Astrophysics of gravitational wave sources

Lecture 7: Pair instability, chemically-homogeneous evolution

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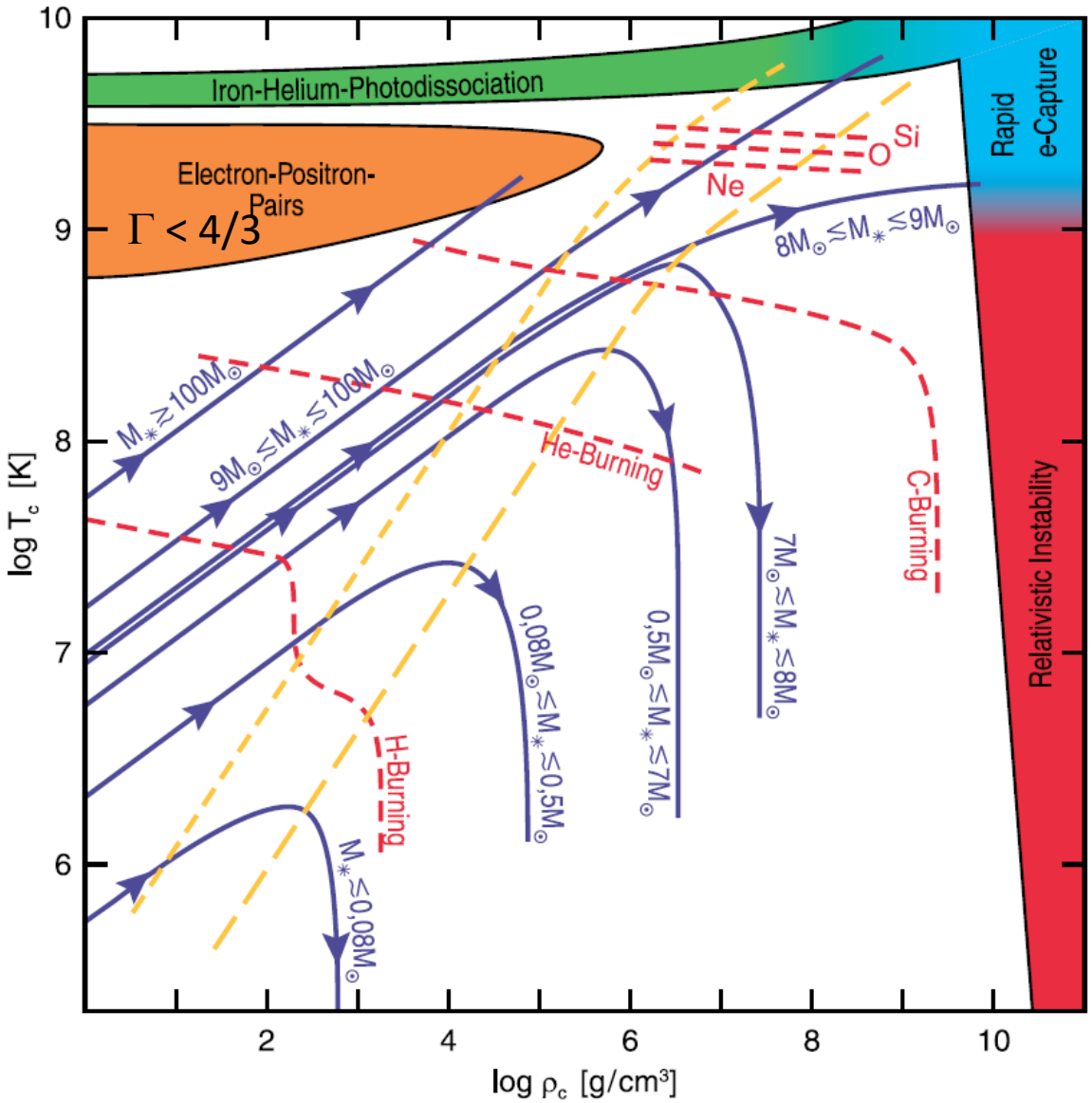
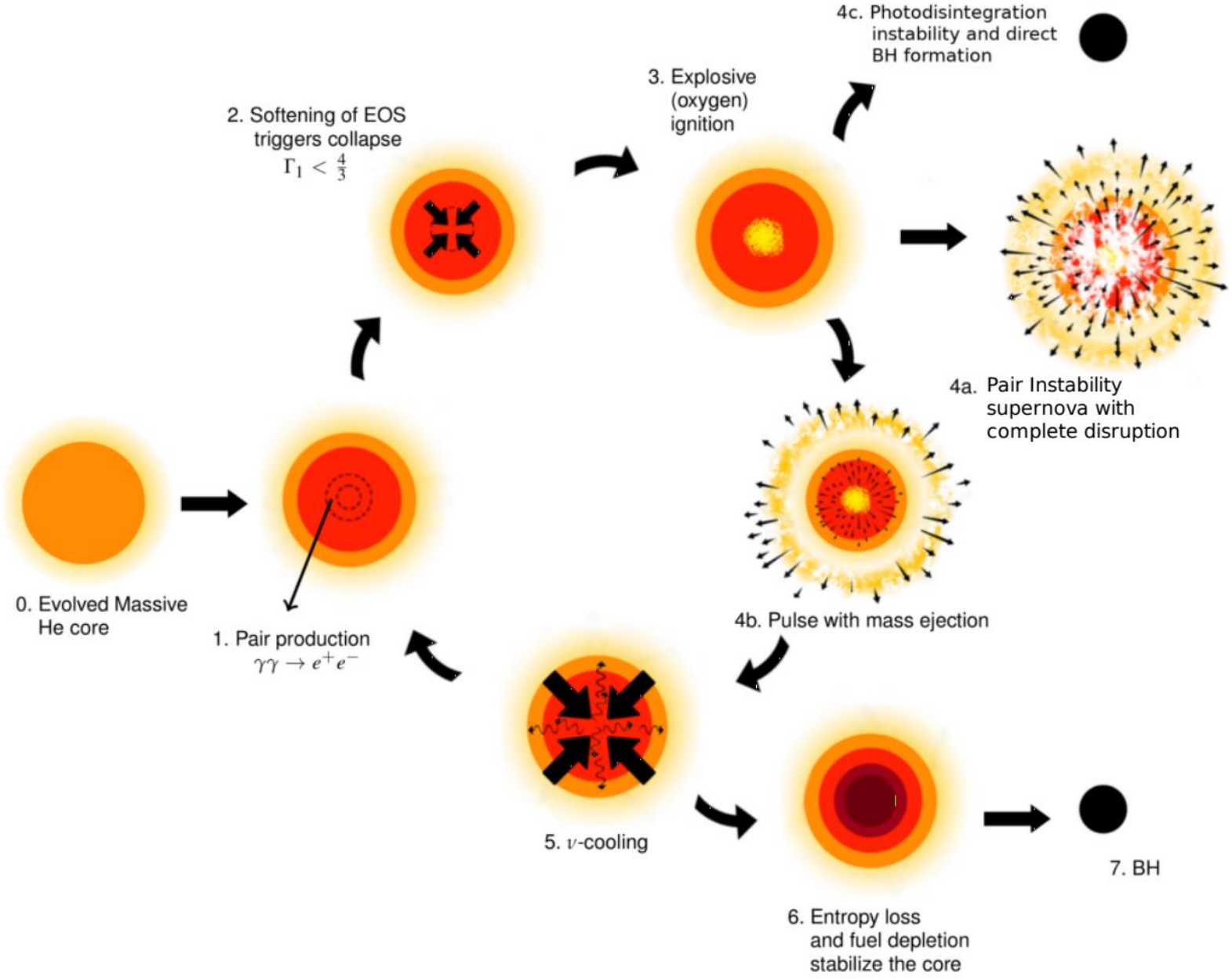
Pair instability



Janka (2012)



Renzo et al. (2020)

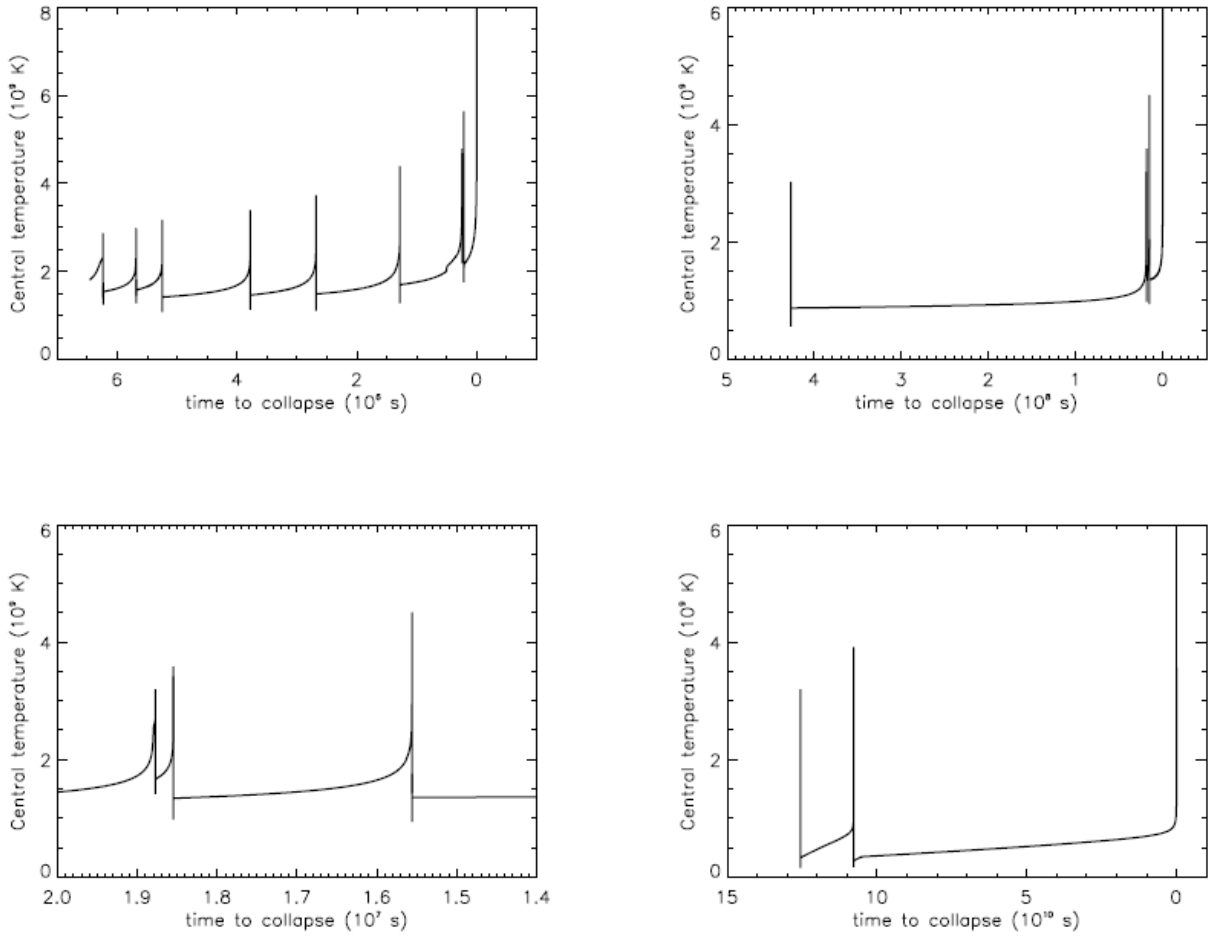


Fig. 2 Pair-driven pulsations cause rapid variations in the central temperature (10^9 K) near the time of death for helium cores of 32, 36, 40, 44, 48, 52 (on two different time scales) and 56 $M_\odot$ (left to right; top to bottom). The log base 10 of the time scales (s) in each panel are respectively 4, 4, 5, 5, 6, 8, 7, and 10. The last rise to high temperature marks the collapse of the iron core to a compact object. More massive cores have fewer, less frequent, but more energetic pulses. All plots begin at central carbon depletion.

Woosley & Heger (2015)

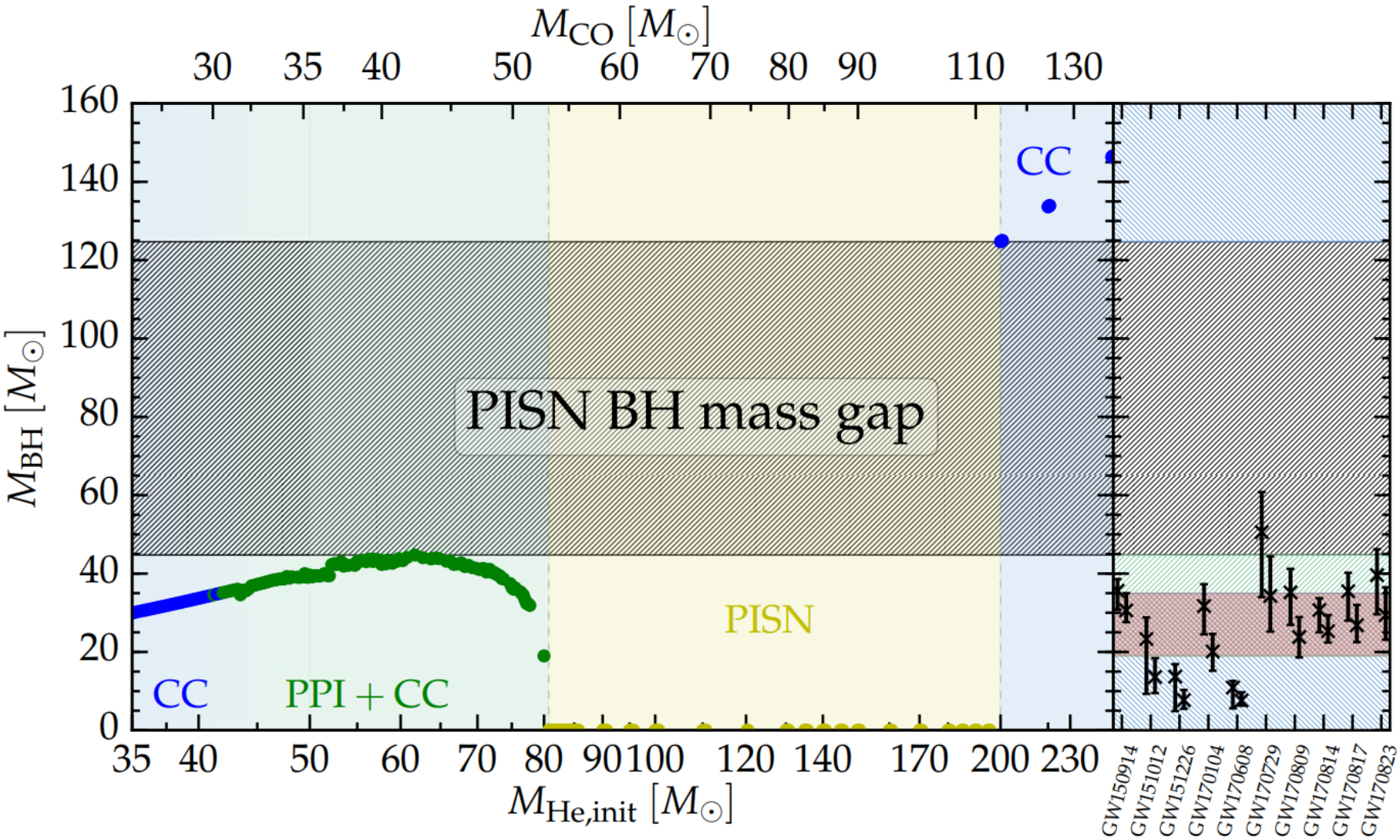


Fig. 2. Final BH masses as a function of the initial He core mass. The scale in the horizontal direction is logarithmic. The colors in the background indicate the approximate range for each evolutionary path, see also Section 3. The right panel shows the masses inferred from the first ten binary BH mergers detected by LIGO/Virgo, with a red shade to emphasize the overlap between PPI and CC, and green and blue hatches to indicate the fate of the progenitor in different BH mass ranges.

Renzo et al. (2020)

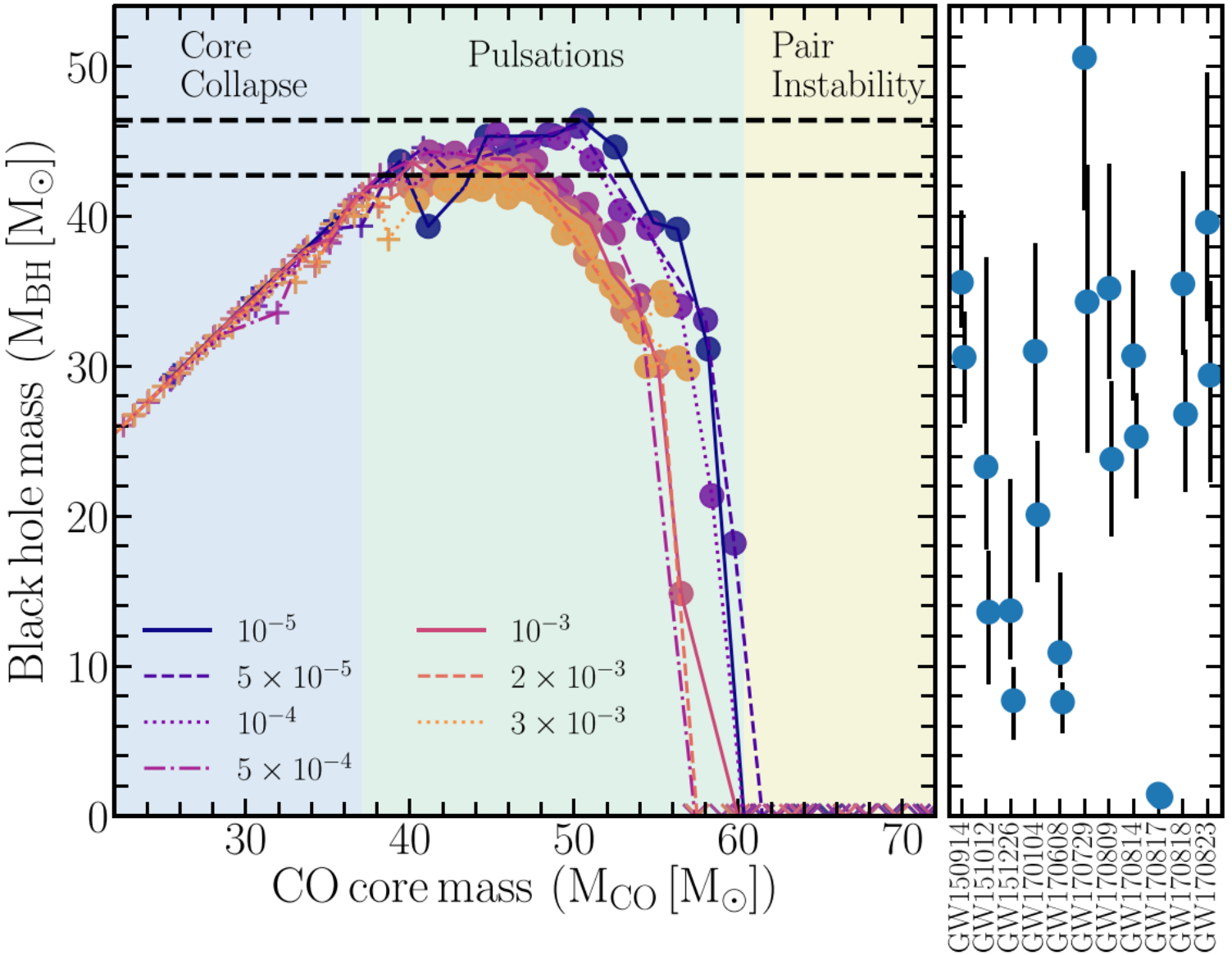


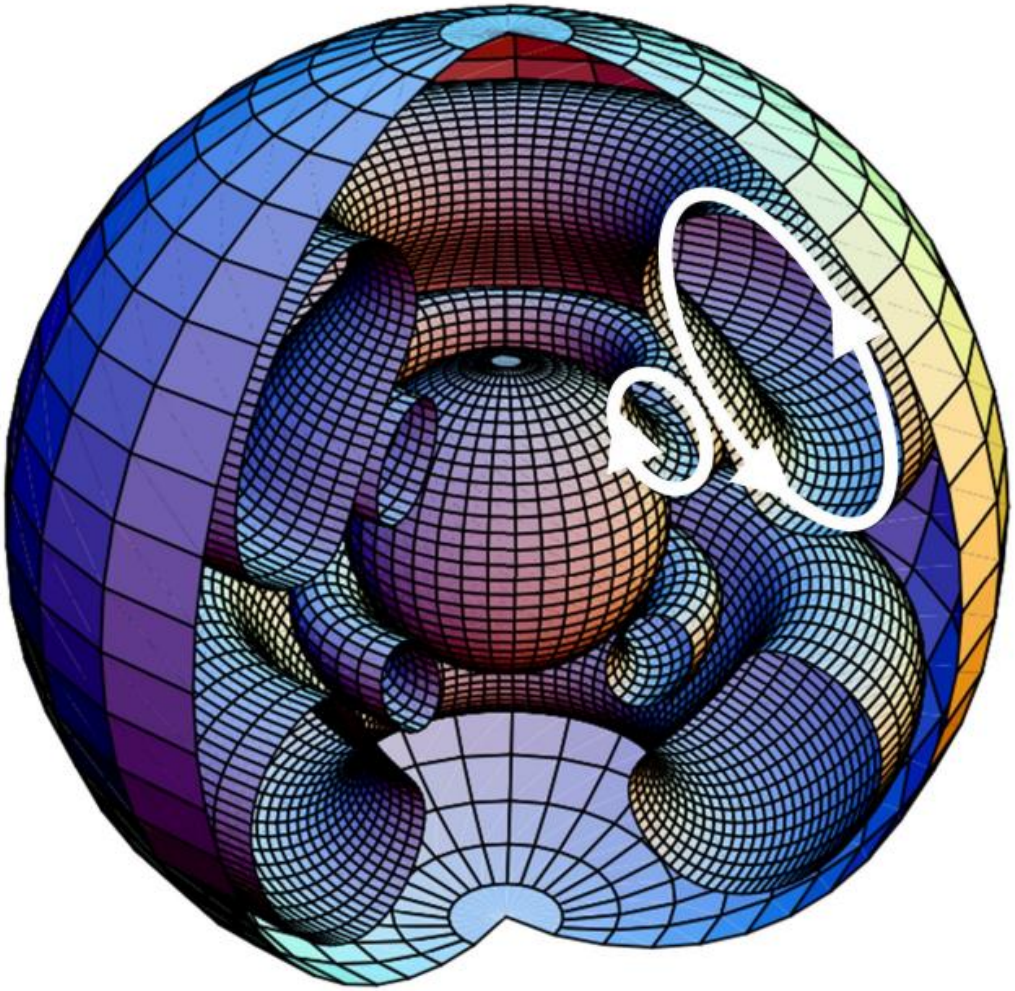
Figure 2. Mass of final BH as a function of the CO core mass for different metallicities. Circles denote models that underwent at least one pulse, pluses evolved directly to CC, and crosses undergo a PISN. The left (blue) region denotes where models undergo CC, the middle (green) region denotes PPISNe, while the right (yellow) region denotes PISNe, as determined by stars with $Z = 10^{-5}$. Points in the right panel show the current median mass estimates for the double compact objects detected by LIGO/VIRGO with their 90% confidence intervals (Abbott et al. 2019a). Dashed horizontal lines emphasize the maximum spread in the locations for the edge of the BH mass gap, or in other words the spread in the maximum BH mass below the PISN BH mass gap.

Farmer et al. (2019)

Chemically-homogeneous evolution

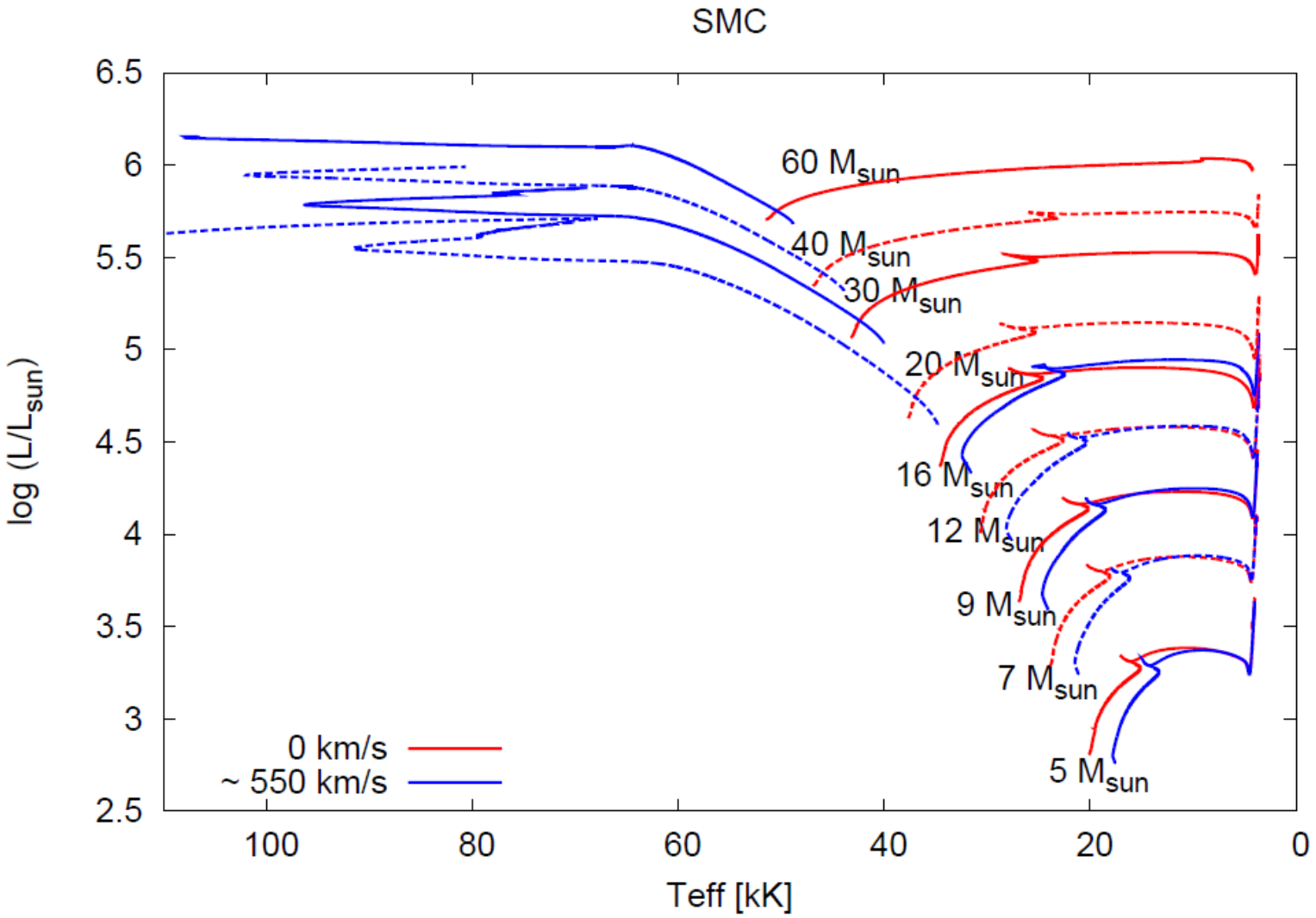
What drives evolutionary expansion of stars?

Rotation in stars



https://astro.uni-bonn.de/~nlanger/thesis/abel.pdf

Chemically-homogeneous evolution



Brotts et al. (2011)