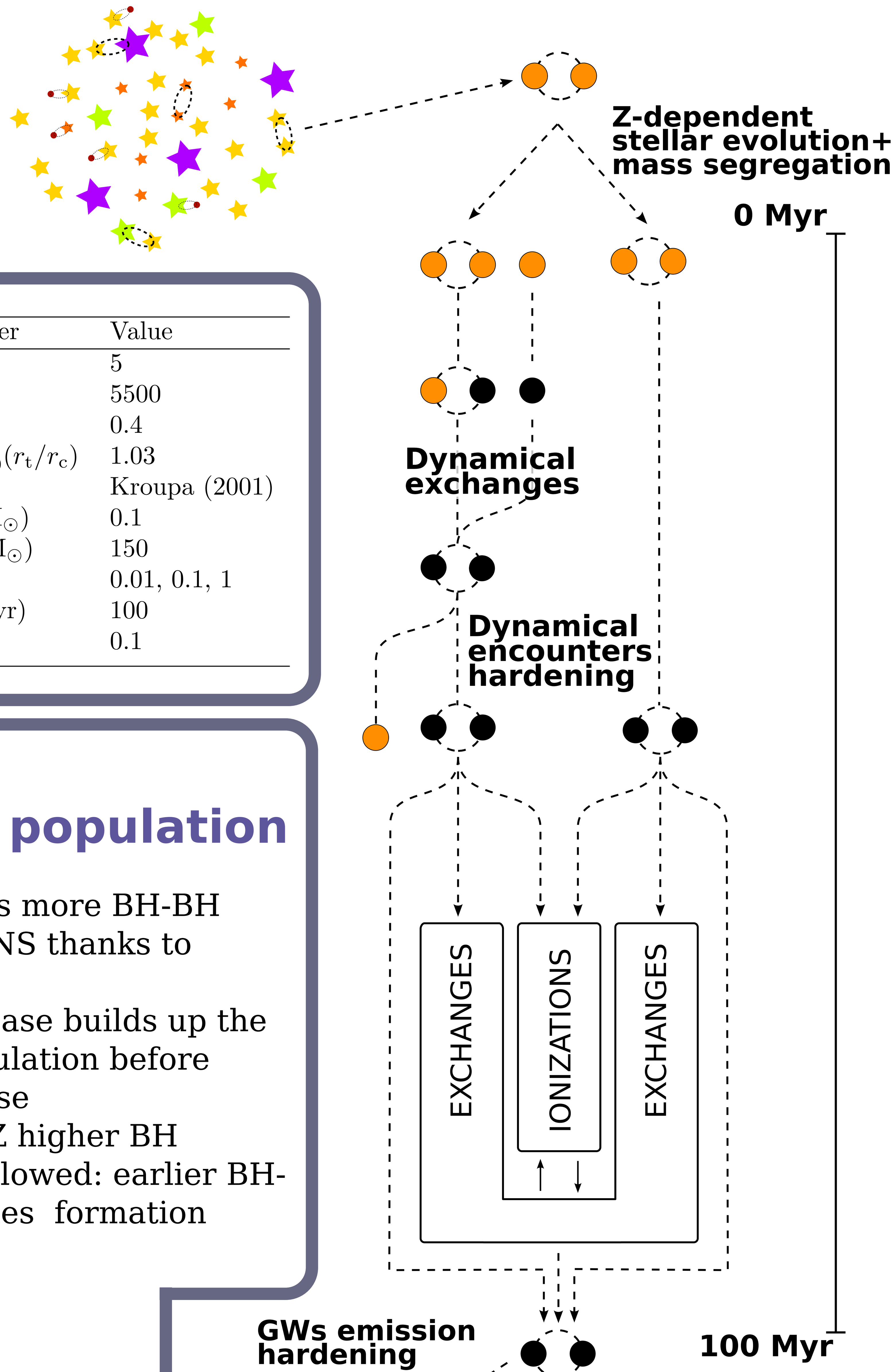
Influence of dynamics and metallicity on the formation and evolution of black-hole binaries in star clusters

Brunetto Marco Ziosi[1, 2], Michela Mapelli[2], Marica Branchesi[3, 4, 5], Giuseppe Tormen[1]

More info
arxiv.org/abs/1404.7147
brunetto.ziosi@gmail.com



Overview

BH-BH binaries produce gravitational waves (GWs) during inspiral and merger events.
With the advent of Adv. Virgo/LIGO it is important to estimate the demography of such promising sources of GWs.
To investigate the impact of dynamics and metallicity on the formation and evolution of BH-BH binaries we run N-body with stellar and binary evolution simulations of young dense star clusters. The simulated clusters are dense enough to provide a perfect environment to probe the effect of dynamics on short timescales, while their size makes them suitable for being simulated with direct N-body codes.

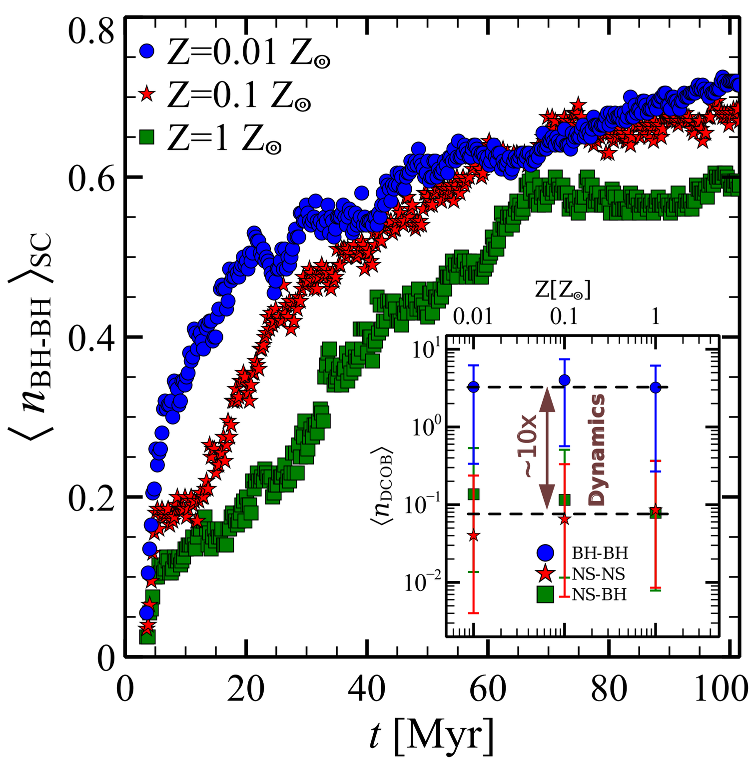
Methods

- 600 direct summation N-body realization of the same cluster at three different metallicities.
- We used our modified version of the public code STARLAB to include up-to-date stellar and binary evolution.

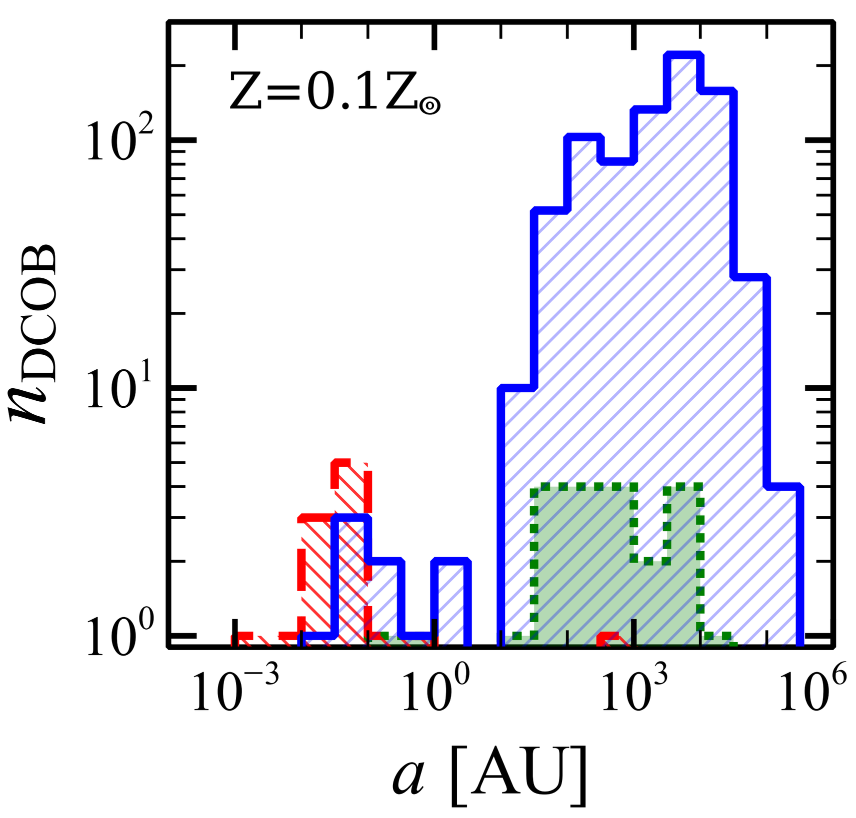
Parameter	Value
W_0	5
N_*	5500
r_c (pc)	0.4
$c \equiv \log_{10}(r_t/r_c)$	1.03
IMF	Kroupa (2001)
m_{min} ($M_\odot$)	0.1
m_{max} ($M_\odot$)	150
Z ($Z_\odot$)	0.01, 0.1, 1
t_{max} (Myr)	100
f_{PB}	0.1

Outcomes

BH-BH population

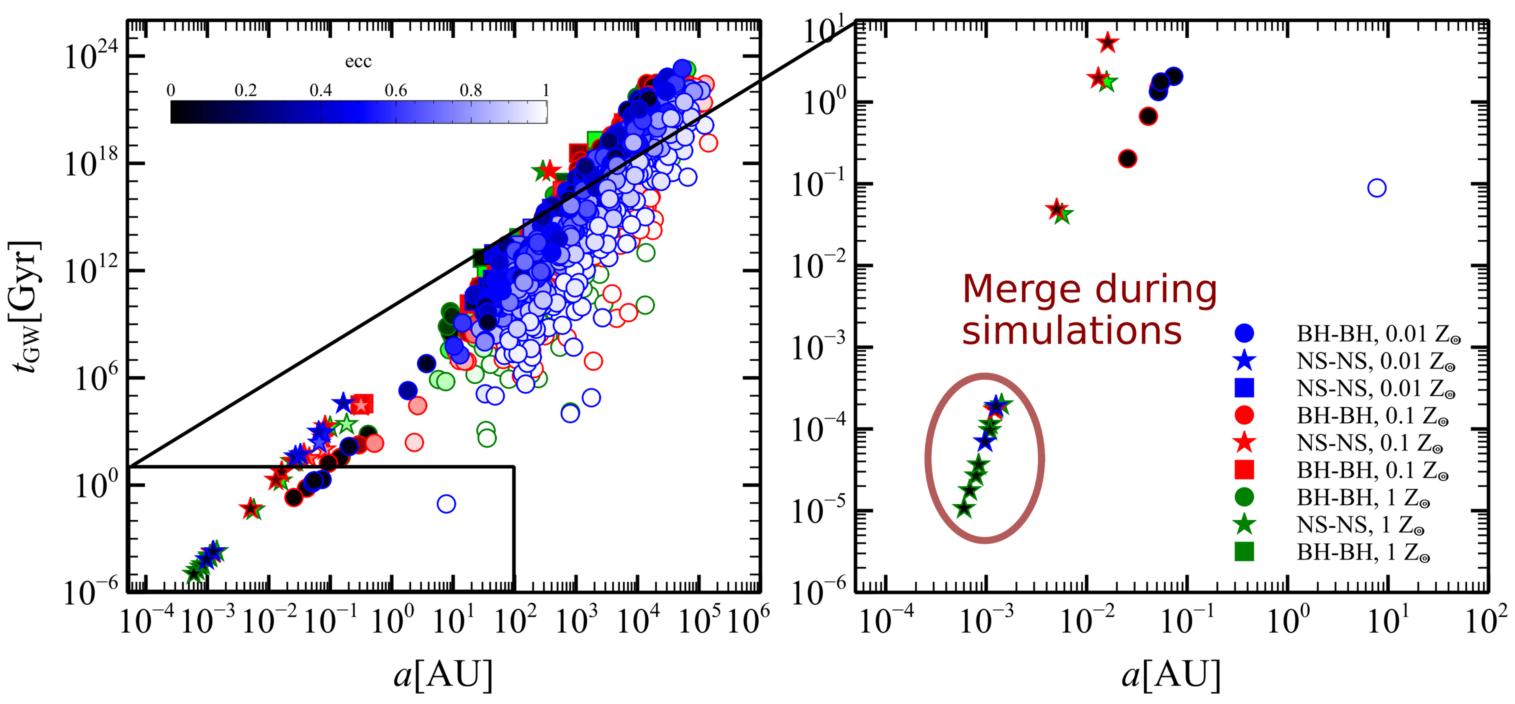


- 10 times more BH-BH than NS-NS thanks to dynamics
- Low-Z case builds up the DBH population before high-Z case
- At low-Z higher BH masses allowed: earlier BH-BH binaries formation



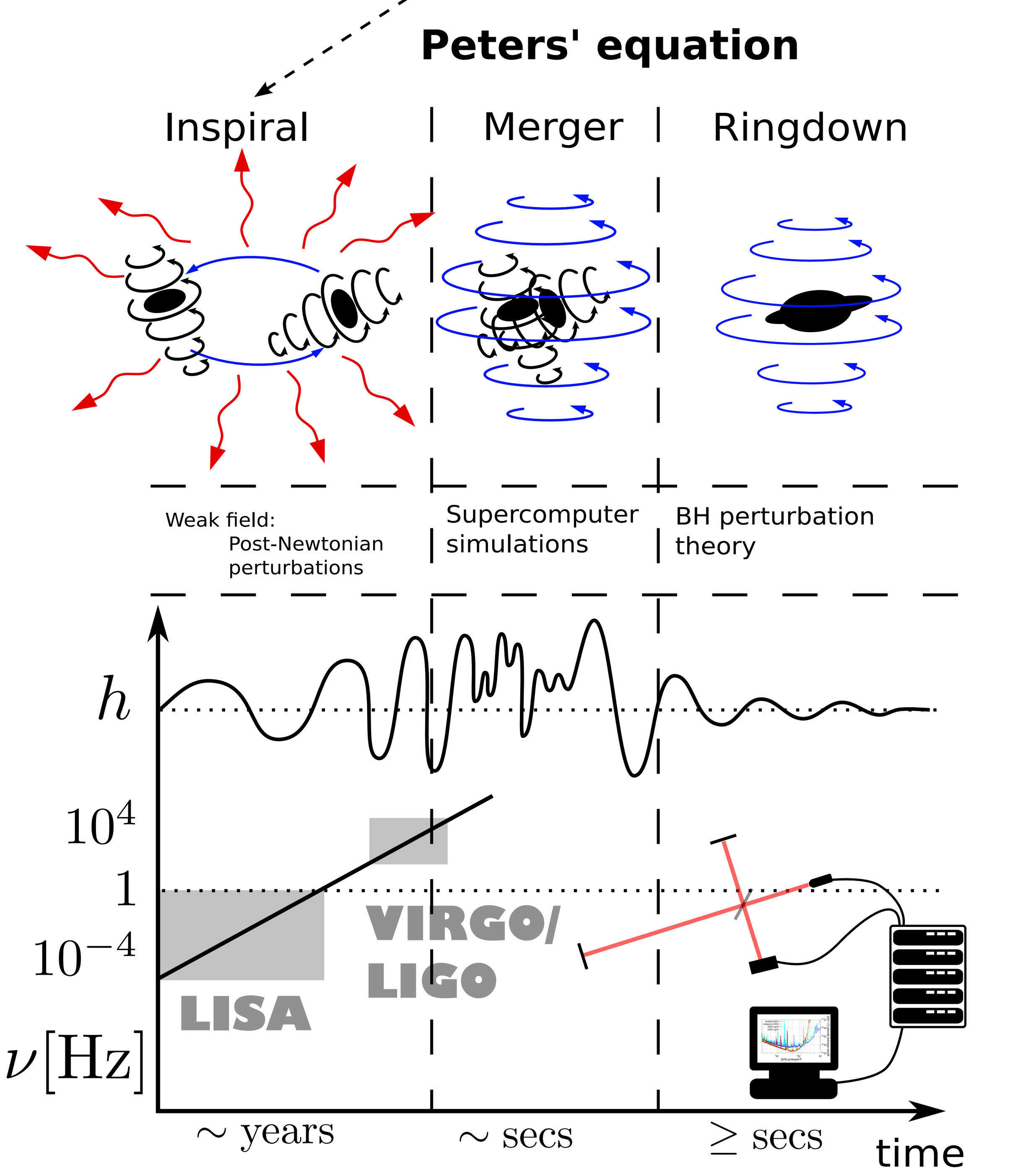
Orbital properties

- Distribution of orbital parameters is critical for coalescence times and mergers detection.
- NS-NS are 10 times less numerous but have small semi-major axes (SMAs) and short periods
- This is a selection effect against ionization by natal kicks and exchanges with more massive BHs.



Coalescence times

- Time to reach SMA=0 considering only GW emission
- Computed using Peters' equations
- 7 DBHs with t_{GW} < 13 Gyr (0 for Z=$Z_\odot$)
- 17 DNSs with t_{GW} < 13Gyr
- 11 DNS mergers during the simulations

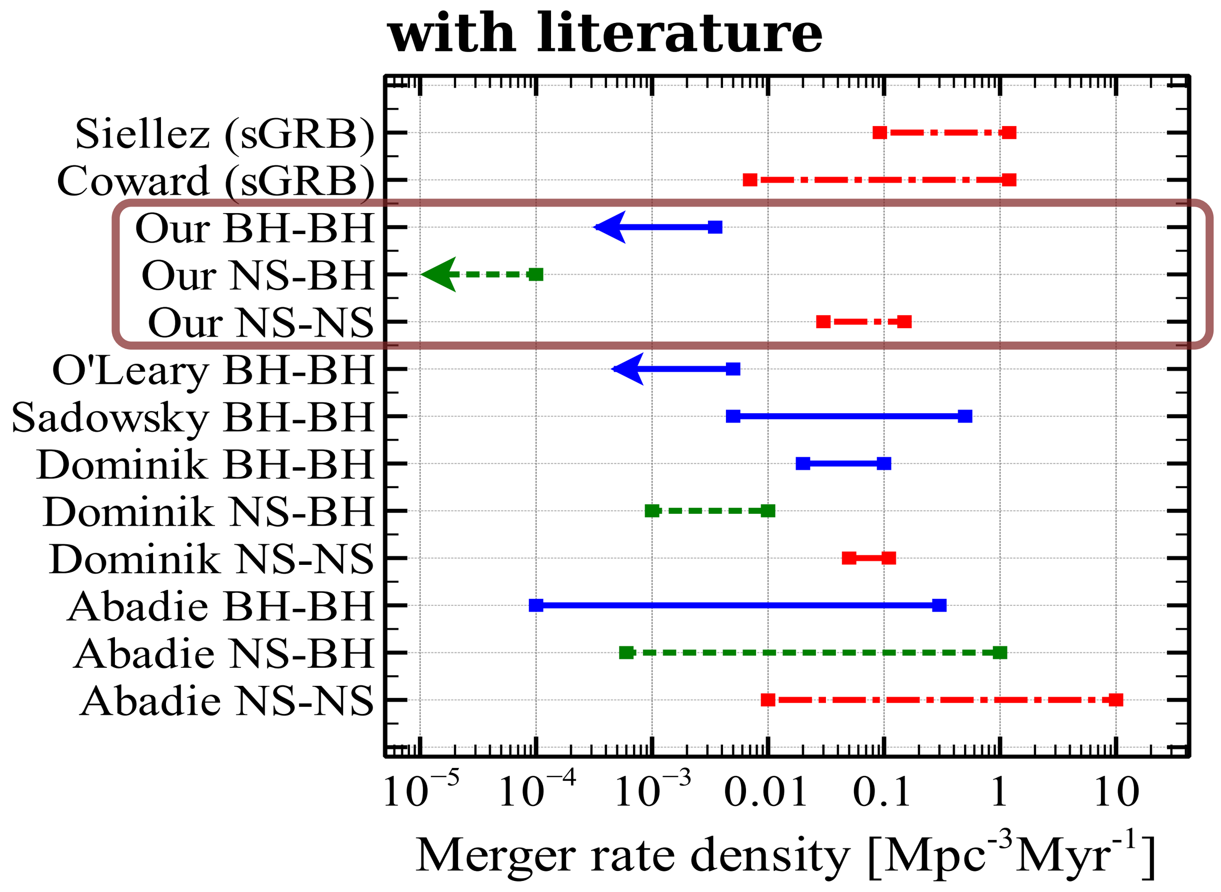


Conclusions

Metallicity is important:
- Heavier BHs form at low Z
- They tend to form BH-BH binaries at early times
- These binaries are more stable

Dynamics is important:
- It enhances the formation of DCOBs: 97% of BH-BH binaries come from exchanges
- It hardens binaries and can modify the eccentricity

Our final rates compared with literature



Bibliography

- Ziosi et al., 2014, arxiv.org/abs/1404.7147
- Mapelli et al. 2013, MNRAS, 429, 2298
- Portegies Zwart et al. 2001, MNRAS, 321, 199
- Abadie et al., 2010, CQG, 27, 173001
- Hurley et al., 2000, MNRAS 315, 543
- Fryer et al., 2012, ApJ, 749, 91
- Vink et al., 2001, A&A, 369, 574

1-Università degli studi di Padova, 2-INAF-Osservatorio Astronomico di Padova, 3-Università degli studi di Urbino "Carlo Bo", 4-INAF-Osservatorio Astronomico di Roma, 5-INFN, Sezione di Firenze, I-50019 Sesto Fiorentino, Firenze, Italy