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# Dust and Gas from AGB stars

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Recent advances made by our group in the studies of low- and intermediate-mass stars in advanced evolutionary phases are here presented, focusing on AGB stars which are among the most important gas and dust polluters of the Universe.

## 1. Introduction

As low- and intermediate-mass stars reach the asymptotic giant branch evolutionary phase (AGB) after the exhaustion of the central helium, they became complex objects powered by alternating burning of H and He in thin shells surrounding their inert C-O core.
Although the duration of the AGB phase is extremely short when compared to the evolutionary time of the star, it is of paramount importance for the feedback of these stars on the host environment, becoming the major players in the cosmic gas/dust cycle.
This is because it is during the AGB evolution that stars lose their external mantle, thus contributing to the gas pollution of the interstellar medium. In addition, these stars have been recognized as important manufacturers of dust, owing to the thermodynamic conditions of their winds, which are a favorable environment for the condensation of gas molecules into solid particles.
Understanding the role of AGB stars as gas and dust polluters is not a simple task: the surface chemistry of stars may be altered by two mechanisms during AGB, called Hot Bottom Burning (HBB) and Third Dredge-Up (TDU). TDU can increase the C surface abundance, and to a smaller extent O, while HBB reflects proton capture nucleosynthesis, and depends on the temperature at which HBB occurs. For temperatures of the base of convective envelope below $8 \times 10^7$ K, the main effect is the production of nitrogen at the expense of carbon, whereas at higher temperatures oxygen destruction also occurs.

### *1.1 Why we care about AGB stars?*

Stars in the AGB evolutionary phase are very important for many reasons. Due to the complexity of their internal structure, they are ideal laboratories to test stellar evolution theories and are also essential for the interpretation of the chemical trends traced by stars observed in different parts of the Milky Way. On a larger scale, AGB stars play a crucial role in the formation and evolution of galaxies because they are crucial to interpret the infrared fluxes of the galaxies and they prove essential for understanding of the dust content observed in the galaxies and in the high redshift Universe.

## 2. AGB stars modeling

The description of AGB stars is extremely difficult, owing to the very short time steps (of the order of one day) required to describe the thermal pulses phases, which leads to very long computation times. Furthermore, the evolutionary properties of these stars are determined by the delicate interface between the degenerate core and the tenuous, expanded envelope, thus rendering the results obtained extremely sensitive to convection modeling. Theoretical stellar nucleosynthesis calculations provide an important dataset for the interpretation of chemical abundances that are derived from the spectra of stars and to predict the quantity and mineralogy of the dust that forms in the circumstellar envelopes of AGB stars. In particular to understand the role of AGB as gas and dust polluters we needs to know: 1) how varies the superficial chemistry during the evolution of the stars and 2)how effectively these stars lose mass.

### *2.1 Our project*

Several years ago, our group has started an important project that consists in the computation of yields from stars in the AGB phase with different masses and metallicities. The yields are based on full evolutionary computations following the evolution of the stars from the pre-main sequence through the asymptotic giant branch phase, until the external envelope is lost. The stellar evolutionary code used for these computations is ATON3.1 [1]. We also decided to couple the results from stellar evolution modeling with the description of the wind in order to derive a self-consistent description of the dust formation process. Our simple approach allowed us to study the properties of gas and dust formed in the winds of AGBs and how the pollution depends on mass and metallicity of the stars as by the implementation of some fundamental features of the model, such as (i) the macro-physics adopted to describe the AGB evolution; (ii) the thermodynamical description of the wind: (iii) the formation and growth of grains.

All the computed models are described in [2–11].

Actually we are organizing the database that will be put online by the end of 2019. In the meantime we are using our computations to interpret observations, with important results in these four research area:

- interpretation and dust budget of AGB observed in MCs( [12–17]);
- study of evolved stars in the local group galaxies [18–20];
- evolution of planetary nebula progenitors [21–24];
- understanding the role played by intermediate-mass stars in the self-enrichment scenario of globular clusters. [25–30]

### *2.2 A recent use of our AGB models: interpretation of the extreme He-rich population of NGC2808*

Recently, we focused on the chemical composition of stars belonging to the extreme He-rich population of NGC2808 populated by stars with the most extreme abundance of Mg, Al, Na, O, and Si. We checked whether the most recent measures are consistent with the AGB yields of stars of 6.5 –8M⊙. According to our models, these stars evolve on time scales of the order of 40 – 60 Myr and eject matter strongly enriched in helium, owing to a deep penetration of the surface convective zone down to regions touched by CNO nucleosynthesis occurring after the core He-burning phase. Since the big unknown of massive AGB stars is the mass-loss, we have proposed a new approch that takes into account the effects of the radiation pressure on dust particles.

We show that this more realistic description of mass loss is able to reproduce the observed abundances of Mg, Al, Na, and Si in these extreme stars. The large spread in the oxygen abundances is also explained by invoking deep mixing during the red giant branch phase (see details in [30]).

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