The C-flame Quenching by Convective Boundary Mixing in Super-AGB Stars and the Formation of Hybrid C/O/Ne White Dwarfs and Supernova Progenitors

After off-center C ignition in the cores of super-AGB stars the C flame propagates all the way down to the center, trailing behind it the C-shell convective zone, and thus building a degenerate ONe core. This standard picture is obtained if the Schwarzschild condition is strictly applied at the bottom of the C-shell convective zone. However, this convective boundary is prone to additional mixing processes, such as thermohaline convection and convective boundary mixing (CBM). Using hydrodynamic simulations we show that, contrary to previous results, thermohaline mixing is too inefficient to interfere with the C-flame propagation. However, even a small amount of CBM removes the physical conditions required for the C-flame to propagate all the way to the center. This result holds even if we allow for some turbulent heat transport in the CBM region. As a result, super AGB stars build in their interiors hybrid C-O-Ne degenerate cores composed of a relatively large CO core ($M_{CO}\approx0.2M_{\odot}$) surrounded by a thick ONe zone ($\Delta M_{ONe}\approx0.85M_{\odot}$) with another thin CO layer above (Fig.1). If exposed by mass loss, these cores will become hybrid C-O-Ne white dwarfs. Otherwise, the ignition of C-rich material left in the central core may trigger a SNIa. In the single-degenerate scenario the mass range of SNIa progenitors would increase to include the SAGB stars with hybrid cores. This would decrease the minimum delay time of the appearance of the first SNIa after a star formation burst. It would also provide a larger pool of progenitor initial masses. Since hybrid cores have larger masses than CO cores, less mass has to be accreted to reach the Chandrasekhar limit, compared to model predictions without CBM. For the double-degenerate scenario we may expect that the ignition of a C-shell during the merger process may similarly not lead to complete burning of the core of the primary because in this case the C-flame may also be quenched. (For details, see Denissenkov et al. 2013, ApJ, 772, 37).

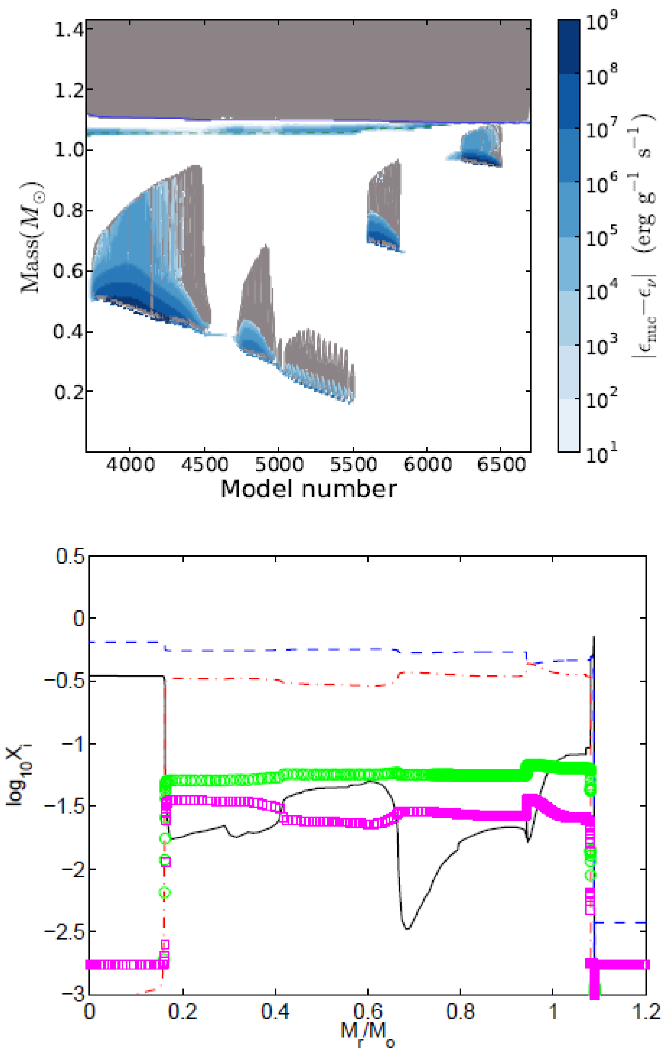

Figure 1: Top panel: A Kippenhahn diagram for the phase of C burning in the core of our $7M_{\odot}$ SAGB star model with the metallicity Z=0.01 in the presence of CBM modeled by a diffusion coefficient that is exponentially decaying in radiative layers adjacent to the C-shell convective boundaries on a length scale of $0.007H_P$, where H_P is the pressure scale height. The uniform grey areas are convective zones. The different shades of blue color map the nuclear energy generation rate. In this case, which includes some turbulent heat transport in the CBM region, the C-flame is quenched before reaching the center. Bottom panel: Abundance mass fraction profiles in the final model of this sequence (solid black: ^{12}C; dashed blue: ^{16}O; dot-dashed red: ^{20}Ne; green circles: ^{23}Na; magenta squares: ^{24}Mg.

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