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ABSTRACT

Common phases of mass transfer in stellar binaries are case A (during the donor's main sequence) and case B (after the donor's main sequence but before helium core depletion). For most masses, radii significantly grow after the main sequence, making case B more common. However, very massive stars ($\gtrsim 30\,M_{\odot}$) may already undergo significant expansion during the main sequence increasing the probability of case A mass transfer, but this depends on uncertain stellar physics. For observationally-informed convective boundary mixing, case A mass transfer dominates for donor masses $\gtrsim 75\,M_{\odot}$. This is not the case without convective boundary mixing or with the values assumed in rapid binary population synthesis. Therefore, case A mass transfer may be more dominant than commonly assumed, with potential impact on rates of all post mass transfer binaries.

1. MASS TRANSFER IN VERY MASSIVE BINARIES

Binary stars with a sufficiently small orbital separation undergo a mass transfer phase in which one donor star transfers mass to an accretor. For very massive stars ($\gtrsim 30\,M_{\odot}$), mass transfer most often occurs as case A or case B **?**.

Case B is expected more often than case A mass transfer, since stars in most mass ranges expand most prominently post-main sequence in the Hertzsprung gap (**?**). However, very massive stars may already undergo a drastic expansion in radius during their main sequence. (e.g., **???**). This may increase the rate of case A (**?**), which could have significant implications on the rates of Wolf-Rayet+O-type binaries, X-ray binaries, and gravitational wave progenitors. The radius of the donor is dependent on unknown stellar parameters, including stellar winds (**??**), metallicity (**?**), close-to-super-Eddington-layers (e.g., **???**), and convective boundary mixing (**??**). Here, we illustrate this comparing the radial evolution of very massive stars varying convective boundary mixing, metallicity, and models commonly adopted in rapid binary population synthesis.

2.

The relative proportion of case A mass transfer in comparison to case B mass transfer scales with mass of the donor star. This is expected, as larger stars see greater rates of radial expansion during the main sequence. This has a significant side effect for stars with($\gtrsim 75 M_{\odot}$), case A mass transfer is expected to explain in all possible mass transfer processes. For stars of lesser mass, the thermal expansion of the star at the end of the main sequence expands the star beyond its maximum radius during the main sequence. However, for stars in this mass range, the radius expands drastically during the main sequence, such that the maximum radius during the main sequence and helium core burning phase are similar.

In order to demonstrate the change in ratio between instances of case A and case B mass transfer, we modelled 60 stars while varying mass ($30 - 100 M_{\odot}$; of $5 M_{\odot}$ intervals), metallicity ($Z = 0.001, 0.001$) and model of boundary mixing. The top panels of FIGURE are determined from the exponential boundary mixing model from **?** fit to the expected values from the step boundary mixing model from **?**. This is configured in **?**. This "broad convective boundary mixing" model is compared to a model that does not consider boundary mixing. Both models were instructed to end before the carbon burning phase could commence.

In addition, 30 models generated using the rapid population synthesis code COMPAS using models generated from data gathered in **?** are plotted in the bottom panels of FIGURE. These models match the metallicities of the stellar evolution models in the other panels. These models include data until core collapse.

Convective boundary mixing has a strong effect on stellar radius **??**, which determines Roche lobe overflow. The vast differences in the ratio of expected abundances of case A and case B mass transfer are consequentially expected. The broad convective boundary mixing models limit case B mass transfer for stars of mass ($\gtrsim 75 M_{\odot}$) . In contrast, omitting convective boundary mixing al-

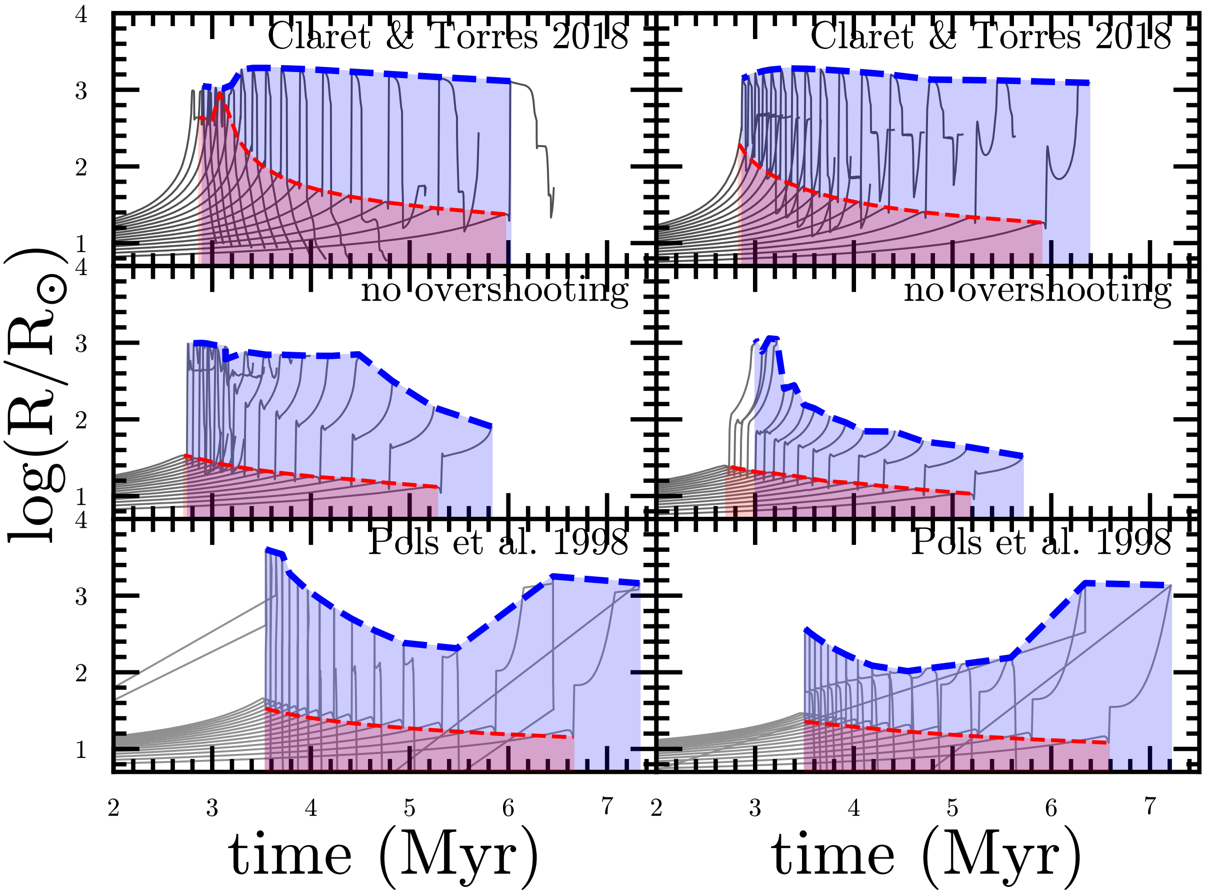

Figure 1. Each panel contain 15 stellar models spanning from a $30\,M_{\odot}$ star on the right to a $100\,M_{\odot}$ with intervals of width $5\,M_{\odot}$. The top panels plot models that feature broad convective boundary mixing, the middle panels plot models that do not feature overshooting, and the bottom panels plot models generated from COMPAS using data from **?**. The left panels have a metallicity $Z = 0.001$ and the right panels have a metallicity $Z = 0.0001$

lows case B mass transfer to occur at a significant scale in all mass regimes such that $M < 100_{\odot}$. HOW TO CITE Brott's paper suggests broad convective boundary mixing models currently provide the best approximation for observed characteristics of massive stars. As a result, many rapid population synthesis softwares and other stellar mass transfer models may underestimate the abundance of case A mass transfer procedures.

Binary interactions are crucial to the formation of X-ray binaries and gravitational waves sources. in particular for BBH stable mass transfer may dominate **??**