Binary stars and related mysteries....

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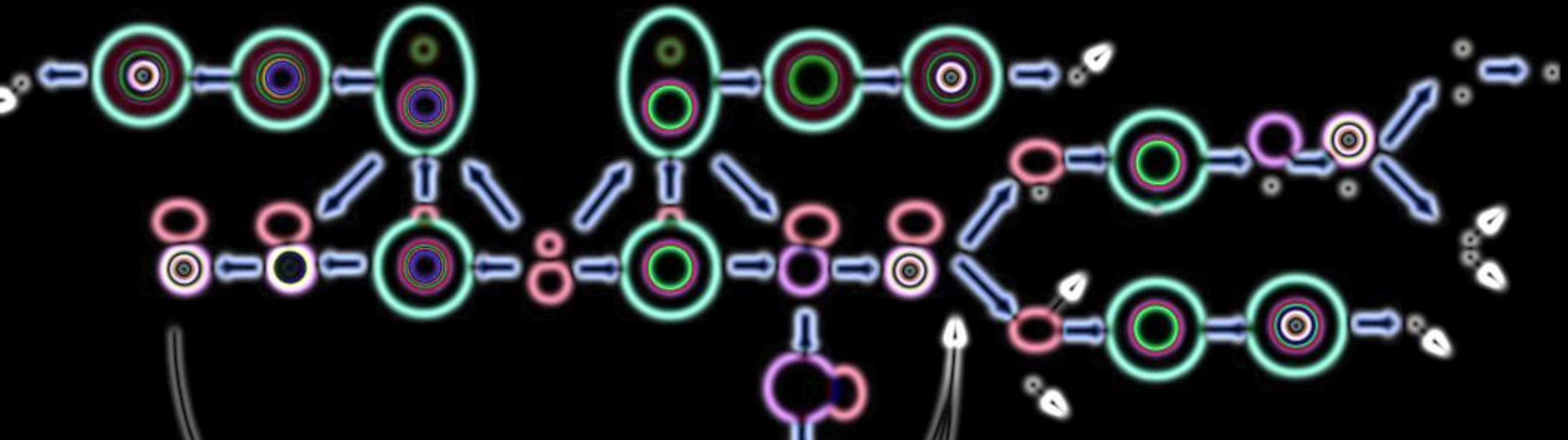
Ebraheem Farag, Sohan Ghodla, Ryosuke Hirai



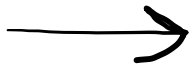
A little binary history….

- Bohdan Paczyński did everything in the 70-80s on binaries.
- Everyone forgot this, a weird situation occurred:
  - For low mass stars and type Ia supernovae binaries were important.
  - For massive stars all were single stars and stellar winds and rotation only important.
- The people like Dany Vanbeveren started reminding everyone about binaries from 90s onwards.
- Then in 2000s with Elizabeth Stanway, I started making binary models with STARS code to do population and spectral synthesis. We found that same thing but made models publicly available. Basically, we showed that binaries improve agreement with observations for everything!
- Binary important sealed in 2012 thanks for Sana, de Mink et al. (2012, Science).
- Since GW150914 everyone wants to work on binaries….
- To learn more see:
  de Marco & Izzard (2017, PASA) and Eldridge, Stanway et al. (2017, PASA).

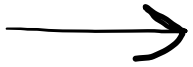
BEC
IBIS
SCENARIO_MACHINE
PARSEC
FRANEC
BRUSSELS
BRUSSELS POP SYNTH
TRILEGAL
BASTI
COMBINE
SEVN
STARBUST99
METISSE
MINT
INTERPOLATORS LAKE
GENEC
COMPAS
STARTRACK
COSMIC
FORESTS
OF UNNAMED CODES
BSELEVELC
POSYDON
BINARY_C
MOBSE
BSEEMP
THE BSE ISLAND
BPASS
MESA
SEBA
STARS
BINARY EVOLUTION VALLEY
STELLAR EVOLUTION MOUNTAINS
Credit: Giuliano Iorio, DEMOBLACK ERC

Let's talk about binary stars...

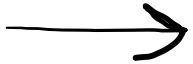
Main sequence star



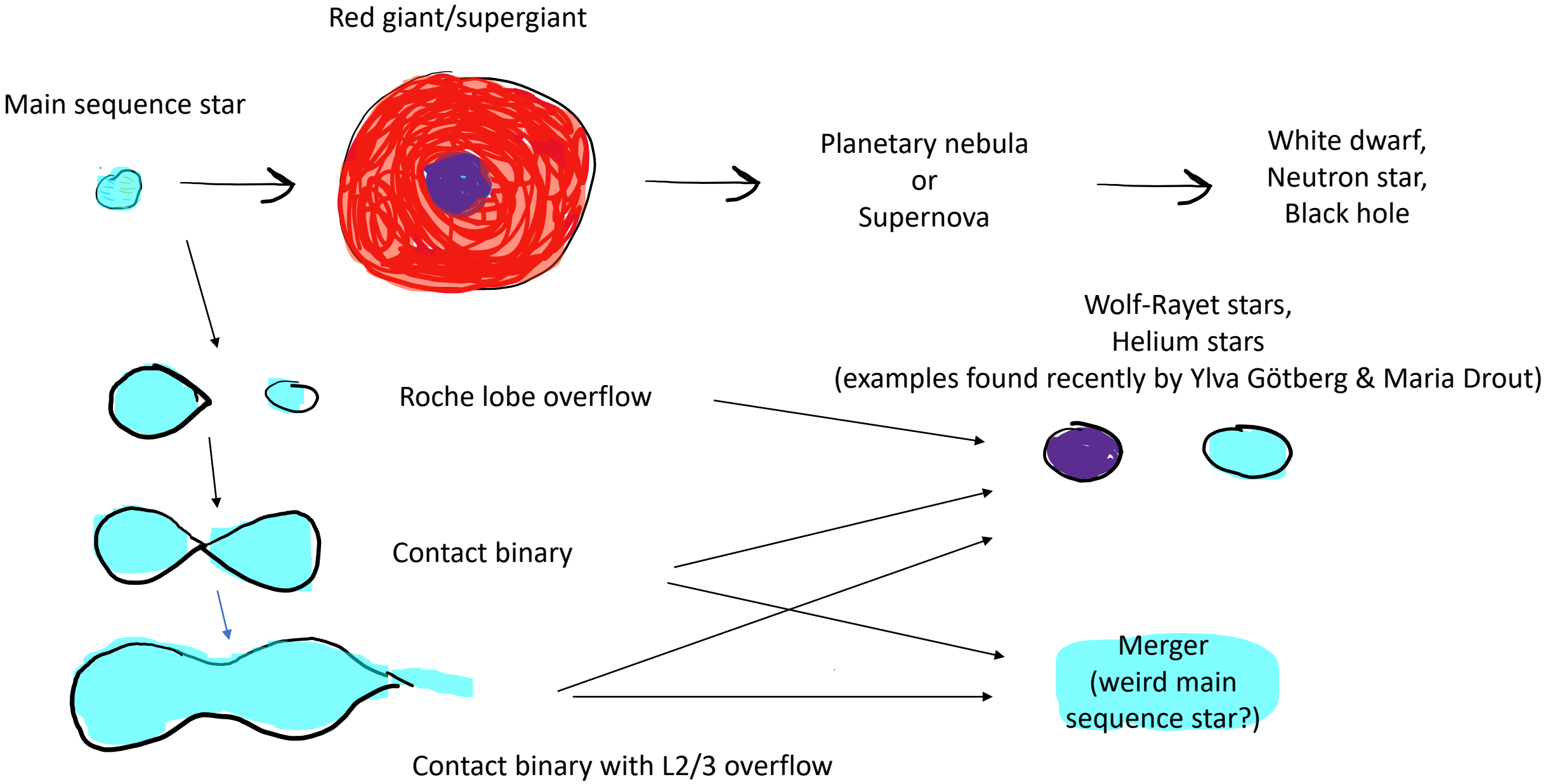
Red giant/supergiant



Planetary nebula
or
Supernova



White dwarf,
Neutron star,
Black hole


Red giant/supergiant
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or
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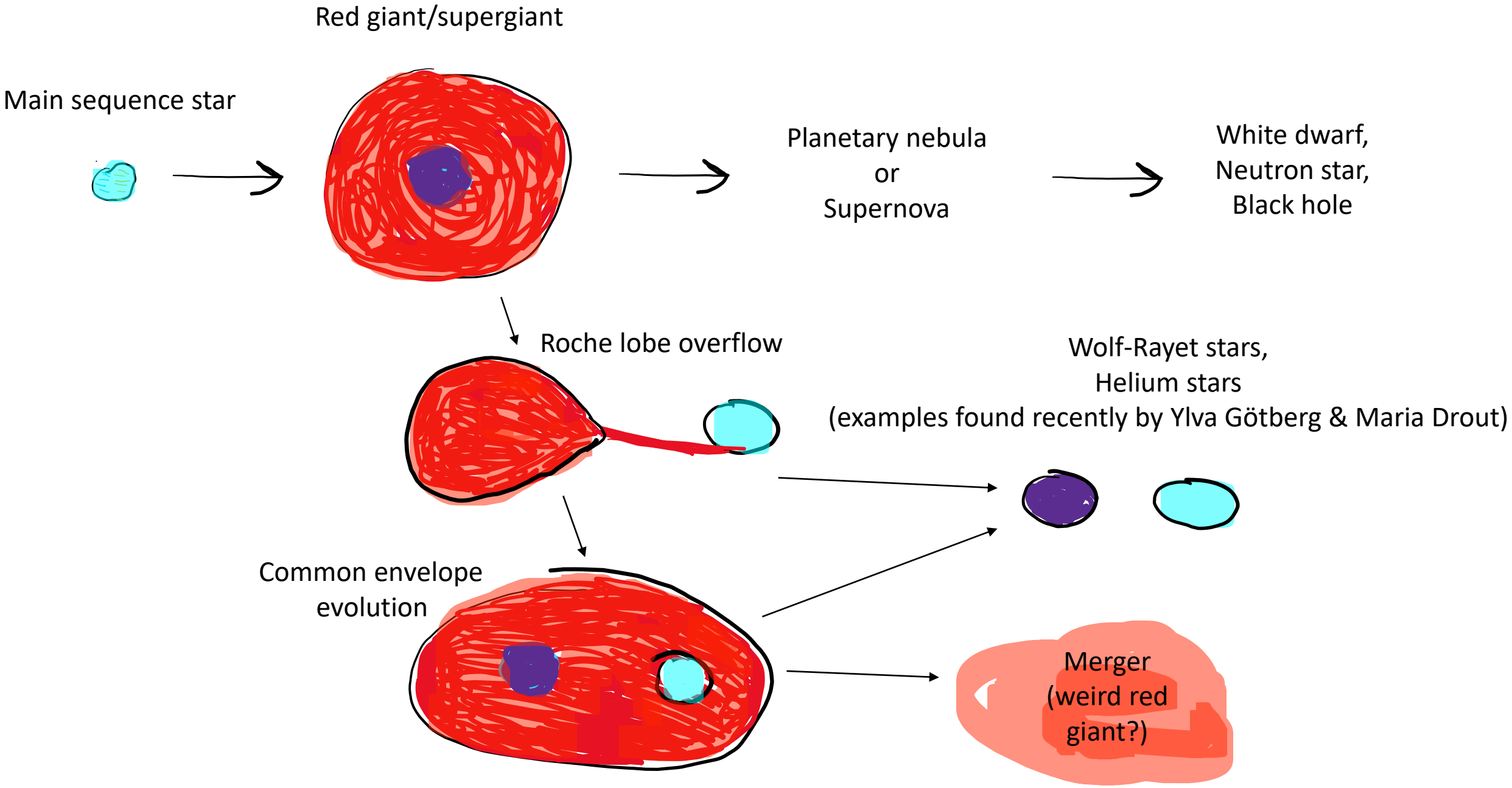
White dwarf,
Neutron star,
Black hole
Wolf-Rayet stars,
Helium stars
(examples found recently by Ylva Götberg & Maria Drout)
Roche lobe overflow
Contact binary
Merger
(weird main
sequence star?)
Contact binary with L2/3 overflow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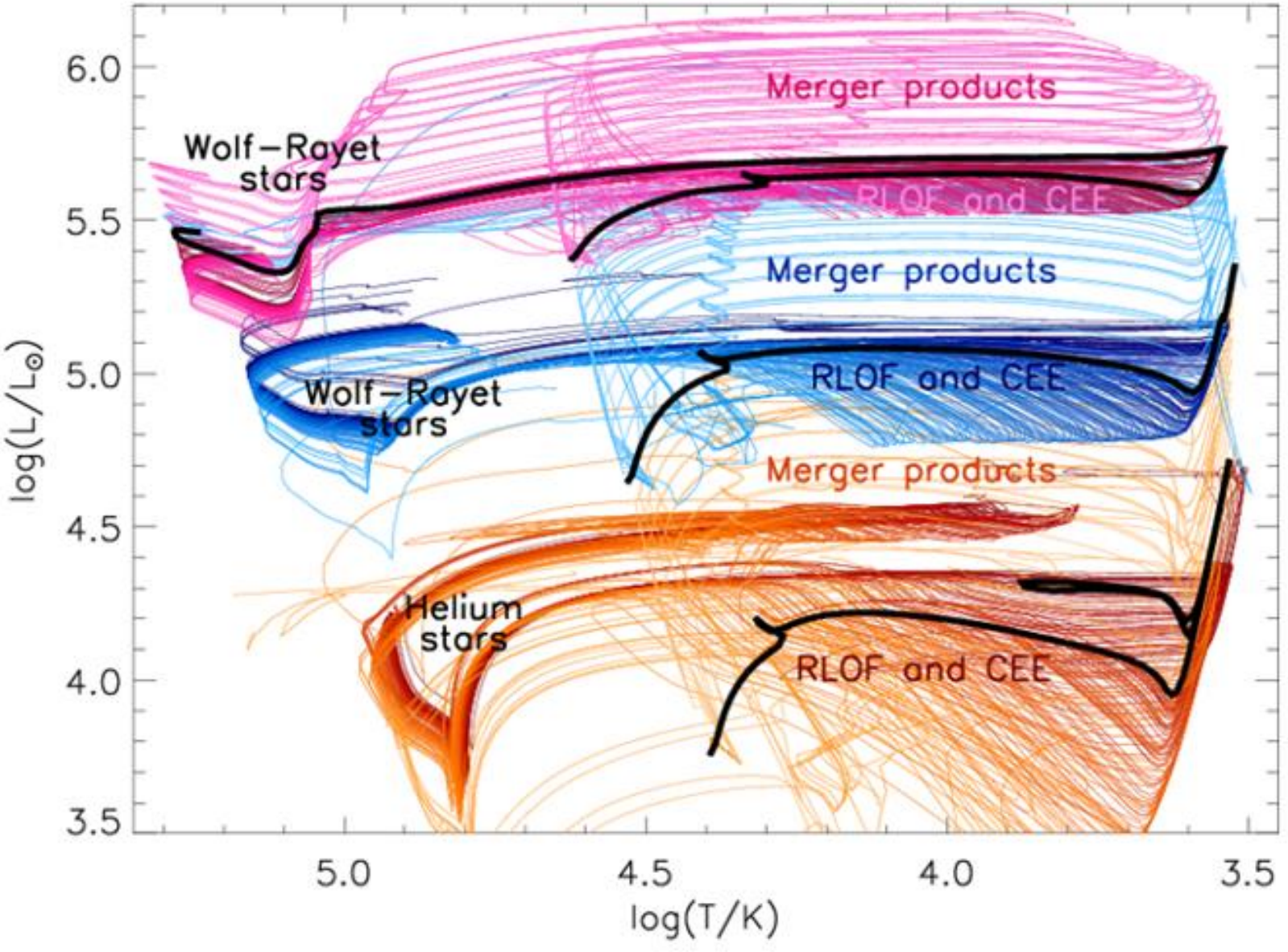
Common envelope
evolution
Merger
(weird red
giant?)

On the HR diagram...



Eldridge (2020).

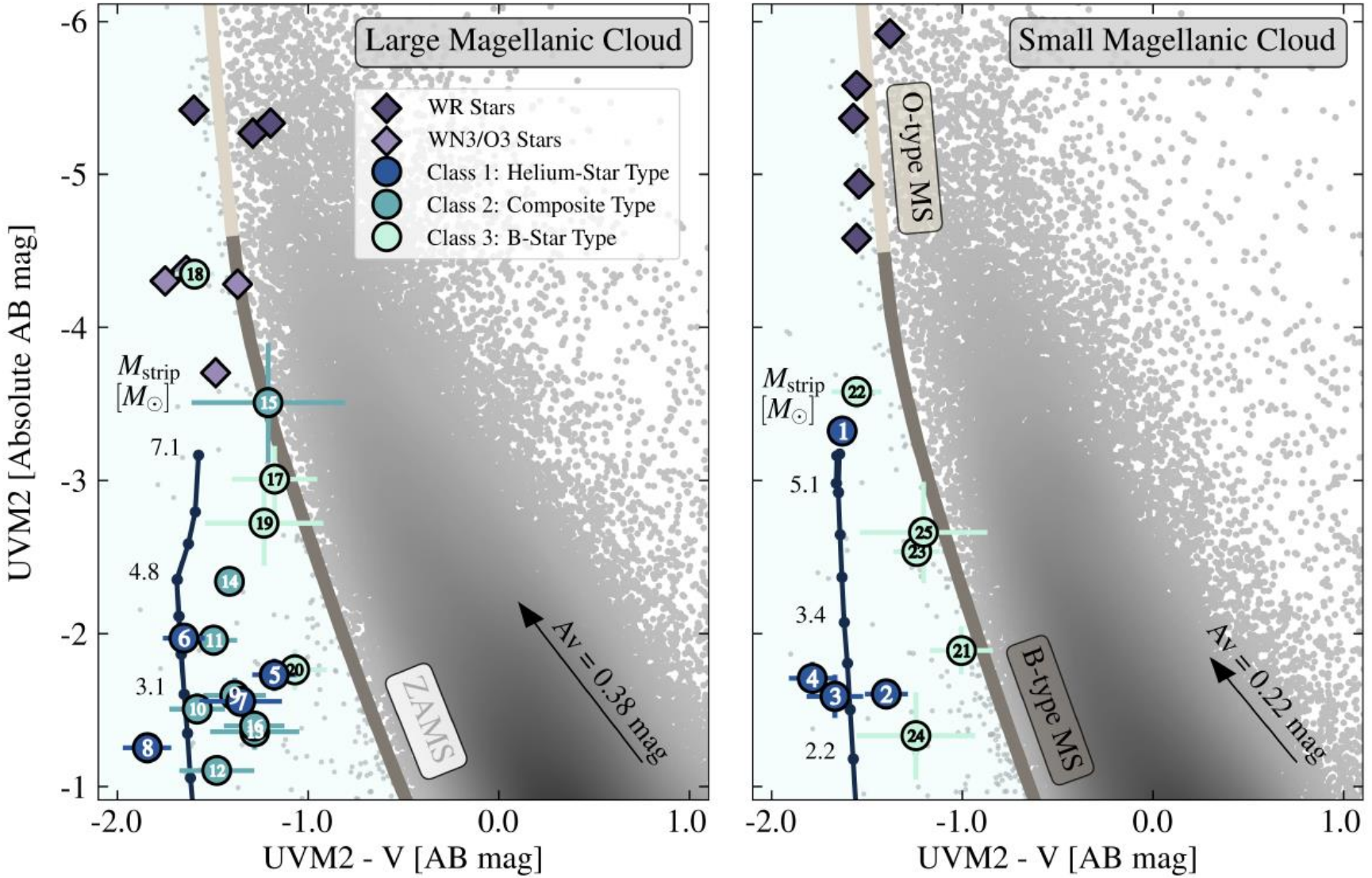
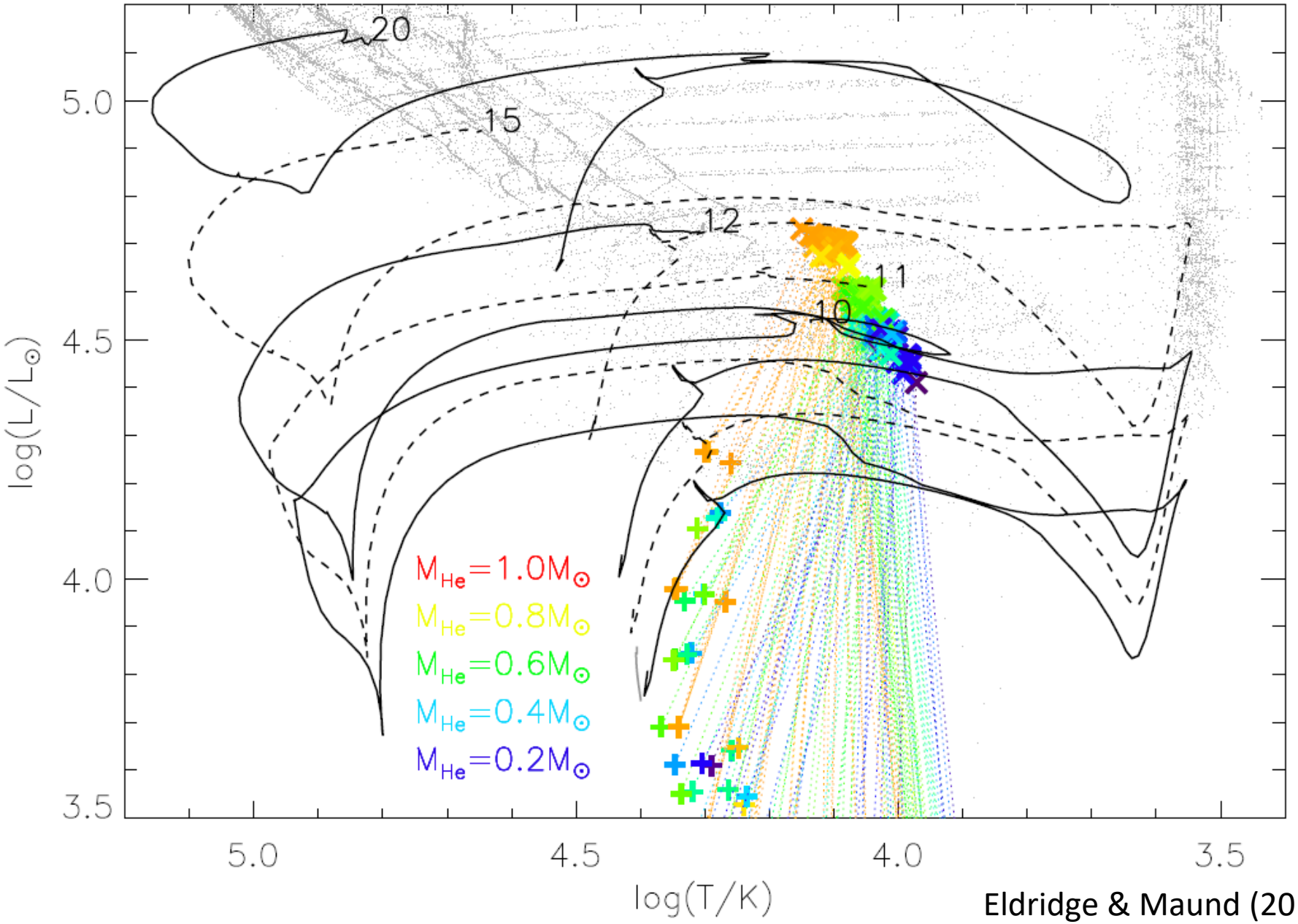


Figure 1: Identification of Candidate Stripped Helium Star Binaries in UV-optical Color-Magnitude Diagrams.

Drout, Götberg et al. (2023, Science)

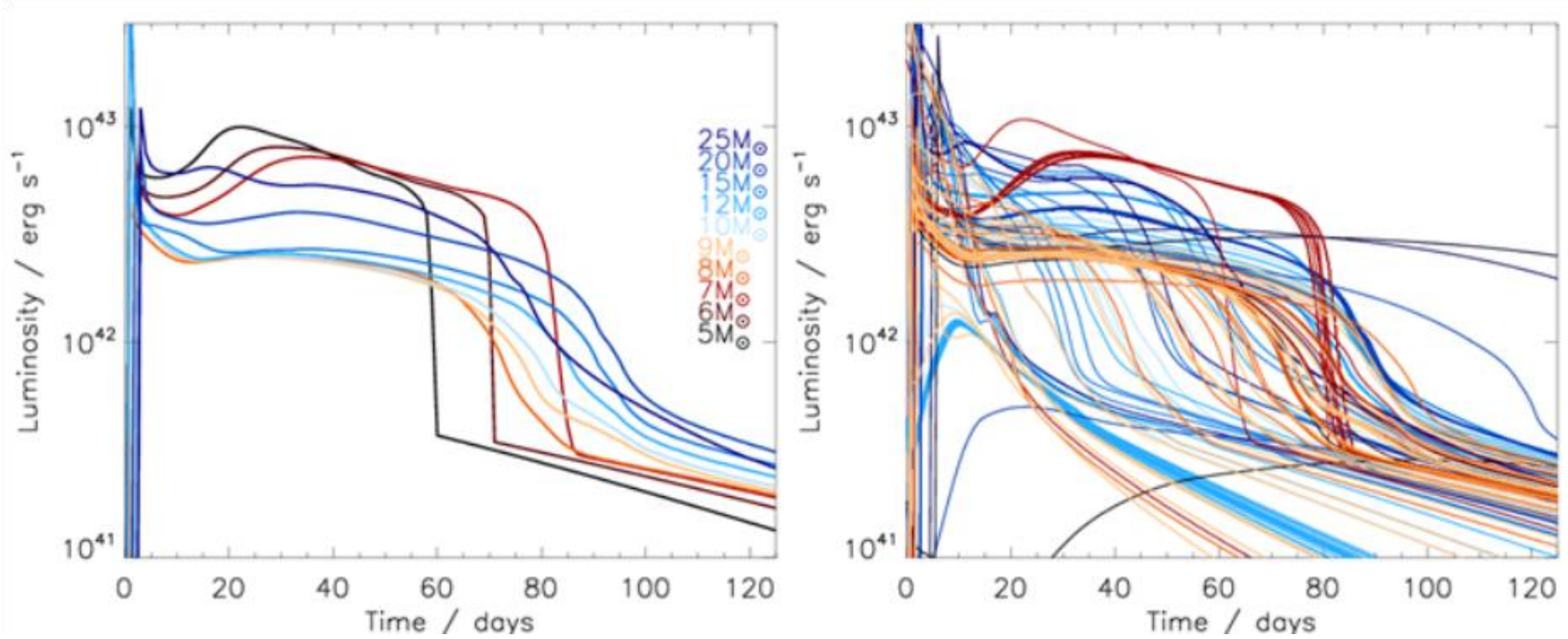
So what do helium stars from binaries do…?

Type Ib SNe
iPTF13bvn

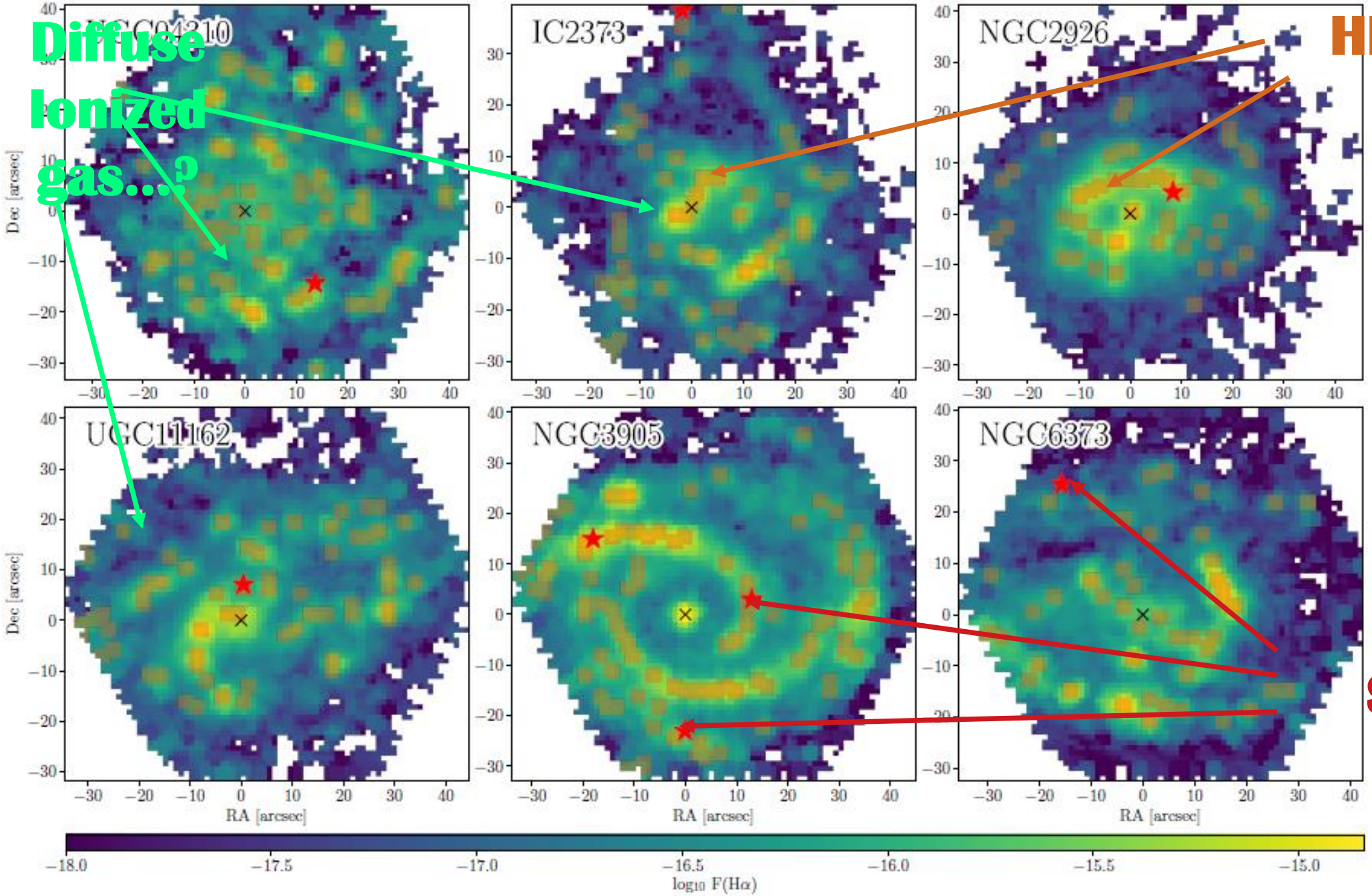


Eldridge & Maund (2016)

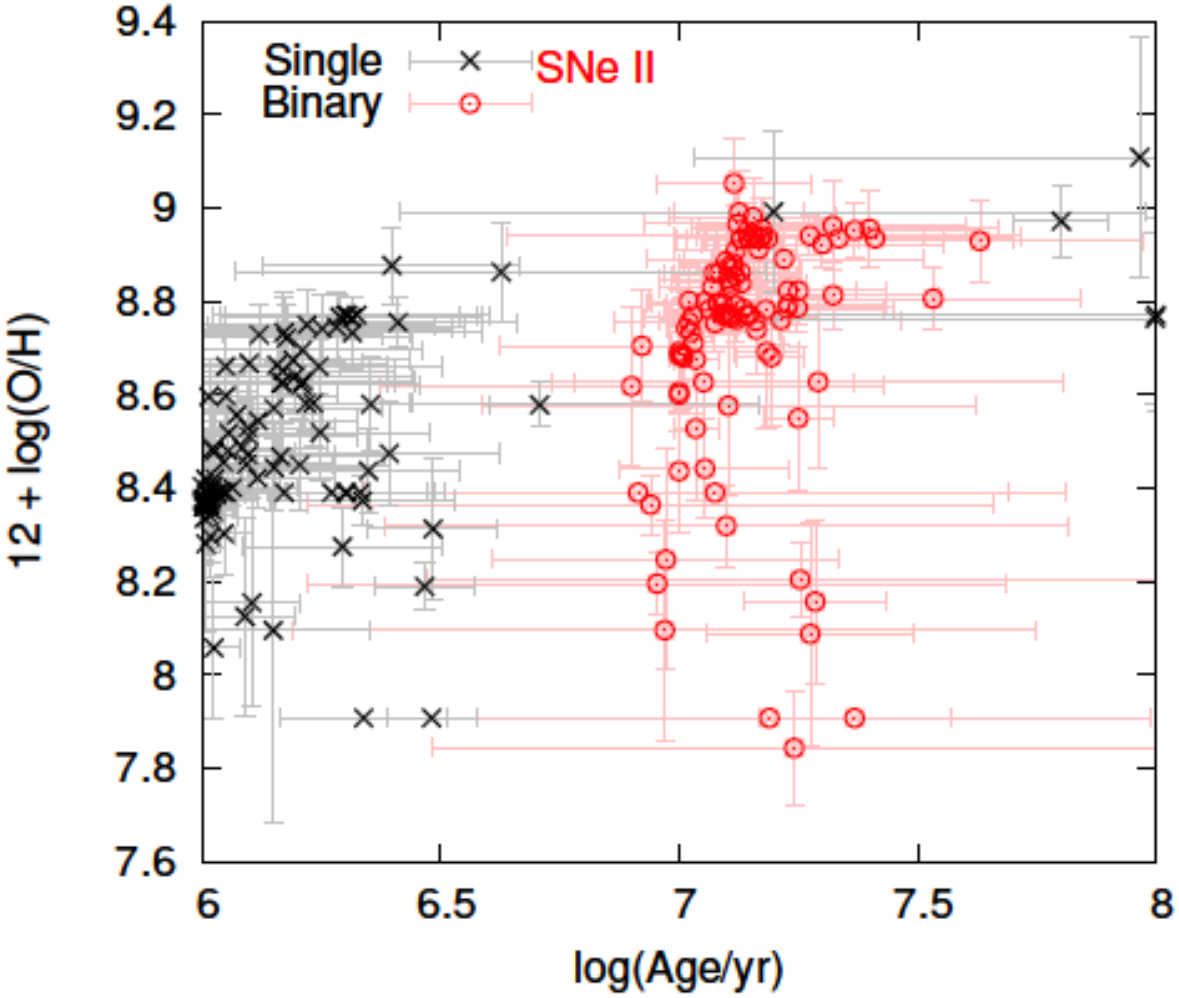
Type II SN lightcruves from interacting binaries

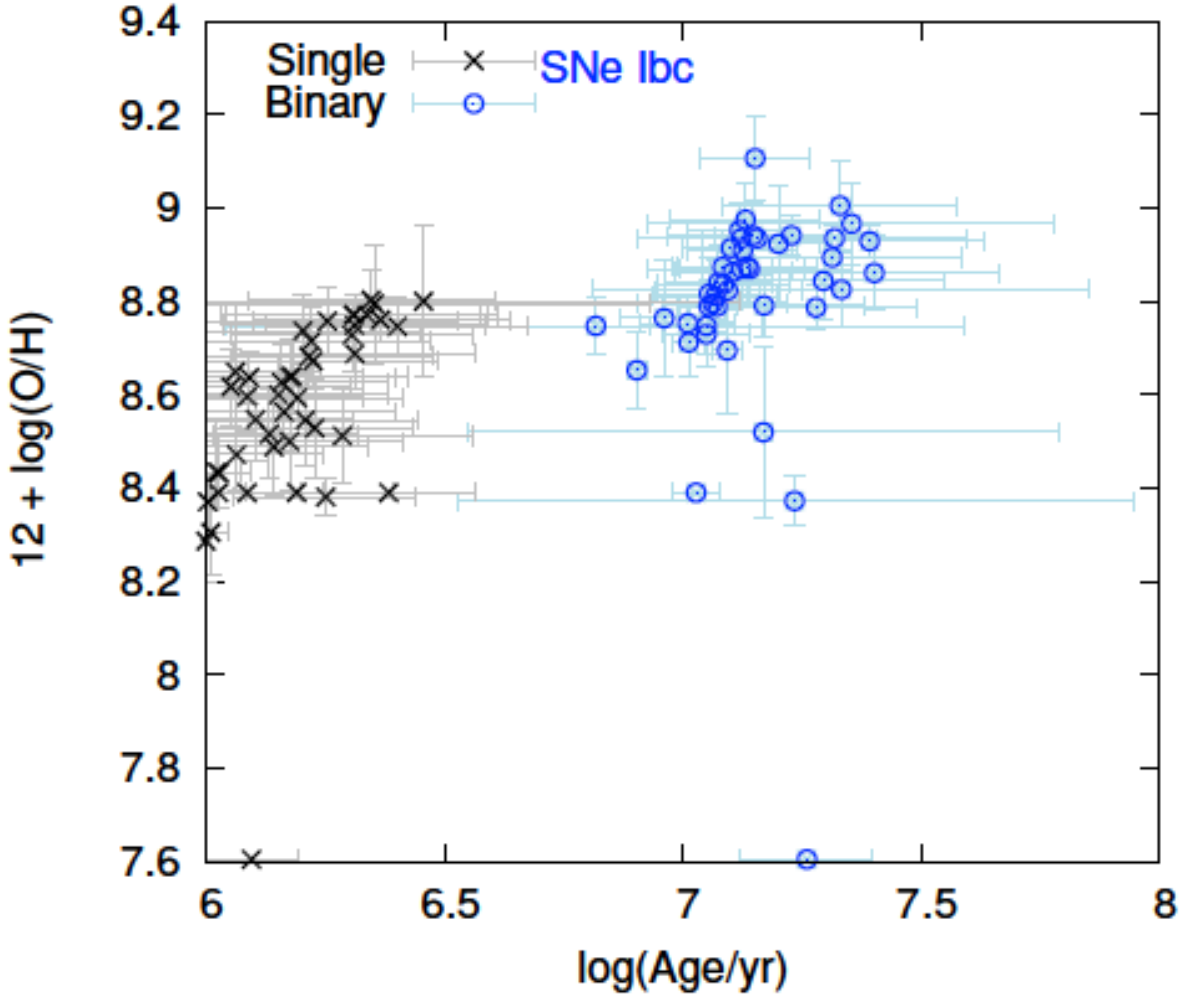


Eldridge et al. (2019, PASA).



Galbany et al. (2018) - “PISCO: The PMAS/PPak Integral-field Supernova Hosts Compilation”.





BPASSv2.1

Xiao et al . (2018, 2019) and see works by Götberg et al. and Zapartus et al..

More things binary stars “do”…?

- Type Ib/c supernovae.
- Produce the ionizing photons for re-ionization.
- Type Ia supernovae.
- Blue stragglers.
- X-ray binaries.
- GW transients (although dynamical formation channels exist).
- Most of the weird objects in the Universe (unless they’re triples)….

LAB 1 – Looking at the Donors!

- Main aim to observed in the models the different evolution the mass loss by Roche lobe overflow.
- Compare a few different models on your tables.
- Remember: before lunch, set both stars evolving in detail to get the accretor model for Lab 2.