

# Massive stars as progenitors of merging compact object binaries

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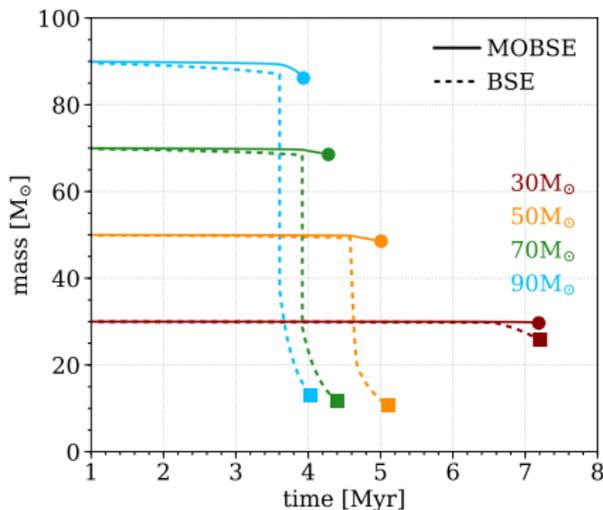
# MOBSE (Massive Objects in BSE)



Updated version of the **BSE** code (Hurley+ 2002).

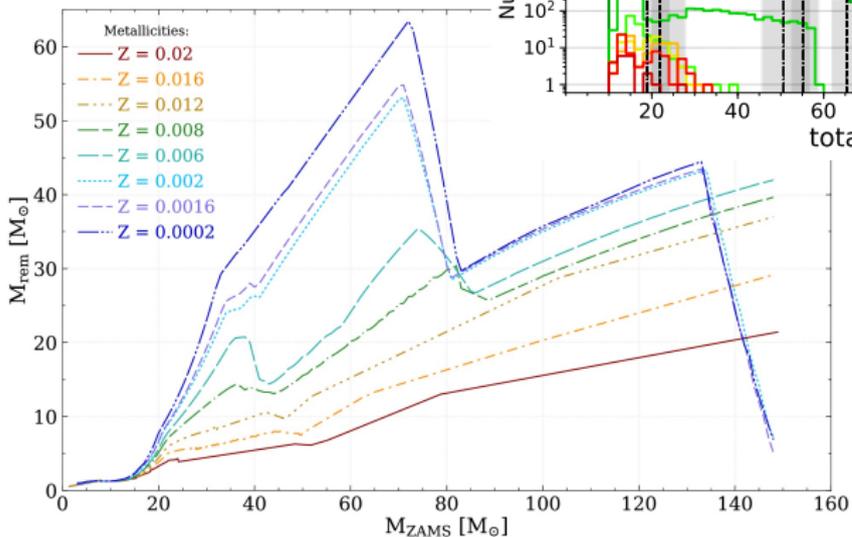
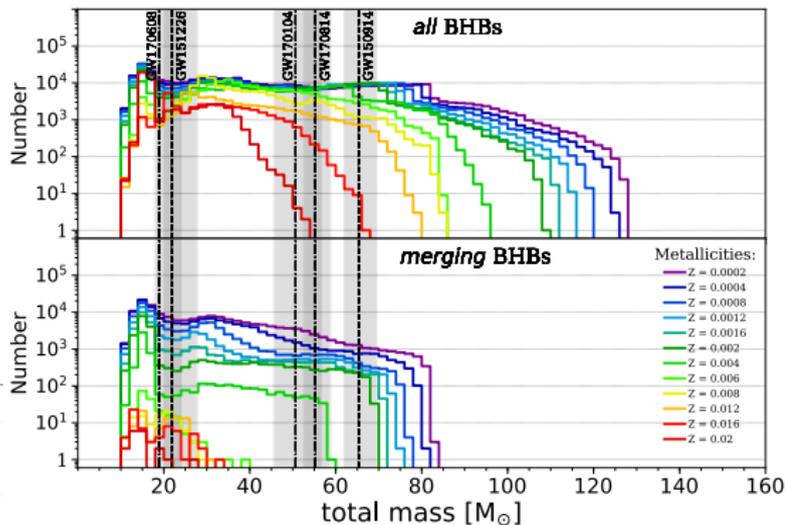
## Major updates:

- recent stellar winds Vink+ 2001 and Gränerfer+ 2011;
- new SNe Fryer+ 2012;
- Pulsation-Pair-Instability (PPISN) and Pair-Instability (PISN) Woosley 2017.

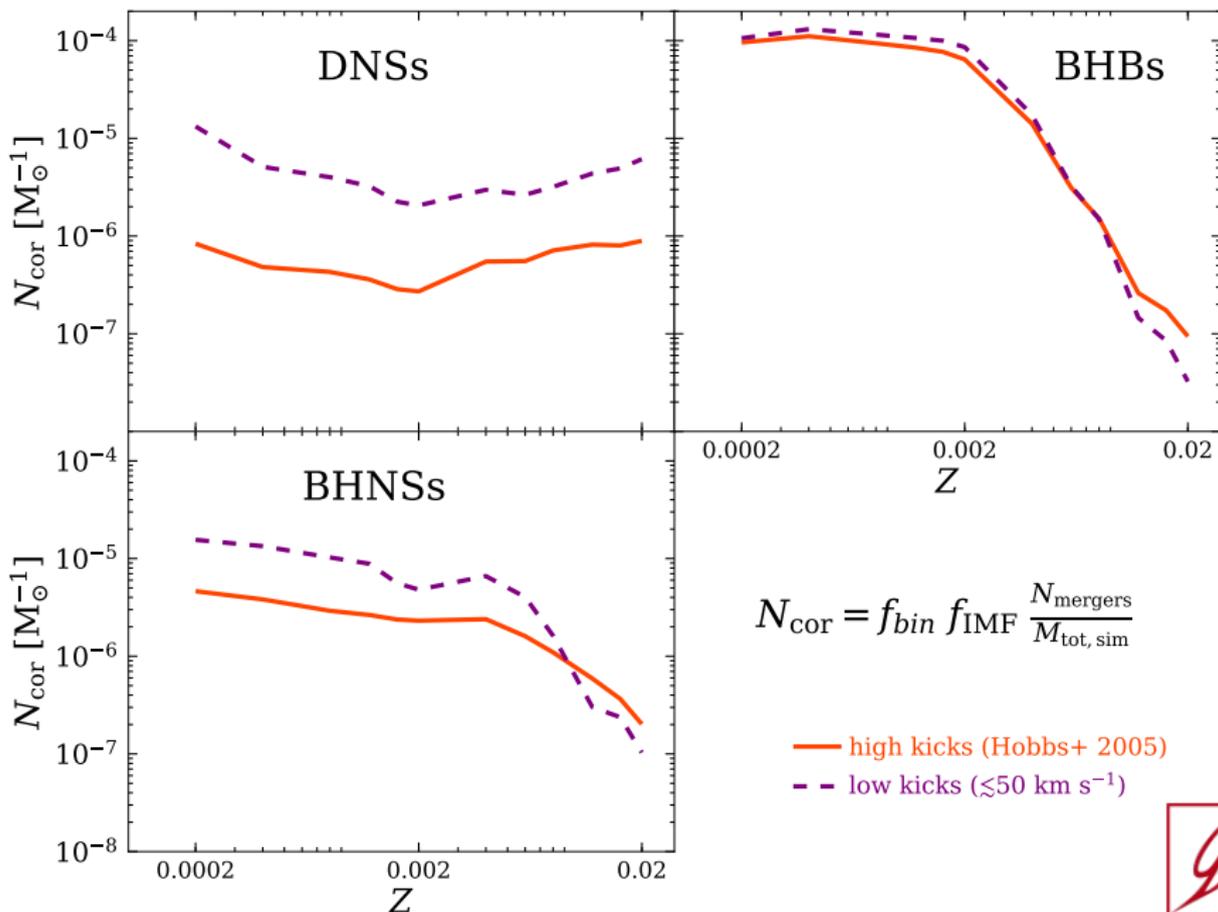


# Black hole masses

As shown in  
Mapelli's talk



# Mergers per unit stellar mass



# Much more:

# Take a look at the poster ...



# ... or ask me.



## A critical look at progenitors of merging compact object binaries

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### Abstract

Six gravitational wave events have been reported by the LIGO-Virgo collaboration and they are associated with mergers of compact objects binaries (COBs). We investigated the progenitors of COBs by means of population-synthesis simulations performed with our population-synthesis code MOBSE. In particular, we studied the impact of progenitor's metallicity and of the natal kicks on the properties of merging COBs.

### A new tool: MOBSE

MOBSE (acronym for 'Massive Objects in Binary Stellar Evolution', see [1]) is an updated version of BSE [2]. MOBSE includes the most recent models of wind mass-loss, core-collapse supernovae and (psilium) pair instability supernovae which are essential to capture the evolution of massive stars. With MOBSE it is possible to form black holes (BHs) with mass up to  $\approx 60 M_{\odot}$  depending on the metallicity (Fig. 1).

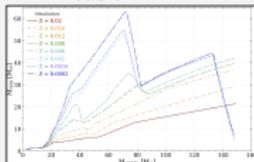


Figure 1. Mass spectrum of compact objects as a function of zero-age main sequence mass ( $M_{ZAMS}$ ) for different metallicities.

### Black hole binaries (BHBs)

We used MOBSE to evolve several sets of  $1.2 \times 10^6$  massive binaries with the aim of studying the population of isolated COBs in different environments [1, 3]. We find that the maximum mass of BHBs increases with decreasing the metallicity but the most massive systems ( $M \gtrsim 85 M_{\odot}$ ) do not merge in a Hubble time (Fig. 2).

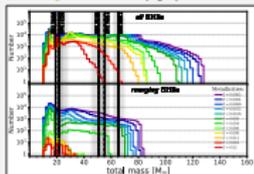


Figure 2. Distribution of total masses of all BHBs (top panel) and of merging BHBs (bottom panel). The vertical lines are the total mass of the GW events with their uncertainties.

### Mergers per unit stellar mass

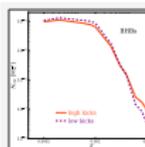


Figure 3.  $N_{merg}$  versus  $Z$  for BHBs

To quantify the efficiency of COB formation we computed the number of mergers per unit stellar mass ( $N_{merg}$ ) and we find that merging BHBs form more efficiently from metal-poor stars ( $\sim 10^{-4} M_{\odot}^{-1}$  at  $Z = 0.0002$ ) than from metal-rich stars ( $\sim 10^{-7} M_{\odot}^{-1}$  at  $Z = 0.02$ ), as shown in Fig. 3. Metal-poor binaries tend to produce also more black hole neutron star systems (BHNS) than metal-rich ones (Fig. 4).

In contrast,  $N_{merg}$  for double neutron stars (DNSs) seems to be weakly sensitive to metallicity. Assuming low natal velocity kicks ( $\leq 50 \text{ km s}^{-1}$ ) the number of merging DNSs is boosted by a factor of 10 (Fig. 5). The number of BHNS and BHB mergers weakly depends on the assumed natal kicks, because we assume that the kick is reduced by the amount of fallback.

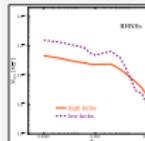


Figure 4.  $N_{merg}$  versus  $Z$  for BHNS

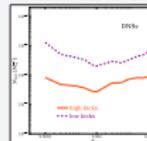


Figure 5.  $N_{merg}$  versus  $Z$  for DNSs

### ... and much more:

We used MOBSE also to study:

1. the importance of natal kicks for DNSs [4],
2. the cosmic merger rate of COBs [5, 6].

### Bibliography

- [1] N. Giacobbo, M. Mapelli and M. Spera, MNRAS 474 (2019-2016), 2018
- [2] J. R. Hurley, C. A. Tout and O. R. Pols, MNRAS 329 (191-205), 2002
- [3] N. Giacobbo, M. Mapelli, submitted to MNRAS, <https://arxiv.org/abs/1805.05001>, 2018
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- [5] M. Mapelli, N. Giacobbo, accepted for publication in MNRAS, <https://arxiv.org/abs/1806.04856>, 2018
- [6] M. Mapelli, N. Giacobbo, E. Ripamonti, M. Spera, MNRAS 472 (2422), 2018

