Mass evolution of black hole progenitors

Implications for the formation of gravitational wave sources

Amedeo Romagnolo
Nicolaus Copernicus Astronomical Center, of the Polish Academy of Sciences
European Southern Observatory, Garching bei Munchen, Germany

Supervisors:
Tomasz Bulik
Jakub Klencki

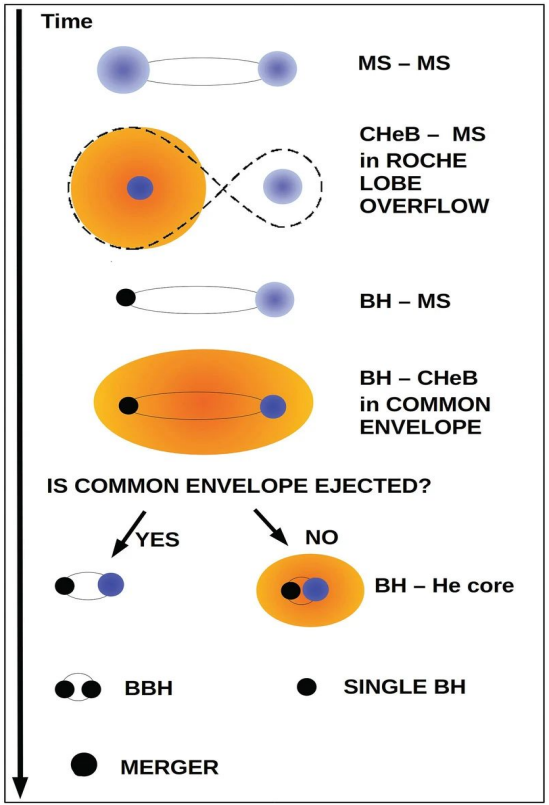
CAMK Annual Meeting - 2024

How do we get to close binary black-holes?

- Isolated binaries
- A star expands beyond its Roche lobe
- **Mass exchange/loss change the binary architecture**

- Common envelope: mass exchange/loss + friction
- Donor's binding energy vs binary's orbital energy

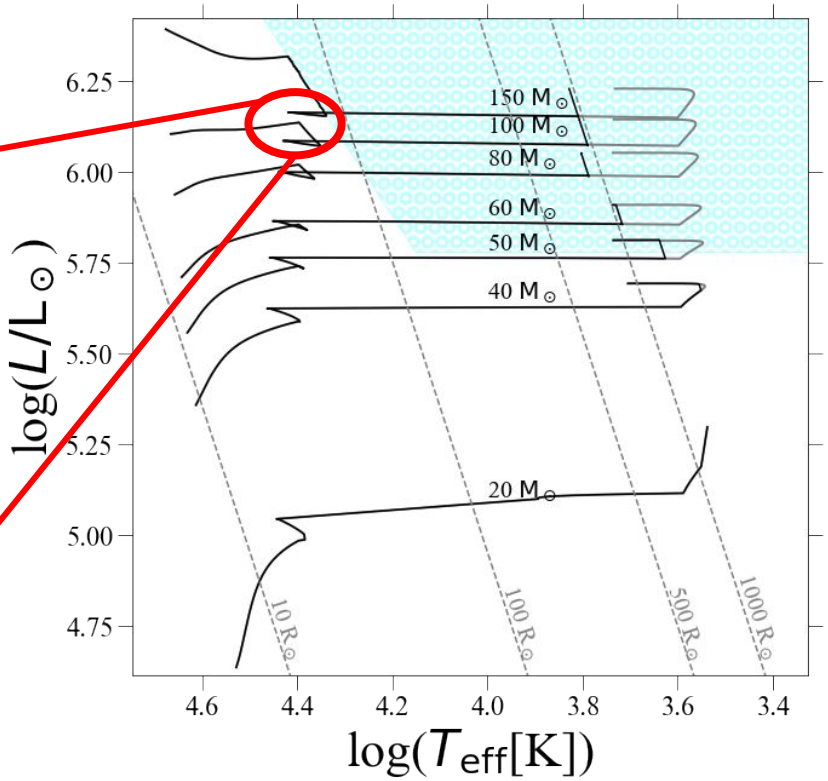
We use 1D models [MESA] and Hurley et al. (2000) equations for population estimates [StarTrack (Belczynski+ 2002, 2008)]



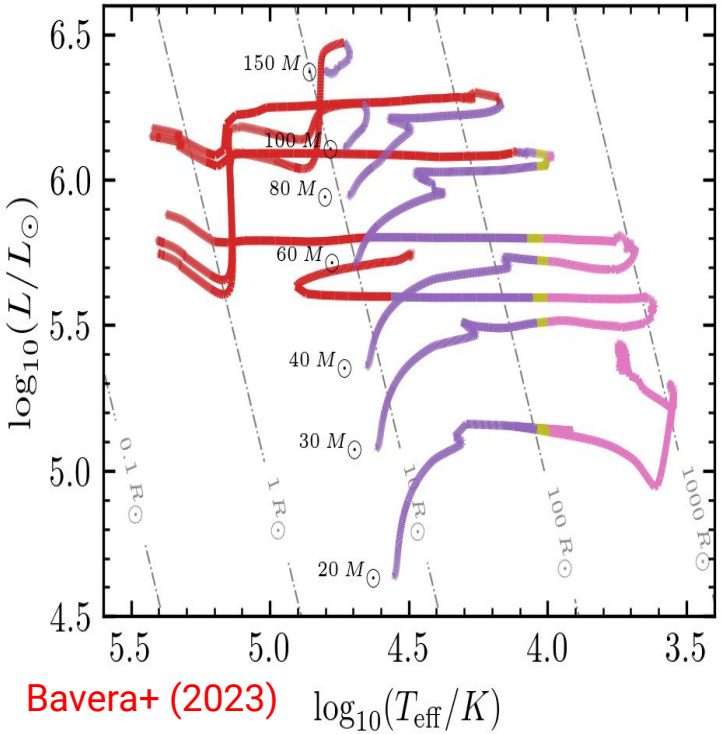
M. Mapelli (2021)

How our models tackle the problem of the HD-limit?

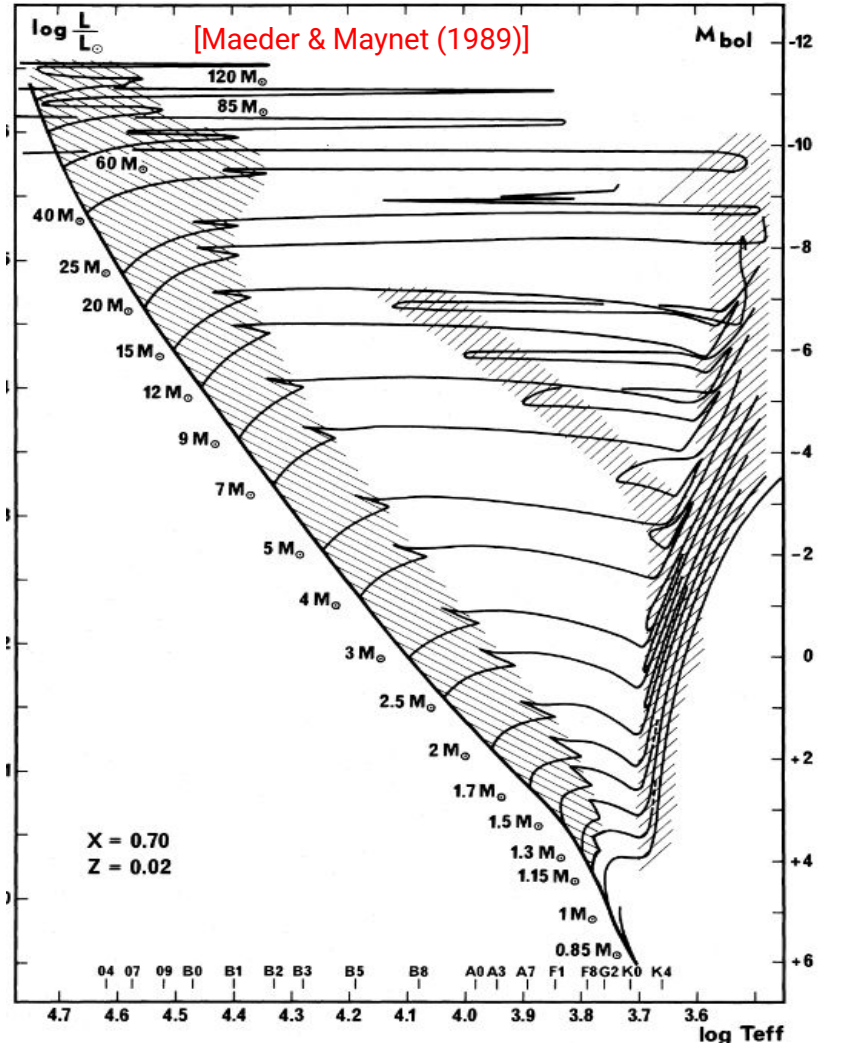
- 100% artefact
- Here there should be Wolf-Rayet stars already
- Many population synthesis models work this way



What we get from stellar evolution?



Bavera+ (2023)



1D models are unfortunately used as blackboxes

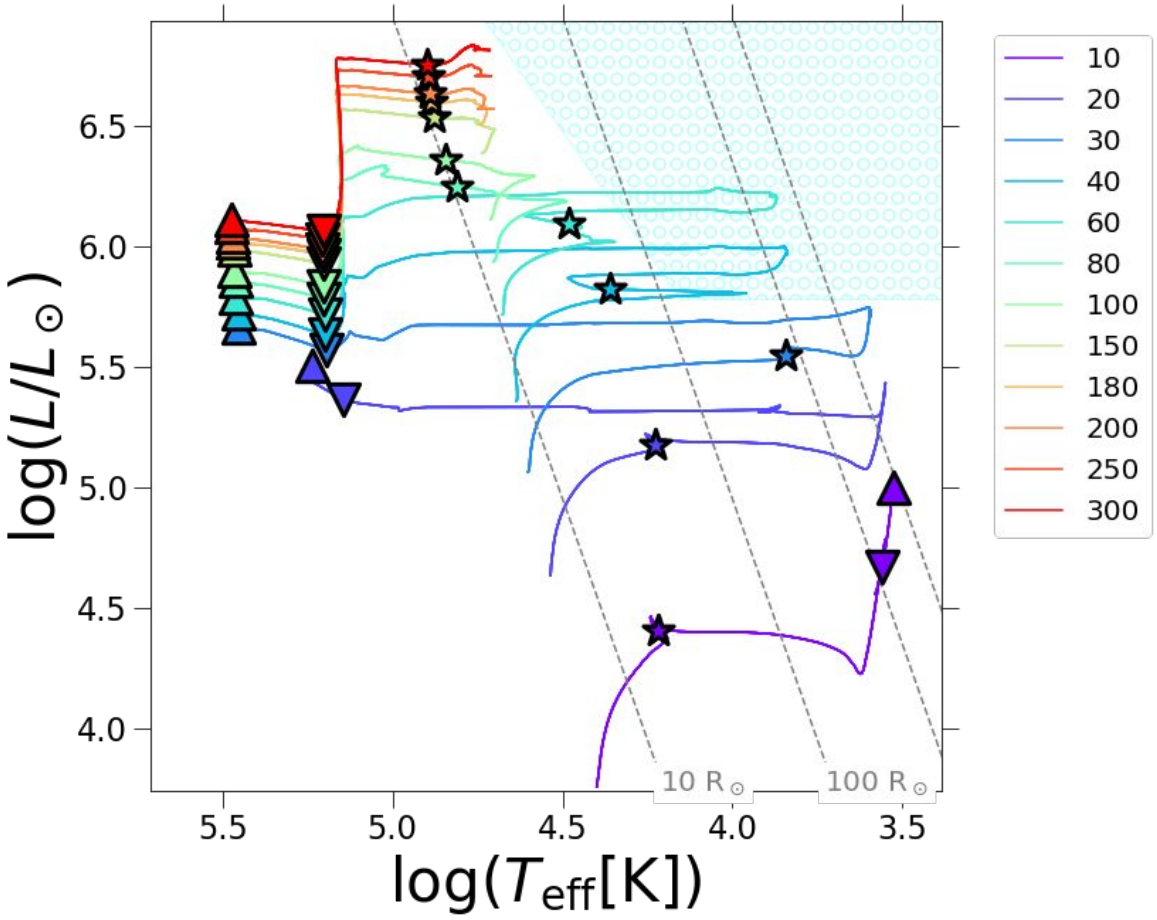
- Usually outdated models for stellar exteriors → **STELLAR WINDS**
- Many don't want to do rotating stars

What we brought

- Updated self-consistent stellar winds prescriptions in MESA (implementation in StarTrack in progress)
- More accurate prescription for internal transport of chemical elements and angular momentum

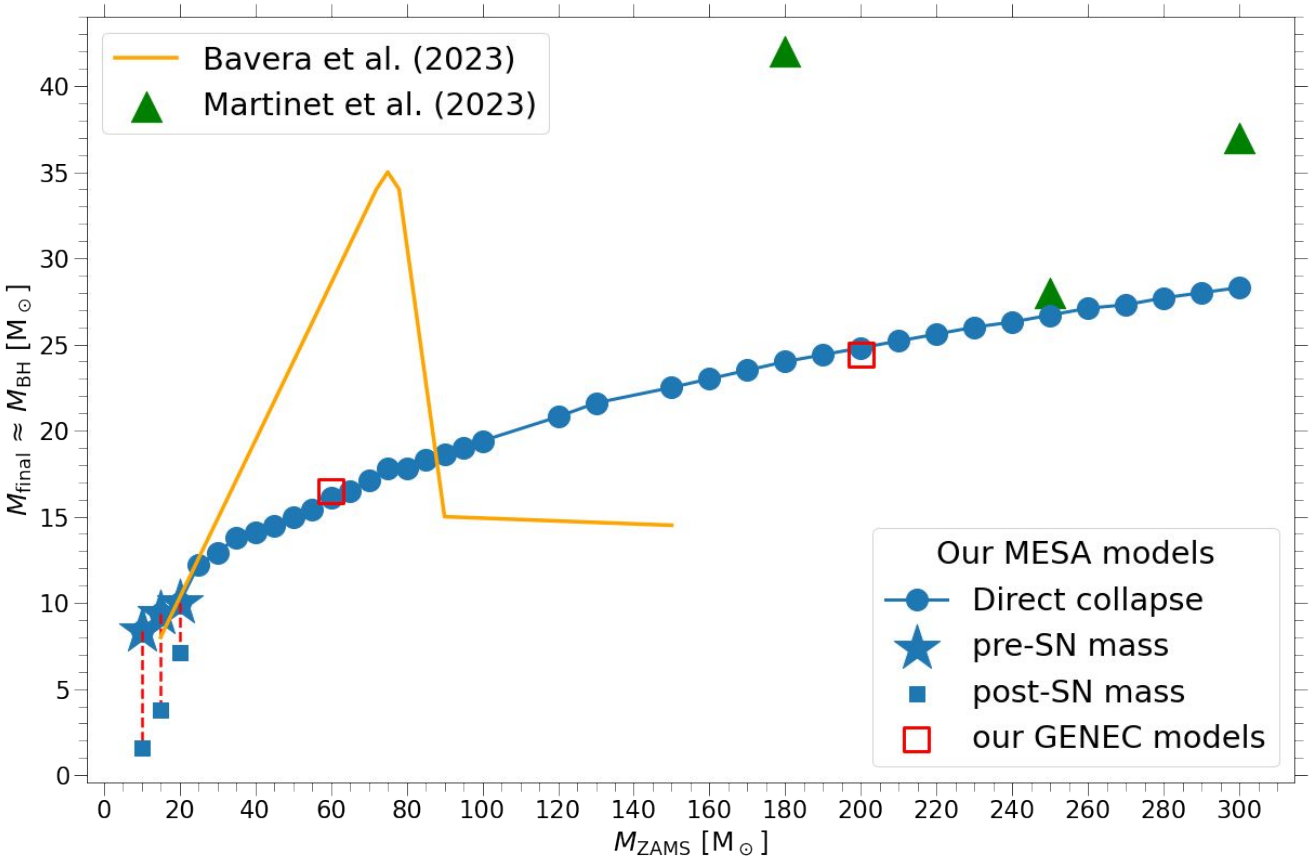
RESULT #1

At $Z_{\odot}$ almost all BH progenitors evolve into helium stars first



RESULT #2

At $Z_{\odot}$ we predict the BH mass to grow monotonically with the initial mass of the progenitor



During last year

5 months research ESO Garching

TALKS

- Kavli IPMU, Tokyo
- Max Planck Institute for Astrophysics
- EAS 2023
- KU Leuven
- ESO (x2)

POSTERS

- ESO

PAPERS - First Author

- The role of stellar expansion on the formation of gravitational wave sources, 2023MNRAS.525..706R
- On the maximum black hole mass at solar metallicity (submitted to ApJL)

PAPERS - Second author: 4 in progress

OTHERS

- Reviewer for MNRAS and A&A
- Teaching assistant at MESA summer school
- Orbyts project for high schools

RESULT #3

Generally at high metallicities wind-driven mass loss trumps internal mixing for M_{BH}