Supplementary material to Lower Your Rates: On Claims of a Binary Black Hole Merger-Rate Crisis

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ABSTRACT

This is an accompanying note to "Lower Your Rates: On Claims of a Binary Black Hole Merger-Rate Crisis". Here, we describe the details of how inferred and predicted coalescence rates are extracted from the literature and converted into units of $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. The descriptions are typically based on the literature quoted and we refer the reader to the mentioned studies for more details. We welcome suggestions. Please email `fbroekgaarden@ucsd.edu` for any inquiries, suggestions for additional studies, or questions.

1 CONVERSION FACTORS

Coalescence rates are, in general, functions of redshift; we quote current local rates at redshift $z = 0$ per unit source time per unit comoving volume in units of $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. Where initially stated in different units, we convert these, using, as appropriate, factors of

$$1.7 \times 10^{10} \tag{1}$$

solar blue-light luminosities per Milky Way equivalent galaxy (MWEG),

a MWEG space density of

$$1.17 \times 10^{-2}\ \mathrm{MWEG}\ \ \mathrm{Mpc}^{-3} \tag{2}$$

from (Kopparapu et al. 2008),

a globular cluster space density of

$$2.9\ \mathrm{GC}\ \mathrm{Mpc}^{-3} \tag{3}$$

from (Portegies Zwart & McMillan 2000)

and a local supernova rate of

$$1.06 \cdot 10^{5}\ \mathrm{SN}\ \ \mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1} \tag{4}$$

from (Taylor et al. 2014).

2 OBSERVATIONS

Here we list how we retrieved the different observational LVK based merger rate densities.

2.1 Gravitational-wave observations

GWTC-5 The merger rates of BH-BH, NS-NS, and NS-BH binaries based on the LVK runs up to O4b were taken from The LIGO Scientific Collaboration et al. (2026). We adopt the joint merger-rate intervals reported in Table 2 of that work, which are constructed as the union of the two 90% credible intervals obtained from the `PixelPop` and `FullPop` population models. This choice provides a conservative rate estimate that is less sensitive to the modeling assumptions underlying either individual model. The resulting joint 90% credible intervals are 5.1–154.7 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ for BNS, 6.7–32.8 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ for NSBH, and 27.5–49.4 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ for BBH, with the BNS and NSBH rates quoted at $z = 0$ and the BBH rate at $z = 0.2$.

GWTC-4 The merger rates of BH-BH, NS-NS, and NS-BH binaries based on the LVK runs up to O4a were taken from The LIGO Scientific Collaboration et al. (2025). We adopt the local (i.e., $z = 0$) merger-rate intervals reported in that work, quoted as central 90% credible intervals. The resulting intervals are 7.6–250 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ for BNS, 9.1–84 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ for NSBH, and 14–26 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ for BBH.

GWTC-3 The merger rates of BH-BH, NS-NS, and NS-BH binaries based on the LVK runs up to O3 were taken from Abbott et al. (2021a). We adopt the merger-rate intervals reported in Table II of that work, given as the union of the 90% credible intervals from the PDB (pair), PDB (ind), MS, and BGP models, assuming merger rates that are independent of redshift. The resulting union intervals are 10–1700 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ for NS-NS, 7.8–140 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ for NS-BH, and 16–61 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ for BH-BH.

GWTC-2 The merger rates of BH-BH and NS-NS binaries based on the LVK runs up to O3a were taken from Abbott et al. (2021b). We adopt the median and 90% credible intervals quoted in the abstract of that work, assuming a merger rate that is uniform in comoving volume. The resulting values are $23.9^{+14.3}_{-8.6}$ $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ (i.e., 15.3–38.2 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$) for BH-BH and 320^{+490}_{-240} $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ (i.e., 80–810 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$) for NS-NS.

GW200105/GW200115 NSBH rate The NS-BH merger rate was taken from the analysis of the two NSBH discoveries GW200105 and GW200115 by Abbott et al. (2021c). That work reports two estimates: 45^{+75}_{-33} $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, assuming these two events are representative of the NS-BH population, and 130^{+112}_{-69} $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, under the assumption of a broader component-mass distribution. We adopt the union of the two corresponding 90% credible intervals, 12–242 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, as our NS-BH rate.

3 ISOLATED BINARY EVOLUTION MODELS

We mention below the predicted merger rate densities based on (theoretical) models. The isolated-binary-evolution studies are listed alphabetically by first author and, for multiple studies by the same first author, chronologically by publication year.

Ablimit & Maeda (2018) study the formation of BH-BH, NS-BH and NS-NS from the isolated binary evolution channel using updates versions of the BSE code. We retrieve their rates from Table 2 that lists the Galactic merger rates for a large set of different model realizations. We add all the model realizations and use Equation 2 to convert these rates to $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ which gives rates in the ranges of about $\mathcal{R}_{\mathrm{BH-BH}} = [20, 320]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, $\mathcal{R}_{\mathrm{NS-BH}} = [1, 160]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ and $\mathcal{R}_{\mathrm{NS-NS}} = [240, 1800]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$.

Arca Sedda et al. (2026) use the code B-POP to model BH-BH mergers forming through isolated binary stellar evolution and dynamical interactions in young, globular, and nuclear star clusters. They vary the common-envelope efficiency parameter and the fraction of stellar mass contributing to each formation channel to bracket the range of predicted merger rates. We obtain their BH-BH merger rate densities from their Figure 2, where we read off the range spanned by their model variations using a plot digitizer.

Artale et al. (2019) use MOBSE to calculate the BH-BH, NS-BH and NS-NS rate from isolated binary evolution by combining this with the galaxy catalogs from the hydro-dynamical cosmological simulation EAGLE. We retrieve their local merger rates from their Table 4, where we add the rates from the early-type and the late-type columns for a given compact object type. This gives predicted local merger rates of about $\mathcal{R}_{\mathrm{BH-BH}} = 142\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ $\mathcal{R}_{\mathrm{NS-BH}} = 78\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ and $\mathcal{R}_{\mathrm{NS-NS}} = 238\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$.

Baibhav et al. (2019) use MOBSE to calculate the compact object merger rate densities for future gravitational-wave detectors for a range of common-envelope efficiency parameters and supernovae natal kick assumptions. We retrieve their merger rate densities from reading the rates from Figure 1 at redshift 0 using a plot digitalizer. We retrieve the following rate ranges, $\mathcal{R}_{\mathrm{BH-BH}} = [30, 60]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, $\mathcal{R}_{\mathrm{NS-BH}} = [4, 37]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ and $\mathcal{R}_{\mathrm{NS-NS}} = [12, 400]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$.

Bavera et al. (2021) use an early version of POSYDON to calculate black hole-black hole merger rates across a suite of binary population synthesis model variations. They explore different prescriptions for common envelope efficiency, mass transfer stability, supernova kick assumptions, initial binary properties, and critical mass ratio definitions for stable mass transfer. We retrieve their predicted merger rates from Tables 1, 3, and 4, combining contributions from both common envelope and stable mass transfer channels. In total, there are 15 distinct model realizations, with the first entry in Tables 3 and 4 duplicating the fiducial model from Table 1. The BH-BH merger rate range is: $\mathcal{R}_{\mathrm{BH-BH}} = [38.8, 169.7], \mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. We include the parameter variations in our relationship investigation to study how different modeling assumptions for mass transfer efficiency, eddington factor, orbital separation prior, RLOF at ZAMS, and critical mass ratio prescription affect the predicted merger rates.

Belczynski et al. (2018) use StarTrack to simulate NS-NS mergers from the isolated binary evolution channel. We retrieve their rates for isolated binary evolution based on this study from their Table 1, from the row ‘classical binaries’ for the three models pessimistic, realistic and optimistic. We multiply with a factor 1000 to obtain a rate in units of $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. This gives an merger rate density estimate of $\mathcal{R}_{\mathrm{NS-NS}} = [8, 50]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. We do not include the submodels in the parameter investigation, as they do not rely on clear isolated binary evolution parameters.

Belczynski et al. (2020) use StarTrack to model a large set of stellar evolution models. We retrieve their rates from Tables 3 and 4 under the column ‘Rate density’ and use both their optimistic (A) and pessimistic (B) model variants. The suite includes 14 distinct models (M_{10}, M_{13}, M_{20}, M_{26}, M_{25}, M_{23}, M_{30}, M_{35}, M_{33}, M_{40}, M_{43}, M_{50}, M_{60}, M_{70}), each evaluated under both optimistic and pessimistic assumptions, yielding 28 total model variants per DCO type. These models explore variations in key physics: natal kick prescriptions, common envelope efficiency, supernova remnant mass prescription (ECSN and AIC treatment), and stellar wind assumptions. The models are connected through a series of single-parameter variations that allow us to assess the sensitivity of merger rates to individual physics assumptions. Using both model variants, we find the rates: $\mathcal{R}_{\mathrm{BH-BH}} = [1.24, 1368]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, $\mathcal{R}_{\mathrm{NS-NS}} = [49.3, 524]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, and $\mathcal{R}_{\mathrm{NS-BH}} = [0.48, 297]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$.

Boco et al. (2019) use binary population stellar evolution results based on simulations with SEVN. For the double compact object merger rates, they calibrate their models based on a local observed BH-BH rate of $30\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ from the first gravitational waves catalog of LIGO and Virgo, and use this to normalize their predictions. We therefore decide to only use the NS-NS and NS-BH merger rate predictions from the paper, which we retrieve from their Section 4 (and Figure 5 at redshift 0), $\mathcal{R}_{\mathrm{NS-NS}} = 70\ \mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ and $\mathcal{R}_{\mathrm{NS-BH}} = 20\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. We do not include these models in the parameter variations.

Boco et al. (2026) use the SEVN models from Sgalletta et al. (2025) with a large range of star formation history models to investigate the BH-BH merger rate. We retrieve their merger rates from their Figures 6, 7, and 8, and 11. Note that we do not include their later models from Figure 10 that use varying delay time distributions, as those are more used by the authors to investigate how to change the delay time distributions to get consistent rates. We include their variations for CE efficiency and star formation history models in our parameter exploration. All submodel variations are variations in the star formation history model or CE efficiency parameter.

Boesky et al. (2024b,a) use the COMPAS population synthesis code to compute 21 model variations: 12 explore different combinations of the CE efficiency parameter (α_{CE}) and mass-transfer efficiency parameter (β), while the remaining 9 vary the SN natal-kick magnitude (σ) together with the remnant-mass prescription (RMP). We extract the local ($z \sim 0$) merger rates for these 21 variations from Figure 2 of Boesky et al. (2024a) and via private communication with the authors. We include the parameter variations in our parameter variation study.

Bouffanais et al. (2021) use MOBSE to predict BH-BH merger rate densities for a grid of models varying the mass accretion efficiency $f_{\mathrm{MT}} \in [0.05, 1]$, and the common envelope efficiency $\alpha_{\mathrm{CE}} \in [1, 10]$. We retrieve the BH-BH local merger rate densities at $z = 0$ from Figure 2 of Bouffanais et al. (2021) and include the submodel variations in our parameter investigation.

Broekgaarden et al. (2021, 2022) use COMPAS to model a large range of analytical cosmological models in combination with variations of stellar evolution assumptions. We retrieve their rates from Figure 2 of (Broekgaarden et al. 2022), where the range is indicated with the arrow, as well as the individual simulations from the file `rates_MSSFR_Models_BHBH_AllDCOsimulation.csv`, `rates_MSSFR_Models_BHNS_AllDCOsimulation.csv`, and `rates_MSSFR_Models_NSNS_AllDCOsimulation.csv` within `csvFilesForFigure2_and_3_DCOpaper.zip` from `https://zenodo.org/record/5178777` (the authors Zenodo database with BHNS, BHBHm and NSNS simulations all contain the same summary datafiles in the file `csvFilesForFigure2_and_3_DCOpaper.zip`). We include their many star formation history model variations and stellar evolution variations to our parameter investigation. We only do not include the '000' model in the parameter variation investigation as it varies many parameters at a time compared to the other star formation history models.

Briel et al. (2022) use BPASS to model the NS-NS, NS-BH and BH-BH rates. We obtain their rates from their Table 1, which gives rates of $\mathcal{R}_{\mathrm{BH-BH}} = 6.5\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, $\mathcal{R}_{\mathrm{NS-BH}} = 27.0\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, and $\mathcal{R}_{\mathrm{NS-NS}} = 93.1\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$.

Chattaraj et al. (2026) use the POSYDON detailed binary population synthesis code to model the formation of Galactic NS-NS systems. We obtain the NS-NS merger rates from Table 2 of Chattaraj et al. (2026) for their 25 model variations. Note that these rates are computed at solar metallicity only, in contrast to the metallicity-integrated rates from other population synthesis sources in this work. We therefore add a note of this to the label of these rates. We add the rates as they still span a range of metallicities over which is integrated (rather than simple calculations for a fixed metallicity simulation) and because the formation efficiency of NS-NS are expected to be relatively more constant as a function of metallicities, making this somewhat representative of the cosmological rate across all metallicities.

? use an updated version of the BSE code to evolve large sets of simulations and investigate the rate and properties of NS-NS mergers. We obtain the local NS-NS merger rates from their Table 2, which includes results for a grid of models varying the CE efficiency α and the fraction f_{HG} of Hertzsprung gap donors that merge with their companion upon entering a CE phase ($f_{\mathrm{HG}} = 0$ corresponding to optimistic CE and $f_{\mathrm{HG}} = 1$ to pessimistic CE). We include two sets of model relationships. First, for models where only α is varied at fixed f_{HG}, we include six groups: $f_{\mathrm{HG}} = 0$ (M1, M6, M12), $f_{\mathrm{HG}} = 0.2$ (M2, M7, M13), $f_{\mathrm{HG}} = 0.4$ (M3, M8, M14, M20), $f_{\mathrm{HG}} = 0.6$ (M4, M9, M15, M18, M21), $f_{\mathrm{HG}} = 0.8$ (M5, M10, M16, M19, M22), and $f_{\mathrm{HG}} = 1$ (M11, M17). Second, for the optimistic–pessimistic CE comparison (only f_{HG} varied between 0 and 1 at fixed α), we include two pairs: M6 and M11 ($\alpha = 3$) and M12 and M17 ($\alpha = 5$).

Chruslinska et al. (2018) use StarTrack and take into account the cosmic star formation rate of the Universe. They focus on NS-NS. We obtain the local BH-BH rates from their Table 3, which are based on 6 different models (when including both the optimistic and pessimistic common-envelope values quoted) and find a BH-BH rate in the range $\mathcal{R}_{\mathrm{BH-BH}} = [32, 1072]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. For the NS-NS we take the rates from their Table 2 for their variety of models which are all calculated using 32 metallicity bins and take the $\mathcal{R}_{\mathrm{local}}$ rates from this table. We find their NS-NS rate lies in the range $\mathcal{R}_{\mathrm{NS-NS}} = [1.5, 631]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. The submodels include variations in optimistic/pessimistic CE, natal kicks, mass transfer, angular momentum loss, wind mass loss. We include the relationships that vary one parameter at a time.

Chruslinska et al. (2019) use StarTrack to investigate the impact from different star formation histories on the double compact object rates. We take the rates as quoted in Figure 3, where we include the three star formation rate models and the four stellar evolution models (including the reference model). We obtained the numerical values of the predicted rates from private communication with the lead authors. The rates are $\mathcal{R}_{\mathrm{BH-BH}} = [12, 1072]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, $\mathcal{R}_{\mathrm{NS-NS}} = [48, 885]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ and $\mathcal{R}_{\mathrm{NS-BH}} = [6, 222]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$.

Chu et al. (2021) use an updated version of BSE in combination with four different prescriptions for the star formation history to simulate, among other things, the local merger rate density of NS-NS mergers for a large set of binary population synthesis simulations. We retrieve their local merger rate density estimates for NS-NS mergers from their Table B1, B2, B3 and B4. For each table we retrieve all rates for the Millennium-II, EAGLE, Illustris-TNG and Madau & Dickinson (2014) star formation history from the corresponding local merger rate R_0 column. This gives presented merger rate densities by the authors in the range $\mathcal{R}_{\mathrm{NS-NS}} = [0.4, 1404]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. The authors vary many model assumptions, including four different star formation history models, variations in the CE efficiency parameter (α), and mass transfer efficiency. We include this in our parameter variation investigation.

de Mink & Belczynski (2015) use StarTrack and explore how the merger rate densities are impacted by uncertain initial conditions such as the binary fraction and initial period, mass, mass ratio and eccentricity distributions. We retrieve their predicted rates from their Table 2, which are quoted relative to their fiducial model. We then multiplied these relative rates with the fiducial rate to obtain absolute merger rate densities and converted this to $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ using their conversion given by their Equation 9. We quote that they find a BH-BH rate in $[14, 2500]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, NS-BH rate of $[9, 115]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ and NS-NS rate in $[30, 540]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. The submodels include variations in optimistic/pessimistic CE assumptions and in initial conditions.

Deng et al. (2024) use the BSE code to construct 324 binary evolution models for the formation of Galactic NS-NS systems, exploring combinations of mass-transfer efficiency (MT I, II, III), supernova mechanism (SN A–E), neutron star natal kick velocity distributions, and common-envelope efficiency (0.1, 0.5, 1, 2, 5, 10). We obtain the Galactic NS-NS merger rates for all 324 models from Table A (Appendix A), which are also shown in Figure 6. To convert these Milky-Way-like merger rates from Myr^{-1} to a cosmological volumetric rate in $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, we use equations 2 and convert the rates from Mpc to Gpc and from Myr to yr. We add all the variations to our parameter variation investigation.

De Sá et al. (2024) use COMPAS to investigate how estimates of BH-BH, NS-BH, and NS-NS rates and properties change for varying initial conditions assumptions. We retrieve the rates from Local merger rate density ($z_{\mathrm{merger}} \leq 0.014$) for the 'Varying' IMF model, from the 'Full' row of Table 2 / Table 3 of their paper, and list their model variations under varying initial conditions.

? use SEVN to investigate the population properties of NS-NS mergers. They explore a large range of model variations varying parameters such as CE efficiency, mass transfer stability, kick velocity, and supernova models. We retrieve their rates from Figure 2 from their bottom-left panel using a plot digitizer.

Dominik et al. (2015) use StarTrack and a metallicity evolution (with two star formation history scenarios) to study compact object coalescence rates. We retrieve their merger rate densities from their Table 1 under the column $\mathcal{R}_0$. We use both the rates for their high end and low end scaling (number in front and inside the parenthesis in Table 1). They find BH-BH rate of $[0.5, 221]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, NS-NS of $[30, 1700]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ and NS-BH of $[0.04, 20]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. The submodels include variations in optimistic CE, delayed SN, high BH kicks and star formation history model.

Dorozsmai & Toonen (2022) use SeBa to study the properties and rates of binary black hole mergers, particularly paying attention to uncertainties in mass transfer physics. We obtain their rate from their legends in Figure 7, where we sum the rates for the three different formation channels $\mathrm{R}_{\mathrm{Ccee}}$, $\mathrm{R}_{\mathrm{Rcee}}$, and R_{ST}. This gives a binary black hole rate in the range $\mathcal{R}_{\mathrm{BH-BH}} = [19.1, 101.7]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. We include all the parameter variations in our metadata analysis.

Eldridge et al. (2019) use BPASS and predict the rate of many different types of transients. We obtain their BH-BH, NS-BH and NS-NS rates from their Table 1 and Table 2, where we use the NSNS NSBH and BH-BH rates from the redshift $z = 0$ column (note that these are given in log). We take into account the uncertainties that are quoted in the table by also adding the rate values that one obtains when adding or subtracting the uncertainties. We round the answer to ones. We retrieve $\mathcal{R}_{\mathrm{NS-BH}} = [209, 269]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, $\mathcal{R}_{\mathrm{NS-NS}} = [339, 2178]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ and $\mathcal{R}_{\mathrm{BH-BH}} = [65, 174]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. For the parameter variations we include the switches to v2.1 which represent changes in the initial conditions, as well as switches to v2.2 which represent changes in the natal kick model.

Ghodla et al. (2021) use BPASS to model the NS-NS, NS-BH and BH-BH rates for several supernova model variations. We retrieve their local merger rates by taking the numbers in brackets from Table 1. For BH-BH we do not include the model with 0 BH-BH (AlwaysNS) as this by construction does not produce BH-BH mergers. This gives: $\mathcal{R}_{\mathrm{BH-BH}} = [31, 873]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, $\mathcal{R}_{\mathrm{NS-BH}} = [8.7, 498]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, and $\mathcal{R}_{\mathrm{NS-NS}} = [43, 745]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. Their submodels vary supernova and natal kick prescriptions.

Giacobbo & Mapelli (2018) use MOBSE to estimate the BH-BH, NS-BH and NS-NS merger rates as a function of metallicity and assumptions for the common envelope phase and supernovae. We retrieve their local merger rates from their Table 2. We use the local merger rates and only quote the rates under 'Model 1' and 'Model 2' for each simulation, which are based on a simplistic metallicity distribution/model. This gives predicted rates in the ranges BH-BH: $[43, 1500]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, NS-BH: $[5, 780]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, NS-NS: $[10, 510]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. The authors vary the natal kick magnitude, CE efficiency parameter, and the star formation history model, which we include in the parameter variations investigation.

Giacobbo & Mapelli (2020) use MOBSE to calculate compact object merger rate densities across three independent axes of variation: natal kick prescriptions, common envelope efficiency, and cosmic metallicity evolution. They present merger rates for four different natal kick prescriptions (H05, σ15, EJ1, and EJ2) combined with five common envelope efficiency values (α1 through α5), for a total of 12 model variants per DCO type. We digitized their predicted merger rates from Figures 4 and 5 using a plot digitalizer tool. For each of the 12 model realizations, we obtained rates for both cosmic metallicity evolution models (D18 and D18Z), yielding 72 total rates across the three DCO types. The predicted merger rate ranges are: $\mathcal{R}_{\mathrm{BH-BH}} = [43, 190], \mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, $\mathcal{R}_{\mathrm{NS-NS}} = [20, 640], \mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, and $\mathcal{R}_{\mathrm{NS-BH}} = [5, 80], \mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. We include relationships showing how each of these three independent axes—natal kick prescription, common envelope efficiency, and metallicity evolution—affect the predicted merger rates.

Hendriks et al. (2023) use the BINARY_C population-synthesis code to model BH-BH mergers and to investigate how different prescriptions for pair-instability supernovae affect the resulting merger population. We extract the total BBH merger rate for their model from the BBH merger rate including CE in Figure 4 (at $z \sim 0$), which is approximately $25\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$.

Klencki et al. (2018) uses StarTrack to study the impact of initial distributions on the compact object coalescence rates. We retrieve their rates from their Table 2 using the column 'Rate density' for the local merger rate. This gives rate ranges of $\mathcal{R}_{\mathrm{NS-NS}} = [24, 68]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, $\mathcal{R}_{\mathrm{BH-BH}} = [89, 203]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ and $\mathcal{R}_{\mathrm{NS-BH}} = [13, 27]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. All model variations vary the initial conditions.

Kruckow et al. (2018) developed the code COMBINE to predict the compact object coalescence rates. We retrieve the merger rates for NS-NS, BH-BH and NS-BH from their Table 8 and Table B3. We use the rates quoted in the column $\mathcal{R}_{z=0}$ as well as the rates in the column $\mathcal{R}_{\mathrm{cSFR}}$. The two columns are estimates that are calculated with two different star-formation history and galaxy-density scaling methods. For the NS-BH estimates we sum the quoted NSBH and BHNS rates in the tables. We retrieve: BH-BH $[0.6, 109]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, NS-BH: $[2, 53]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, NS-NS: $[2.7, 159]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. We do not include the model variations (in mass transfer efficiency) since the models are calculated at a fixed metallicity.

Lamberts et al. (2016) focus in their study on studying where and when gravitational GW150914 formed. They base their star formation history model on data/studies including based on the FIRE simulations. For the binary stellar evolution they use the BSE code that they update to match more recent population synthesis codes. We retrieve their single estimate for the total BH-BH merger rate density from their Section 4, which yields $850\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$.

Levina et al. (2026) use the ILLUSTRISTNG cosmological simulations to evaluate the accuracy of analytical fits for the metallicity-specific cosmic star formation rate density star formation history models, commonly used as proxies for the underlying star formation and chemical enrichment history in binary population synthesis studies, and assess the impact of simulation resolution and volume on the inferred BH-BH merger rate. We obtain the BH-BH merger rates from the simulation-based values in Table 2 of Levina et al. (2026), which the authors find to be more accurate than the corresponding analytical-fit values, for the TNG50-1, TNG100-1, and TNG300-1 simulation volumes.

Li et al. (2025) study the formation channels, mass distributions, and merger rates of HB-BH systems using the binary population-synthesis code MOBSE, explicitly incorporating chemically homogeneous evolution (CHE) alongside the more traditional CE and SMT isolated-binary evolution pathways. The authors explore a grid of population-synthesis models in which key uncertain physical parameters are varied, including the angular-momentum loss prescription during non-conservative mass transfer, the CE ejection efficiency $\alpha_{\rm CE}$, the Wolf–Rayet wind mass-loss multiplier, the natal kick velocity dispersion, and the mass-transfer stability criterion. Across all models, BBH mergers are classified into three mutually exclusive formation channels: (i) a CHE channel, in which both stars evolve chemically homogeneously without undergoing any Roche-lobe overflow; (ii) a CE channel, in which at least one dynamically unstable mass-transfer episode leads to envelope ejection; and (iii) a SMT channel, in which both interaction phases proceed stably without a CE phase. We extract the intrinsic merger rates at redshift $z = 0.2$ for each formation channel directly from the legends of Figure 4 in Li et al. (2025), which report channel-specific merger rates in units of $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ for each model in the parameter study. For our analysis, we take the CHE rates as the CHE channel and combine the CE, and SMT channel into one isolated binary evolution rate for each model[1].

Lipunov & Pruzhinskaya (2014) use Scenario Machine to calculate the merger rate density of NS-NS mergers from the isolated binary evolution channel. We take their predicted NS-NS rates from their Figure 3 (gray bands) which span approximately $0.9 \cdot 10^{-5}$–$3.3 \cdot 10^{-4}\,\mathrm{yr}^{-1}$ for a MWEG. We convert this to $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ using Equation 2, which gives the range of $\mathcal{R}_{\rm NS-NS} = [1050, 3860]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$.

Lipunov et al. (2017) use Scenario Machine to simulate the merger rate density of BH-BH systems. We retrieve their rate estimation from the text just below Equation 2 which gives a rate of $\mathcal{R}_{\rm BH-BH} = 100\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$.

Mapelli et al. (2017) study the formation of BH-BH mergers by coupling MOBSE with Illustris. We take their BH-BH rates from their Table 2 for redshift $z \approx 0$, which gives a rate estimate for BH-BH in the range $[20, 572]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. The authors have submodel variations in delayed/rapid supernova prescription, common envelope efficiency, binding energy parameter, optimistic/pessimistic CE, and natal kicks.

Mapelli & Giacobbo (2018) use MOBSE in combination with the cosmological code Illustris-1 simulations to estimate the BH-BH, NS-BH and NS-NS merger rates as a function of redshift and assumptions for the CE efficiency parameter and supernovae natal kick magnitude. We retrieve their local merger rates from their Table 2. This gives predicted rates in the ranges BH-BH: $[146, 240]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, NS-BH: $[9, 115]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, NS-NS: $[19, 591]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$.

Mapelli et al. (2021) use MOBSE to simulate BH-BH mergers from the isolated binary evolution channel and in nuclear star clusters, globular clusters and young star clusters. They compare the results for a variety of model assumptions including common-envelope assumptions and mass transfer efficiency assumptions. We obtain their isolated rates from the yellow lines in Figure 8 and Figure 9. We retrieve the local merger rates by reading out the rate value using a plot digitalizer at lookback time of 0 Gyr. The quoted numbers obtained are hence approximate. They find BH-BH rates in the range $\mathcal{R}_{\rm BH-BH} = [6, 37]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. For the parameter variations we only include the submodels that vary isolated binary evolution parameters which include variations in CE efficiency and mass transfer efficiency.

Marinacci et al. (2026) use SEVN and cosmological simulations from MillenniumTNG to calculate the BH-BH, NS-BH, and NS-NS merger rates. We retrieve their rates from reading out their Figure 3 rates at redshift $z \sim 0$, which gives a single model value for each merger type.

Mennekens & Vanbeveren (2014) use the Brussels code to predict the coalescence rate of BH and NS. We retrieve their merger rate densities for a MWEG from their Table 2 from their 'Galactic merger rates' column. We convert these rates to $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ using Equation 2. We include all simulations including where they find 0 mergers. Doing this, we retrieve that they find the following ranges for the merger rate densities BH-BH: $[0, 1140]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, NS-BH: $[0.06, 800]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, and NS-NS: $[0, 1800]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. The submodels include variations in star formation history model, common-envelope efficiency, mass transfer efficiency, remnant mass prescription, initial condition, LBV winds, NS kicks, BH kicks, and angular momentum loss. We include the single-parameter variations in our parameter variation study.

Mestichelli et al. (2025) use SEVN to investigate the population II and III NS-BH and NS-NS merger rates. We retrieve their isolated binary evolution rates for population II stars from table 3 and table 5 from the $z \sim 0$ models which gives a single merger rate prediction for isolated binary evolution models as well as for population III formation.

Neijssel et al. (2019) use COMPAS to estimate the BH-BH, NS-BH and NS-NS coalescence rate. They vary many different prescriptions for the star formation history and also vary both the 'optimistic' and 'pessimistic' common-envelope scenario. We retrieve their rates from their Table C1 (both the optimistic and pessimistic table) that are quoted under the column $z = 0$ for local rates. We do not use the sampling uncertainties that are given in the table as these are small compared to the predicted range of merger rates. We obtain rate ranges in $\mathcal{R}_{\rm BH-BH} = [59, 1157]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, $\mathcal{R}_{\rm NS-BH} = [19, 204]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ and $\mathcal{R}_{\rm NS-NS} = [20, 245]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. Their submodels include variations in star formation history model as well as variations in optimistic/pessimistic CE, which we include in our parameter investigation plots.

Olejak et al. (2021) use StarTrack to explore different CE prescriptions (stability) and their effect on COC rates and properties. We retrieve their NS-NS, NS-BH and BH-BH rates from their Table 3 and find BH-BH in $[18, 89]$, NS-BH in $[4, 16]$ and NS-NS in $[148, 322]$

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[1] Note that due to small rounding errors, the total BBH merger rates reported in each figure in Li et al. (2025) is not the sum of the subchannel rates. We take the sum of the subchannel rates for that reason as the total BBH rate to be consistent throughout.

Olejak et al. (2022) calculate compact object coalescence rates using an updated supernova prescription with variations in common envelope treatment, supernova remnant mass limits, and core-collapse supernova models. We retrieve their predicted merger rates from Table 3, which explores a two-by-two grid of CE criteria (standard and revised) and PSN mass limits (revised and strong), combined with three different supernova mixing prescriptions ($f_{\rm mix} = 0.5, 1.0, 4.0$). The merger rate ranges are: $\mathcal{R}_{\rm BH-BH} = [43, 102], {\rm Gpc}^{-3}\,{\rm yr}^{-1}$, $\mathcal{R}_{\rm NS-BH} = [4, 27], {\rm Gpc}^{-3}\,{\rm yr}^{-1}$, and $\mathcal{R}_{\rm NS-NS} = [116, 155], {\rm Gpc}^{-3}\,{\rm yr}^{-1}$. We include relationships showing variations along all three independent axes: the supernova core-collapse mixing timescale, the PSN mass limit prescription, and the common envelope treatment prescription.

O'Shaughnessy et al. (2010) estimate the binary compact object rates for gravitational-wave detector using StarTrack. They particularly focus on the potential significant contribution from binaries produced in elliptical versus spherical galaxies and create their star formation history based on a two-component model with elliptical and spherical galaxy contributions. We take the rates as quoted in their abstract and Section 4.5 and convert this to ${\rm Gpc}^{-3}\,{\rm yr}^{-1}$. This includes both a range and a 'best' rate model. They find NS-BH rates in $[10, 280]$, NS-NS rates in $[30, 1700]$ and BH-BH rates in $[2, 40]$ ${\rm Gpc}^{-3}\,{\rm yr}^{-1}$. No clear combination of submodels and rates is provided, so this study is not included in the parameter break up.

Pellouin et al. (2025) use COSMIC to study the contribution of different isolated binary evolution formation channels to the formation of NS-NS. We extract the NS-NS formation-channel rates from the $z \simeq 0$ results shown in their Figure 10 and convert them to units of ${\rm Gpc}^{-3}\,{\rm yr}^{-1}$. This yields a total local NS-NS merger rate of approximately 298 ${\rm Gpc}^{-3}\,{\rm yr}^{-1}$.

Rauf et al. (2024) combine the COMPAS population synthesis code with the semi-analytic galaxy formation model Shark to predict the volumetric BH-BH merger rate as a function of redshift for four fiducial remnant-mass prescriptions: Fryer et al. (2012), Mandel & Müller (2020), Mandel & Müller (2020) with a reduced Wolf–Rayet wind multiplier ($f_{\rm WR} = 0.2$), and Schneider et al. (2021). We obtain the local ($z = 0$) BH-BH merger rates by reading off the median (solid line) values from Figure 3 of Rauf et al. (2024), giving approximately 290, 39, 47, and 4.7 ${\rm Gpc}^{-3}\,{\rm yr}^{-1}$ for the Fryer et al. (2012), Mandel & Müller (2020), Mandel & Müller (2020, $f_{\rm WR} = 0.2$), and Schneider et al. (2021) prescriptions, respectively.

Riley et al. (2021) use COMPAS and study the formation rate of the classic isolated binary evolution channel as well as Chemically homogeneous evolution as a function of redshift. We retrieve the isolated binary evolution BH-BH merger rates from Figure 10 from the CHE + Non CHE model (solid lines) for redshift 0 for the four different wolf-rayet factors from private communication with the lead author. The rates lie in the range $\mathcal{R}_{\rm BH-BH} = [51, 87]$ ${\rm Gpc}^{-3}\,{\rm yr}^{-1}$.

Romagnolo et al. (2023) use StarTrack to investigate how imposing different upper limits on the radial expansion of massive stars affects the formation of NS-NS, NS-BH, and BH-BH mergers. We obtain their BH-BH, NS-BH, and NS-NS merger rates from Table 3 for their five models (Model 1, 2, 3, 4a, and 4b). The model variations vary the maximum radius (which we group under stellar tracks).

Romagnolo et al. (2025) use StarTrack to investigate how different CE survival criteria, based on the presence of a convective envelope, affect the formation of compact-object mergers. We adopt their reported BH-BH, NS-BH, and NS-NS merger rates from their Table 2. The model variations vary either the maximum radius (which we group under stellar tracks), or the convective envelope criteria.

Román-Garza et al. (2021) use an early version of POSYDON to calculate the merger rates of BH-BH and NS-BH for several different population synthesis assumptions. We retrieve their rates from their Table 3 and use the combined CE + SMT rate (both formation channels). We quote all 9 model combination rates. This gives rates in the ranges $\mathcal{R}_{\rm BH-BH} = [70, 203]\,{\rm Gpc}^{-3}\,{\rm yr}^{-1}$ and $\mathcal{R}_{\rm NS-BH} = [5.7, 77]\,{\rm Gpc}^{-3}\,{\rm yr}^{-1}$. The submodels include variations in supernova remnant mass prescription and natal kick models.

Santoliquido et al. (2020) use MOBSE to study the rate of BH-BH, NS-BH and NS-NS for isolated and YSC formation. We take their isolated rates from their table 1 from the lowest redshift bin and the 'Isolated' column. We retrieve the following merger rate densities: BH-BH: $\mathcal{R}_{\rm BH-BH} = 50^{+71}_{-37}\,{\rm Gpc}^{-3}\,{\rm yr}^{-1}$, NS-BH: $\mathcal{R}_{\rm NS-BH} = 49^{+48}_{-34}\,{\rm Gpc}^{-3}\,{\rm yr}^{-1}$ and $\mathcal{R}_{\rm NS-NS} = 283^{+97}_{-75}\,{\rm Gpc}^{-3}\,{\rm yr}^{-1}$. This paper does not quote rates for submodel variations.

Santoliquido et al. (2021) use MOBSE to study the rate of BH-BH, NS-BH and NS-NS as a function of redshift for a large variety of assumptions for the star formation history as well as several stellar evolution models. We obtain their rates from their Table 2 where we take the values in the column $\mathcal{R}_0$ for the local rates. We find that their rates lie in the ranges $\mathcal{R}_{\rm BH-BH} = [10, 105.4]\,{\rm Gpc}^{-3}\,{\rm yr}^{-1}$, $\mathcal{R}_{\rm NS-BH} = [1.8, 128]\,{\rm Gpc}^{-3}\,{\rm yr}^{-1}$ and $\mathcal{R}_{\rm NS-NS} = [4.3, 1036.8]$ ${\rm Gpc}^{-3}\,{\rm yr}^{-1}$.

Sgalletta et al. (2025) use SEVN coupled to the GalaxyRate framework to investigate the BH-BH merger rate density across a large grid of population synthesis and metallicity-dependent star formation history models (see their Table 1). We retrieve the BH-BH merger rate densities by digitizing Figure 5 and reading off the median values at $z \sim 0$. We do the same for the additional models for a natal kick prescription model variation in Figure 7. We include the star formation history variations and CE efficiency and natal kick variations to our parameter investigation.

Sgalletta et al. (2026) use the binary population synthesis code sevn, coupled to stellar evolutionary tracks computed with parsec v2.0, to investigate how the choice of envelope binding energy prescription affects the BH-BH, NS-BH, and NS-NS merger rate densities. The study examines three prescriptions for the CE binding energy parameter λ: the fitting formula of Claeys et al. (2014), the physically-motivated prescription of Klencki et al. (2021), and new binding energy tables derived directly and self-consistently from the parsec v2.0 stellar tracks used in the simulation. For each λ prescription, the CE efficiency parameter is varied across four values ($\alpha_{\rm CE} = 0.5$, 1, 3, 5), yielding 12 model combinations per DCO type. We retrieve the BH-BH, NS-BH, and NS-NS merger rate densities at $z \sim 0$ by digitizing Figure 8. We add the CE efficiency and binding energy variations to our parameter exploration.

Shao & Li (2021) use BSE (and their earlier updates and improvements of BSE) in combination with MESA to revise the criteria of occurrence of common-envelope phases to simulate the formation of compact object binaries including BH-BH and NS-BH from the isolated binary evolution channel for different model assumptions.

We retrieve their merger rate densities estimations from their Table 1 where we use the columns $\mathcal{R}$ for NS-BH and BH-BH for all three supernova models (delayed, rapid, and stochastic). Doing so we retrieve that the authors find merger rate densities in the ranges $\mathcal{R}_{\text{BH}-\text{BH}} = [43, 76]\,\text{Gpc}^{-3}\,\text{yr}^{-1}$ and $\mathcal{R}_{\text{NS}-\text{BH}} = [10, 72]\,\text{Gpc}^{-3}\,\text{yr}^{-1}$.

Smith et al. (2026) use the SEVN population synthesis code, combined with an empirically constrained galaxy stellar mass function, mass–metallicity relation, and star-forming main sequence, to predict the volumetric BH-BH merger rate density as a function of redshift. They consider two initial-mass-function (IMF) models, a constant-slope IMF ($\alpha = 2.3$, $\beta = 0.0$) and a running-slope IMF ($\alpha = 2.3$, $\beta = 0.3$) that flattens at higher masses, each evaluated for three delay-time distribution (DTD) power-law indices, $P(\tau) \propto \tau^{-\gamma}$ with $\gamma = 0.5$, 0.85, and 1.0. We obtain the local ($z \sim 0$) BH-BH merger rates for these six model variations from Figure 8 of Smith & Kaplinghat (2025), giving approximately 66, 36, and 22 $\text{Gpc}^{-3}\,\text{yr}^{-1}$ for the constant-slope IMF with $\gamma = 0.5$, 0.85, and 1.0, respectively, and approximately 78, 43, and 27 $\text{Gpc}^{-3}\,\text{yr}^{-1}$ for the running-slope IMF with $\gamma = 0.5$, 0.85, and 1.0, respectively. We note that the authors do not directly use the delay times calculated by the SEVN code, but instead fit delay time distributions slopes, which they then use to calculate cosmological merger rates. This might introduce some bias.

Smith et al. (2026) investigate the impact of mass ratio reversal (MRR) — where the initially less massive star in a binary forms the more massive compact object — on the BH-BH merger rate and mass distribution, comparing predictions from the COMPAS and SEVN population synthesis codes. We obtain the total local BH-BH merger rates from the black lines of Figure 1 of Smith et al. (2026), giving approximately 90 $\text{Gpc}^{-3}\,\text{yr}^{-1}$ for the COMPAS model and 200 $\text{Gpc}^{-3}\,\text{yr}^{-1}$ for the SEVN model.

Spera et al. (2019) use the code SEVN to study the formation of BH-BH mergers from the isolated binary evolution channel. The authors calculate the merger rate density for one model realization. We retrieve the local merger rate prediction for BH-BH from their Section 4.3 of $\mathcal{R}_{\text{BH}-\text{BH}} = 90\,\text{Gpc}^{-3}\,\text{yr}^{-1}$.

Srinivasan et al. (2023) use COSMIC to study the typical galactic environments of BH-BH merger progenitors, combining 40 binary population synthesis model variations with 6 star-formation-rate/mass-metallicity relation (SFR/MZR) models, for a total of 240 model combinations. We obtain their intrinsic BH-BH merger rates from Figure 5 for these 240 models. We extract the values using a WebPlotDigitizer and include the model variations in our parameter investigation.

Stevenson & Clarke (2022) review the predicted local BH-BH merger rates from isolated binary evolution, including contributions from the chemically homogeneous evolution (CHE) channel. From their Figure 8, they quote a combined isolated-binary (classical isolated binary evolution + CHE) BH-BH merger rate in the range 10–400 $\text{Gpc}^{-3}\,\text{yr}^{-1}$. Since the authors note that CHE can contribute up to 70% of this rate, we lower the bound of the classical isolated binary evolution rate accordingly, taking $0.3 \times 10 = 3\,\text{Gpc}^{-3}\,\text{yr}^{-1}$ as the lower limit for isolated binary evolution while retaining the upper limit of 400 $\text{Gpc}^{-3}\,\text{yr}^{-1}$, giving 3–400 $\text{Gpc}^{-3}\,\text{yr}^{-1}$ for isolated binary evolution range. For the CHE channel, we adopt 70% of the quoted lower range from Figure 8, i.e., $0.7 \times [10, 400] = 7\text{–}400\,\text{Gpc}^{-3}\,\text{yr}^{-1}$, keeping the upper limit to 400 $\text{Gpc}^{-3}\,\text{yr}^{-1}$ to be conservative as it is not clear if all models have a 70% contribution. Since its not easy to read off individual values for individual parameter runs, we do not include this in our parameter variation investigation.

Tang et al. (2020) use BPASS to calculate compact object merger rates across three independent axes of variation: binary population synthesis models, mass transfer efficiency, and cosmic star formation rate density. They present merger rates for three binary population synthesis model variants (i, ii, iii), six mass transfer efficiency values ($\beta1$–$\beta6$), and five SFRD models (u in $\{4, 4.5, 5, 5.5, 6\}$), yielding 90 rates per DCO type. We retrieved the rates from their Table A1. The predicted merger rate ranges are: $\mathcal{R}_{\text{BH}-\text{BH}} = [10.5, 219], \text{Gpc}^{-3}\,\text{yr}^{-1}$, $\mathcal{R}_{\text{NS}-\text{BH}} = [58.0, 665], \text{Gpc}^{-3}\,\text{yr}^{-1}$, and $\mathcal{R}_{\text{NS}-\text{NS}} = [394, 3190], \text{Gpc}^{-3}\,\text{yr}^{-1}$. We note that Table A1 contains a minor typographical error in model (iii), variant 1 at $u = 5.5$ (NS-BH), where the value should be 622.5 rather than the printed value. We include relationships showing variations along all three axes: the SFRD model (u4 → u6), mass transfer efficiency ($\beta1$ to $\beta6$), and the binary population synthesis model prescription changes from (i) to (ii) and (ii) to (iii), which isolate the initial binary distribution and supernova kick prescription variations, respectively.

Van Son et al. (2022a) use COMPAS to compute BH-BH merger rates, with particular emphasis on the relative contributions of the only stable mass transfer and CE formation channels. We adopt their total local merger rate of $R_{\text{BBH}} \simeq 73\,\text{Gpc}^{-3}\,\text{yr}^{-1}$ at $z \approx 0$ from the main text (Section 7.3).

Van Son et al. (2022b) use COMPAS to investigate the formation of NS-BH and BH-BH from the stable mass transfer channel. We obtain their merger rates from their Table 2 and Table 3 where we take the BHNS and BBH rates quoted there at $z \sim 0.2$. The model variations include variations in the core mass fraction (which we list as a new parameter variation), mass transfer stability, mass transfer efficiency, supernova prescription and angular momentum loss.

Van Son et al. (2023) use COMPAS to study how different metallicity-dependent star-formation histories affect the BH-BH merger rate in different formation channels. We extract their BH-BH merger rates from their Figures 3 and 4, summing the stable channel and CE channel components to obtain the total rate for the fiducial model and each model variation. We include the full set of cosmic star formation history model variations in our parameter exploration study.

Xing et al. (2024) use the POSYDON binary population synthesis framework to study the formation of NS-BH mergers across a broad range of metallicities. We extract the total NS-BH merger rates from Table 1, using the reported $\mathcal{R}_{\text{NSBH}}$ values from the published version of the paper.[2] This yields four models: a fiducial model, a variant with $\alpha_{\text{CE}} = 2$, and two variants with modified core-collapse kick dispersions σ_{cc}. The authors additionally explore versions of each model with the maximum neutron-star mass reduced from the default 2.5 $M_\odot$ to 2.0 $M_\odot$. However, formation-channel contributions for these submodels are not tabulated, and inspection of Figure 3 indicates that this variation has a negligible effect on the relative channel fractions. We therefore exclude these submodels from our analysis.

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[2] Note that their earlier arXiv version reports slightly different NS-BH merger rates.

Vigna-Gómez et al. (2018) use COMPAS to study the merger rate of NS-NS for a range of simulation assumptions. We retrieve their NS-NS merger rates from their Table 2 from the column $\mathcal{R}$. As this rate is quoted in Myr per MWEG we convert these rates to $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ using Equation 2. Doing so we obtain NS-NS rates in the range $\mathcal{R}_{\mathrm{NS-NS}} = [61.5, 362]\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. The authors vary model assumptions including SN physics, natal kicks, angular momentum loss (mass loss mode), initial conditions, and CE physics.

Zevin et al. (2020) use COSMIC to calculate compact object merger rate densities across multiple model assumptions. They present rates for a suite of binary population synthesis variations exploring different common envelope efficiency prescriptions (optimistic and pessimistic assumptions), supernova kick models (Bimodal versus Geller & Metzger 2020), and mass transfer efficiency scenarios (Rapid and Delayed). We retrieve their predicted merger rates from Table 1. The merger rate ranges across all model realizations are: $\mathcal{R}_{\mathrm{BH-BH}} = [84, 6900], \mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, $\mathcal{R}_{\mathrm{NS-BH}} = [3.7, 1100], \mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$, and $\mathcal{R}_{\mathrm{NS-NS}} = [600, 8900], \mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$. We include the relationships between model variations to investigate how the common envelope survival probability and supernova kick prescriptions affect predicted merger rates across all three DCO types.

Zhu et al. (2024) use COMPAS to calculate the NS-BH merger rate. We retrieve their rates from their Table 1, which includes model variations in CE efficiency and supernova natal kick magnitude. We do not include the error bars in our rate retrieval for simplification.

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