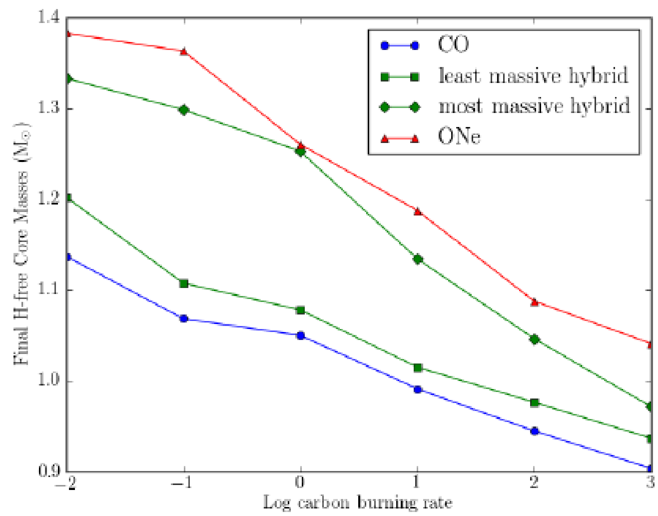
The dependence of the evolution of SN type Ia progenitors on the C burning rate uncertainty and parameters of convective boundary mixing

Evolution of a supernova type Ia progenitor requires formation of a CO white dwarf (WD), which implies a dependence on the C burning rate (CBR). It can also be affected by the recently identified possibility of C flame quenching by convective boundary mixing. Here, we present first results of our study of the combined effect of these two potential sources of uncertainty on the SN Ia progenitor evolution. We consider the possibility that the CBR could be higher than its currently recommended value by as much as a factor of 1000 at the relevant temperature if unidentified resonances are important, or that it could be significantly lower because of the hindrance effect. For stellar models that assume the Schwarzschild boundary for convection, the maximum initial mass for the formation of CO WDs increases from $M_i \approx 5.5M_\odot$ for the CBR factor of 1000 to $M_i > 7.0M_\odot$ for the CBR factor of 0.01. For C-flame quenching models, hybrid C-O-Ne WDs form for a range of initial mass of $\Delta M_i \approx 1M_\odot$, and therefore a significant fraction of stars that have previously been considered unavailable for SN Ia progenitors may in fact form WDs that will ignite carbon in a thermonuclear runaway. For the recommended CBR, the initial mass range for hybrid C-O-Ne WDs is $6.6M_\odot \leq M_i \leq 8.8M_\odot$, the larger initial mass corresponding to the larger WD mass. The most extreme case is found for the CBR factor of 0.1 that is supported by the hindrance model. When combined with a small amount of convective boundary mixing, that still causes C flame quenching, this nuclear physics assumption leads to the formation of a hybrid C-O-Ne WD with a mass of $1.3M_\odot$ (Fig.1, upper panel). If such WDs really exist, they do not need to accrete much mass to reach the Chandraskhar limit.



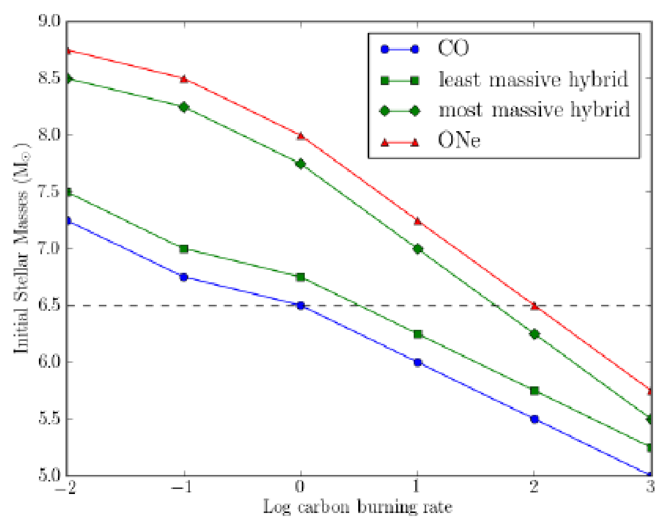


Figure 1: The highest masses of the CO cores and the lowest masses of the ONe cores (top), and the initial masses of the stars that produce the highest CO core masses and the lowest ONe core masses (bottom), all plotted against the carbon burning rate (CBR) factor. These models include convective boundary mixing for C burning. The mass range between CO and ONe WDs is occupied by C-O-Ne hybrid core models.

Researchers: Michael C. Chen[1] , Falk Herwig[1,2], Pavel A. Denissenkov[1,2], and Bill Paxton[3].
[1]UVic, [2]JINA, [3]UCSB
Accepted for publication by MNRAS (see Chen et al. 2013, arXiv:1310.1898v2 [astro-ph.SR])