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FRUITY Upgrades on AGB Evolution and Nucleosynthesis

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Abstract. Asymptotic Giant Branch (AGB) stars are among the major polluters of the interstellar medium. These objects produce both light (C, N, O, F, Na) and heavy elements (via the slow neutron capture process, the *s*-process). We have devoted a long-standing project to study the physical and chemical properties of AGB stars. Our models are available on the on-line FRUITY database, which currently provides the surface isotopic compositions and yields from hydrogen to lead of low-mass AGB stars ($1.3 \leq M/M_\odot \leq 3.0$). We present a new set of intermediate-mass AGB models (4.0, 5.0 and 6.0 $M_\odot$ with $-2.15 \leq$ [Fe/H] $\leq +0.15$). We discuss their physical and chemical properties, highlighting the differences with respect to the set already on-line. Moreover, we check the reliability of our models by comparing them to observed quantities, such as the initial-to-final mass relation and AGB luminosity functions.

1. AGB Stars and the FRUITY Database

Past generations of AGB stars contributed significantly to the pollution of the proto-solar nebula, being major producers of both light and heavy elements. In these stars, isotopes heavier than iron ($A \geq 56$) are created by means of the slow neutron capture process, the *s*-process (Gallino et al. 1998; Busso et al. 1999; Straniero et al. 2006).

An AGB star consists of a partially degenerate carbon-oxygen core, an He shell and an H shell separated by a small He-rich region (He-intershell), and an expanded and cool convective envelope. The energy is mainly provided by the H-burning shell; this situation is repeatedly interrupted by the occurrence of thermonuclear runaways (Thermal Pulses, TPs) driven by the sudden ignition of the 3α process at the base of the He intershell. As a consequence of a TP, a convective shell develops in the He intershell, the external layers expand, and the H shell-burning temporarily switches off. Hence, the convective envelope can penetrate into the C-rich He intershell (the Third Dredge Up episode, TDU), carrying out to the surface the products of the internal nucleosynthesis. For reviews on AGB evolution see Herwig (2005) and Straniero et al. (2006).

We have made available to the community our AGB nucleosynthesis results on the web pages of the FRUITY database[1] (Cristallo et al. 2009, 2011). The database is currently hosting more than 50 models of low-mass AGB stars ($1.3 \leq M/M_\odot \leq 3.0$) computed with the FUNS evolutionary code (Straniero et al. 2006). These stars provide the major contribution to the main component of the *s*-process. In these objects, the

[1]`http://fruity.oa-teramo.inaf.it`

main neutron source is the $^{13}C(\alpha,n)^{16}O$ reaction, which releases neutrons in radiative conditions when the temperature reaches T ~ 10^8 K (Straniero et al. 1995).

2. Intermediate Mass AGB stars

As part of a long-term project devoted to the AGB nucleosynthesis, we have extended the FRUITY mass range to low and intermediate-mass stars ($1.0 \leq M/M_\odot < 1.3$ and $3.0 < M/M_\odot \leq 6.0$ (Cristallo et al., in prep.). Massive AGB stars are of particular interest because the temperatures attained at the base of convective shells during TPs can easily exceed 3×10^8 K. In these conditions, the $^{22}Ne(\alpha,n)^{25}Mg$ reaction is efficiently activated and neutrons are released in a convective environment (Kaeppeler et al. 1994). On the other hand, the increased compactness of the He-intershell region and the larger temperatures attained at the base of the convective envelope during TDUs do not allow the formation of large ^{13}C pockets. Therefore, these objects show a marginal production of the heaviest *s*-process elements (i.e. those belonging to the second and third peak of the *s*-process), unless the metallicity is very low (Straniero et al. 2014). Thus, the main nucleosynthesis products expected from these stars are elements belonging to the first *s*-process peak (i.e. the Sr-Y-Zr region). Moreover, the production of some neutron-rich isotopes (such as ^{87}Rb and ^{96}Zr) is particularly large.

The integration of our AGB set with the aforementioned models will allow us to evaluate the effects of those masses on the luminosity functions of Galactic C-rich stars (Guandalini & Cristallo 2013) and O-rich stars (Guandalini & Cristallo, in prep.). Finally, we will compare our theoretical initial-to-final mass relation with data in the extant literature (e.g. Catalán et al. 2008; Williams et al. 2009; Zhao et al. 2012; Kalirai et al. 2014).

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