H_0 likelihood within the implementation of Equation (7) in the published article. This factor should be present in order to account for cosmological time dilation while providing a prior from the galaxy redshift distribution. The introduction of this factor affects the results only marginally, since the corrections modify both the numerator and the denominator of the expression in Equation (7), and only a higher-order effect propagates to the final results. This, however, changes Figure 2 of the published article, since the correction of the error affects only the numerator of the quantity $p_{\rm cat}(z)/p_{\rm vol}(z)$ plotted in the figure. The revised Figure 2 is provided here.

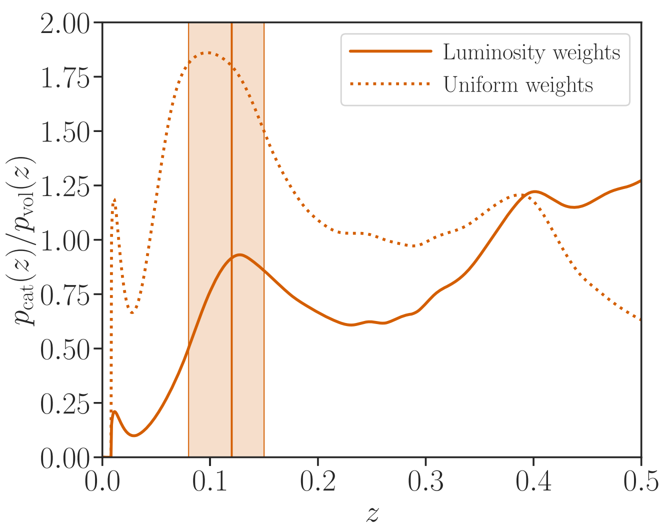

Figure 2. Probability distribution for the redshifts of potential host galaxies $p_{\rm cat}(z)$, with redshift uncertainties taken into account, divided out by a uniform in comoving volume distribution $p_{\rm vol}(z)$ of galaxies. When computing $p_{\rm cat}(z)$ we include all galaxies brighter than $0.05L_g^*$ within the corresponding event's 99% sky localization region and weight each galaxy by weights proportional to their g-band luminosity (solid lines) as well as with uniform weights (dotted lines). We show these distributions for the DES-Y1 galaxies within the GW170814 sky localization region. We also show the 90% median estimated redshift range for GW170814 (calculated assuming a Planck 2015 cosmology) for reference.

[195] Deceased, July 2018.

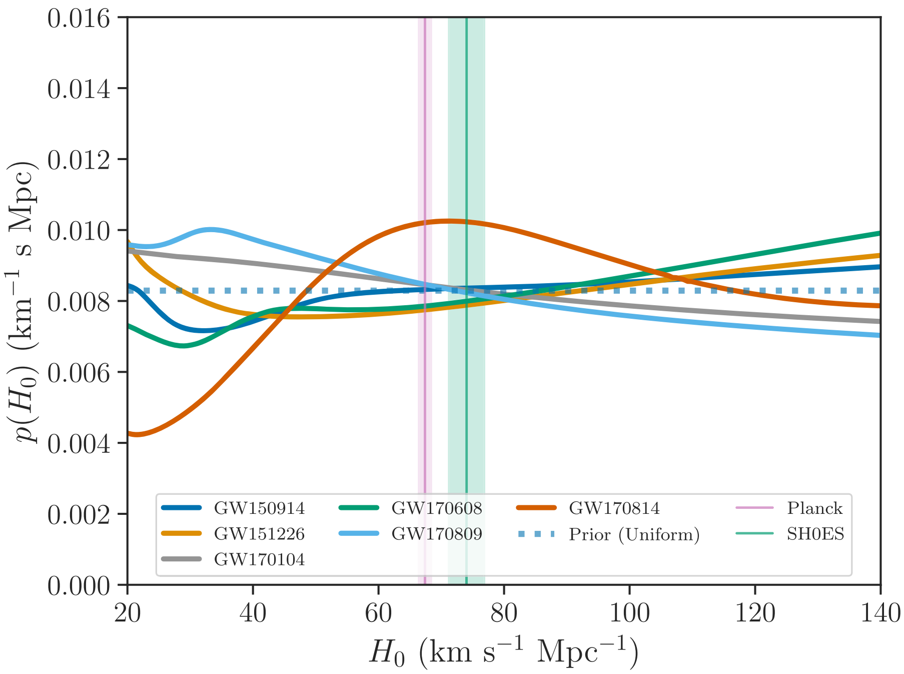

Figure 3. Individual estimates of H_0 from the six binary black hole detections which satisfy the selection criterion of network S/N > 12 in at least one search pipeline. These results assume a $m^{-1.6}$ power-law distribution on masses and a non-evolving rate model. All results assume a prior on H_0 uniform in the interval [20, 140] km s^{-1} Mpc^{-1} (dotted blue). We also show the estimates of H_0 from CMB (Planck; Aghanim et al. 2020) and supernova observations (SH0ES; Riess et al. 2019).

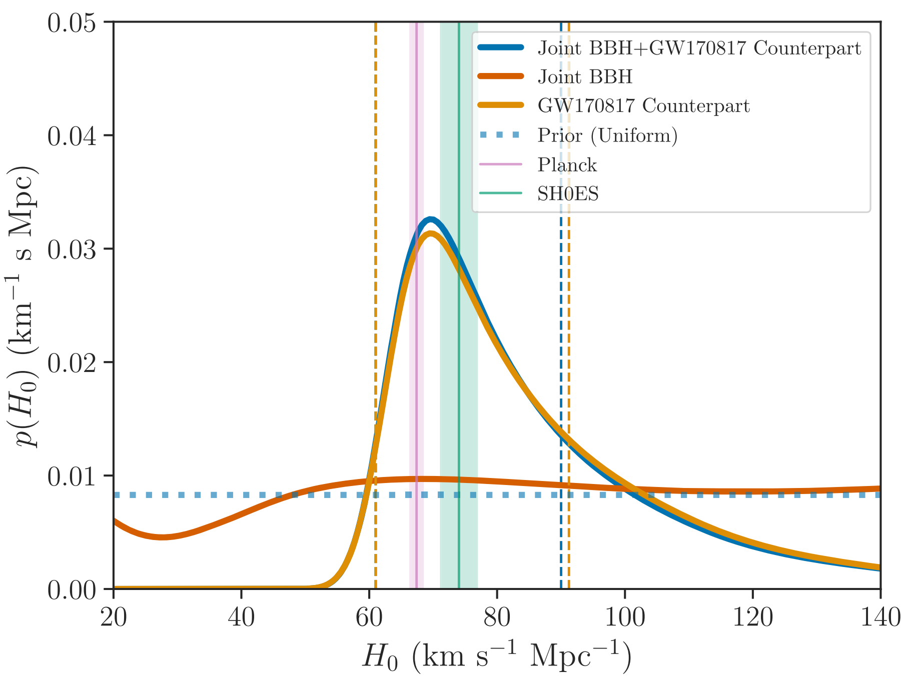

Figure 4. The gravitational-wave measurement of H_0 (dark blue) from the detections in the first two observing runs of Advanced LIGO and Virgo. The GW170817 estimate (orange) comes from the identification of its host galaxy NGC4993 (Abbott et al. 2017). The additional contribution comes from binary black holes in association with appropriate galaxy catalogs; for GW170814 we use the DES-Y1 galaxy catalog, while for the remaining five BBHs, GW150914, GW151226, GW170104, GW170608, and GW170809, we use the GLADE catalog. The 68% maximum a posteriori intervals are indicated with the vertical dashed lines. All results assume a prior on H_0 uniform in the interval [20, 140] km s^{-1} Mpc^{-1} (dotted blue). We also show the estimates of H_0 from CMB (Planck; Aghanim et al. 2020) and supernova observations (SH0ES; Riess et al. 2019).

The second error reflects a mistake in our understanding of redshift uncertainties reported in the GLADE galaxy catalog (Dálya et al. 2018). For a significant fraction of galaxies in the GLADE catalog, the redshift uncertainties are reported as an absolute error Δz. We had erroneously interpreted this as a relative error. This primarily affects the contribution from the 2MPZ galaxies with photometrically measured redshifts, for which $\Delta z \approx 1.5 \times 10^{-2}$ (Bilicki et al. 2014). Although this is a relatively small change, its effect is visible in the plots of the individual likelihoods, particularly for the nearby events such as GW170608 and GW150914. In view of this, we also update Figures 3 and 4 of the published article, and H_0 values in the final result. We have checked that the trends reported in Figures 5–8 of the published article are not affected significantly by these errors.

2. Updated Results

Our updated individual contributions from the O1 and O2 binary black holes (BBHs) that pass the selection criterion of $S/N > 12$ are shown in the revised Figure 3. Our final combined result is shown in the revised Figure 4, with the posterior distribution plotted assuming a uniform H_0 prior. We obtain $H_0 = 69.6^{+20.4}_{-8.6}$ km s^{-1} Mpc^{-1} (68.3% highest density posterior interval). To compare with values in the literature, we also use a flat-in-log prior, $p(H_0) \propto H_0^{-1}$, and calculate $H_0 = 68.7^{+17.0}_{-7.8}$ km s^{-1} Mpc^{-1}, which corresponds to an improvement by a factor of 1.04 (about 4%) over the GW170817-only value of $68.7^{+17.5}_{-8.3}$ km s^{-1} Mpc^{-1}. The median and symmetric 90% credible interval for this measurement is $74.9^{+39.2}_{-13.9}$ km s^{-1} Mpc^{-1}.

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