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Bridging the Mass Divide: Super and Massive AGB Star Yields

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Abstract. Super Asymptotic Giant Branch Stars (Super AGBs) lie in the mass range 6-11 $M_{\odot}$, which bridges the divide between low/intermediate mass AGB and massive stars. During the thermally pulsing phase of evolution competition between hot bottom burning (HBB) and third dredge up (3DU) events determine the stellar yields. Obtaining these yields is far more computationally demanding than those of most AGB stars because Super AGBs undergo up to a few thousand thermal pulses. We describe results from evolutionary and nucleosynthetic calculations for these stellar models. We examine element production in these Super AGB stars over time, with results from five metallicities spanning the range Z = 0.02-10^{-4} ([Fe/H] 0 to −2.3). Super AGB star nucleosynthetic yields have hitherto been neglected in galactic chemical evolution modelling.

1. Introduction/Results

There has been a striking gap in stellar yields models in the intermediate 6-11 $M_{\odot}$ mass range due to their highly computationally demanding nature. This gap has been a source of uncertainty in Galactic chemical evolution modelling. We have computed the evolution of Super and massive AGB models using the Monash version of the Mount Stromlo stellar evolution program (MONSTAR), for current reviews see Campbell & Lattanzio (2008), Doherty et al. (2010). The nucleosynthesis was performed using a post processing code with either a 77 species network (e.g. Karakas 2010) or 475 species network (e.g. Church et al. 2009). The large network allows us to examine s-process element production in detail.

This study of Super AGB stars is the first to find very efficient third dredge up. We can see this in Figure. 1, which plots $\lambda_{\max}$ (the quotient of mass dredged-up by the convective envelope over the mass increase of the core in a thermal pulse) as a function of initial mass.

We examine element production in Super /Massive AGB stars over time, with results from five metallicities spanning the range Z = 0.02-10^{-4} ([Fe/H]≈ 0 to −2.3) and find that the effects of hot bottom burning dominate over the third dredge up in

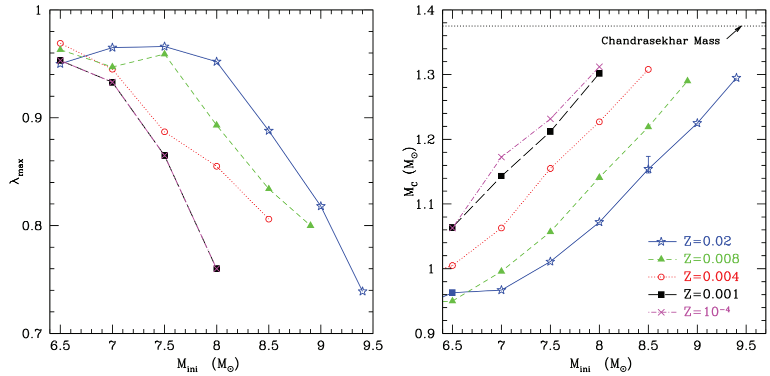

Figure 1. The left panel details λ_{max}, the maximum dredge up efficiency as a function of initial mass M_{ini}. The right panel relates the initial mass M_{ini} to final core mass M_C for a range of metallicities.

the nucleosynthetic yields for the most metal rich models. We see large production of ^{13}C,^{14}N,^{17}O as well as ^{25}Mg, ^{26}Mg and ^{26}Al.

In Super AGB stars very large temperatures are attained at the base of the thermal pulse (in excess of 430MK!), which results in a large neutron flux from the ^{22}Ne (α,n) ^{25}Mg reaction. These neutrons facilitate s-process element production. We are currently producing s-process yields for Super and massive AGB stars over a range of metallicities, e.g. Lau et al. (2011). Figure. 1 shows the final core mass as a function of the initial stellar mass for a range of metallicities. Gil-Pons & Doherty (2010) have explored the upper mass limit and the dredge-out phenomenon for metallicities as low as Z=10^{-5}. At the high mass tail of Super AGB stars the final fate, either as a white dwarf or as a neutron star remnant is highly contentious.

2. Conclusions

We have computed the evolution and yields for a grid in mass and metallicity of Super and Massive AGB stars, finding efficient third dredge up. We find that the effects of hot bottom burning dominate over the third dredge-up in the nucleosynthetic yields for the most metal rich models. These stellar models go a long way to bridge the scarcity of yields in this mass range. The final fates and upper mass limits for the formation of Super AGB stars and our produced stellar yields are to be available imminently.

References

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