Models of AGB Stars Envelopes and Atmospheres

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The possible existence of a hot CN-cycle at the bottom of the AGB convective envelopes ("hot-bottom burning" or HBB) encounters some revealing difficulties with observations (e.g. Reid and mould, 1985). On the other hand, existing models disagree with each other about it.

In a first step, we have studied in detail the convective properties of AGB stars by developing a new envelope code (the classical mixing-length theory being assumed). Molecules and grains contributions are included in the radiative opacity calculation. We have introduced an atmospheric temperature profile incorporating blanketing effects (the optical depth being corrected for the sphericity in thick atmospheres). Such a code is required in order to obtain accurate effective temperatures, which determine the structure of the ionization zones, and, in this way, the convection extension. The H and He ionic abundances are calculated in a self-consistent way, resolving the Saha equations together with the charge neutrality constraint by a minimization method. Previous iterative methods do not give accurate electronic number densities, affecting the adiabatic gradient, and thus, the stellar convective structure. As firstly emphasized by Sackmann and Boothroyd (1985), electronic number density variations could have similar effects in the region where CNO elements are produced, below the bottom of the convective envelope. We have consequently calculated all the ionization stages of these elements.

We obtain convective bottom temperatures between 5×10^6 and 2.5×10^6 K (the corresponding densities being about 10^{-6} to 10^{-3} g/cm^3) in models having total luminosity corresponding to the beginning of the thermal pulses period (following Iben and Truran, 1978). Such conditions are inhospitable for the HBB process. This conclusion is roughly insensitive to a change of the core mass-luninosity relation used. More luminous models have progressively less deep convective envelopes. This conclusion is hardly strengthened by introducing a realistic mass loss rate for AGB stars (at constant luminosity). Such a stellar wind, probably activated before the thermal pulses epoch, could substantially modify this phase (as suggested by the observations of Mould and Reid, 1987).

References

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