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Binary synthesis of merging compact object populations from evolving initial conditions

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In this work, we implement models for a metallicity- and SFR-dependent IMF and correlated initial mass ratio, orbital period and eccentricity in performing binary population synthesis with the code `COMPAS` for binaries born at redshifts up to 10. We are able to obtain the time-evolution of all three classes of compact binary mergers, which we find found to peak between redshift 1 and 4 depending on the model; additionally, we found a robust trend of merging black holes to be more massive at higher redshift.

We have studied two variations of initial condition models in performing binary population synthesis (BPS) with the code `COMPAS`. In the "Canonical" model, when sampling our newborn binaries for evolution, we implement the invariant Kroupa (2001) IMF, for sampling masses, and the traditional independent distributions for orbital parameters: uniform for the mass ratio (q), log-uniform for the orbital period (P), and set $e = 0$. In the "IGIMF" model, we implement the varying IMF by Jeřábková et al. (2018), based on empirical fits that make it top-heavy at low metallicities and high SFRs, alongside the correlated orbital parameteres by Moe & Di Stefano (2017).

Based on the work of Chruślińska et al. (2020) (and references therein), we sample metallicity-SFR (or redshift) pairs based on the cosmic star formation history in order to build a composite binary population with binaries born between redshift 0 and 10. For each of our two initial models, we sample and evolve $\sim 10^8$ binaries over 120 different metallicity-SFR/redshift pairs.

Our main results are the time-evolution of the merger rates up to redshift 10 for black hole-black hole (BHBH), black hole-neutron star (BHNS) and neutron star-neutron star (NSNS) mergers. Two differences between the results for the IGIMF model and for the Canonical model stand out: the later positions for the merger rate peaks; and rates one order of magnitude greater for BHBH and BHNS mergers. Both are a consequence of implementing a IMF

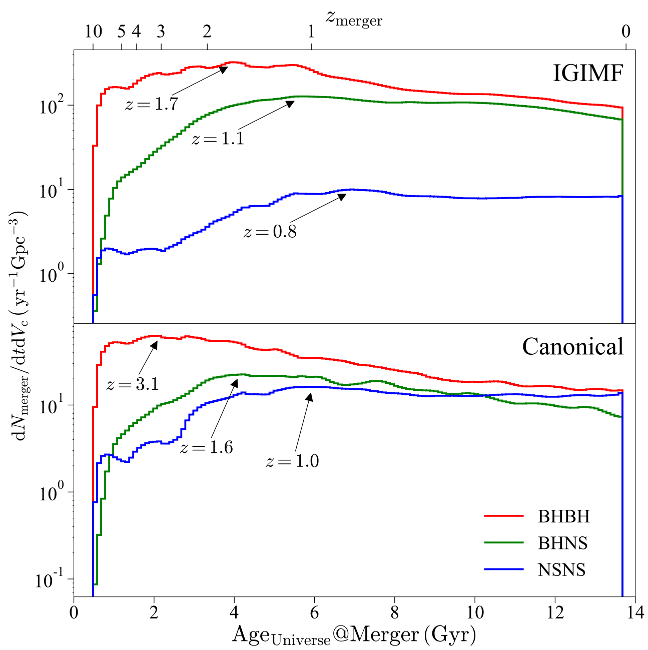

Figure 1. Merger rate time-evolution for BHBH, BHNS and NSNS mergers in both IGIMF and Canonical models.

that becomes top-heavy for high SFRs. Because the SFR peaks around $z = 2$, the rate peaks come at later redshift; and because a top-heavy IMF increases the production of black hole merges more strongly than that of neutron star mergers, the BHBH and BHNS rates are more affected. We also find a trend of black hole masses to increase with redshift, particularly strong in the IGIMF model.

A complete exposition and discussion of results for rates and masses of all three merger classes, in both IGIMF and Canonical models, will be published in the near future as de Sá et al. (submitted).

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References

Chruślińska, M., Jeřábková, T., Nelemans, G., & Yan, Z. 2020, A&A, 636, A10, doi: 10.1051/0004-6361/202037688

Jeřábková, T., Zonoozi, A. H., Kroupa, P., et al. 2018, A&A, 620, A39, doi: 10.1051/0004-6361/201833055

Kroupa, P. 2001, MNRAS, 322, 231, doi: 10.1046/j.1365-8711.2001.04022.x

Moe, M., & Di Stefano, R. 2017, ApJS, 230, 15, doi: 10.3847/1538-4365/aa6fb6

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