EBERHARD KARLS UNIVERSITÄT TÜBINGEN

Faculty of Science
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GERMAN ASTROPHYSICAL GAVO VIRTUAL OBSERVATORY

Heavy Metal Factory

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The metal enrichment in the cosmic circuit of matter is dominated by the yields of asymptotic giant branch (AGB) nucleosynthesis, that are blown back into the interstellar medium just before these stars die as white dwarfs. To establish constraints on AGB processes, spectral analyses of hot post-AGB stars are mandatory. These show that such stars are heavy metal factories due to the AGB s-process.

The Virtual Observatory service *TheoSSA* offers access to synthetic stellar spectra calculated with our Tübingen non-local thermodynamic equilibrium model-atmosphere package that are suitable for the analysis of hot post-AGB stars.

Post-AGB Stars

The asymptotic giant branch (AGB) is the last evolutionary stage of low- and intermediate-mass stars (0.8 – 8 $M_\odot$) driven by nuclear burning. On the AGB, the star experiences a series of thermal pulses (TPs) due to unstable double-shell burning. These are followed by pulse-driven convective mixing processes providing ideal conditions for neutron-capture nucleosynthesis (s-process) and transporting the outcomes to the surface. Thus, AGB stars are an important source of heavy elements in the universe. The processes at the transition phase from the AGB to the white dwarf (WD) cooling track are affected by several uncertainties and yet not well understood. Due to the fact, that at the end of the AGB, the stars lose their external layers and return up to 90% of their mass to the interstellar medium via stellar winds, they are an essential factor for the chemical evolution and the metal enrichment of galaxies. By the lucky coincidence, that about 25% of all post-AGB stars lose their H-rich envelope in a final helium- (He) shell flash [1] and display intershell matter at the surface, we get the unique insight to AGB nucleosynthesis. This group of stars comprises Wolf-Rayet and PG1159 stars as well as DO-type WDs. Abundance determinations for these stars are not only important for the improvement of stellar-evolution models but also for the modelling of Galactic chemical evolution.

We use the well established Tübingen Model-Atmosphere Package (*TMAP*) to calculate non-local thermodynamic stellar atmospheres in hydrostatic and radiative equilibrium and compare synthetic to observed spectra. Figure 1 shows the element abundances of a set of post-AGB stars compared to the yields of different model calculations.

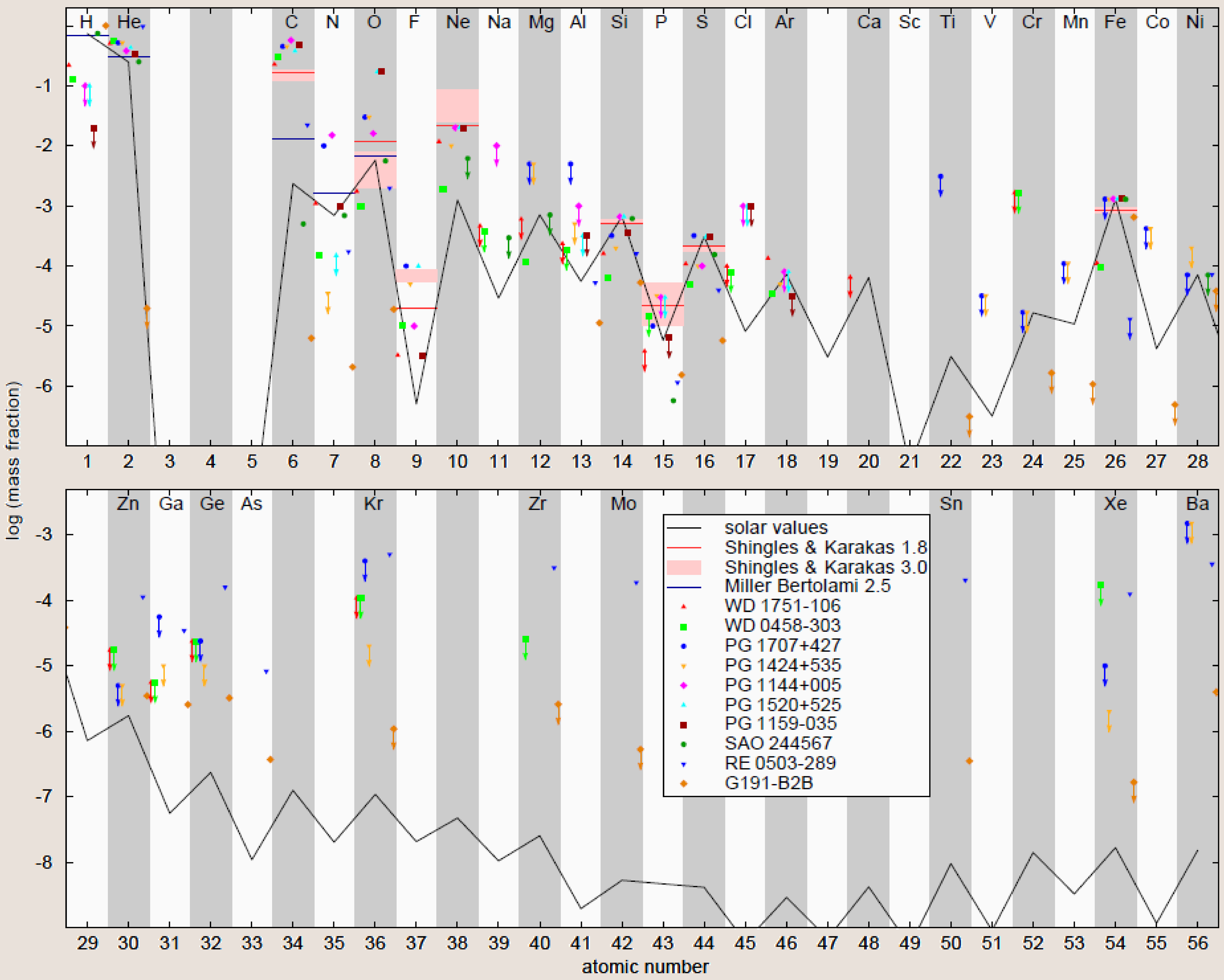

Fig. 1: Element abundances of the set of hot post-AGB stars. Data from [2], [3], [4], [5], [6], [7], [8], [9]. Solar values from [10]. Upper limits are indicated with arrows. The abundances yields of models from [11] and [12] are included. The number behind the author in the legend box gives the initial mass of the star in $M_\odot$ in the evolutionary models.

The detection of s-process elements in hot post-AGB stars is hampered by the lack of atomic data. Recently it came available for 13 trans-iron elements, namely zinc, gallium, germanium, arsenic, selenium, krypton, strontium, molybdenum, tin, tellurium, iodine, xenon, and barium. In the hot DO WD RE0503-289, all these elements could be discovered (e.g., [7], Fig. 1) showing strong overabundances of 155 to 23,000 times solar. Evolutionary models predict an enhancement of 2-3 dex [13]. The question to work on is now whether the determined abundances are dominated by the outcomes of nucleosynthesis or affected by an interplay of gravitational settling and radiative levitation.

References

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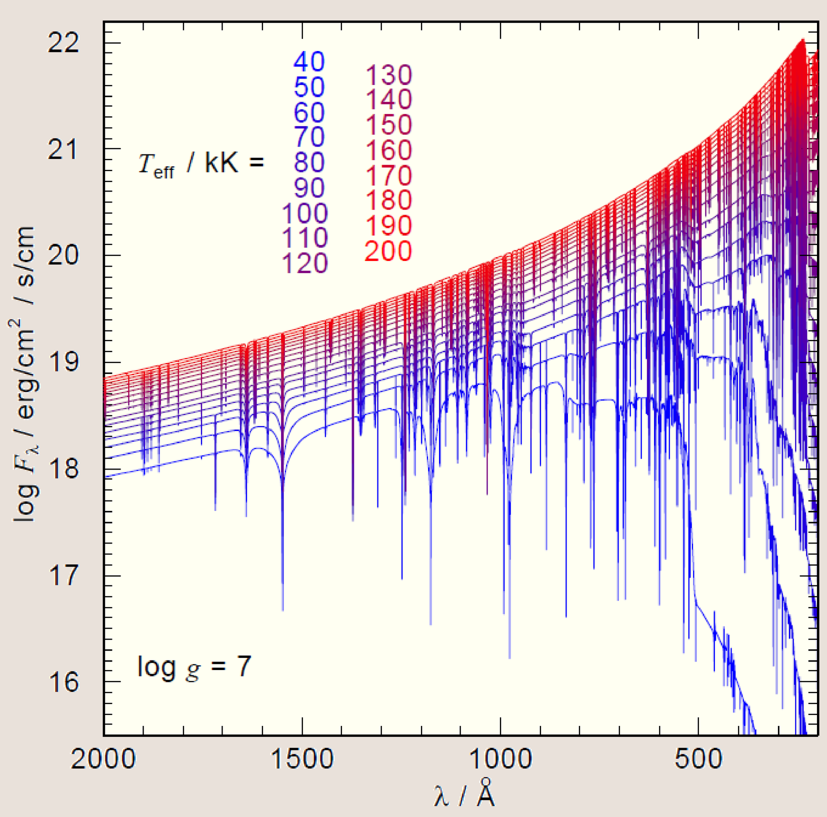

Fig. 2: Example for an SED grid available via TheoSSA. PG 1159-type star model fluxes with He:C:N:O=33:50:2:15 (mass ratio) for $T_{\rm eff}$ = 40 – 200 kK and log (g / cm/s²) = 7.

Synthetic Post-AGB Star Spectra on Demand

The service *TheoSSA* (Theoretical Stellar Spectra Access, http://dc.g-vo.org/theossa) is provided in the framework of the German Astrophysical Virtual Observatory. It contains about 200,000 grids of spectral energy distributions (SEDs, Fig. 2) calculated with *TMAP* for various abundance patterns including the elements H, He, C, N, O, F, Na, Mg, Al, Si, P, S, Cl, Ar, Ca, Fe, Co, Ni, Ge, Kr, Sn, Xe, Zn, and Ba. These SEDs are suitable for the analysis of post-AGB stars. Via the *TheoSSA* web interface (Fig. 3), parameters like $T_{\rm eff}$, log g, and abundances for several elements can be requested to download SEDs.

TMAW (http://astro.uni-tuebingen.de/~TMAW), the *TMAP* web interface, can be used to calculate SEDs that are not yet available. All calculated *TMAW* spectra are included automatically into the *TheoSSA* database.

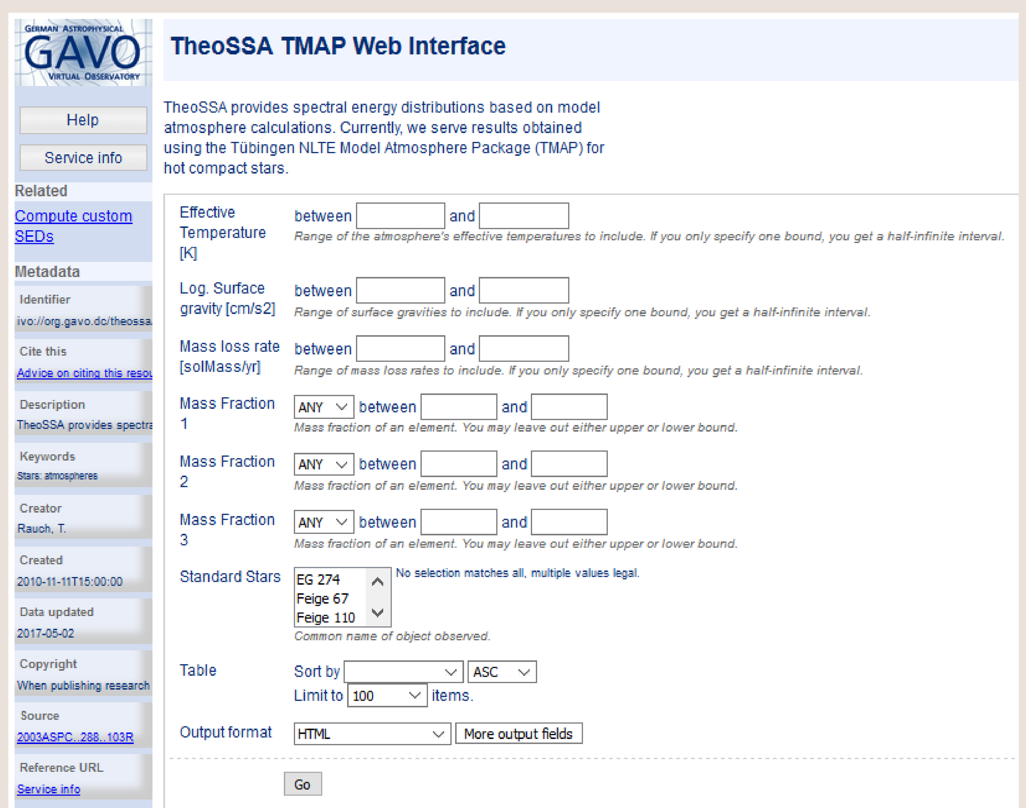

Fig. 3: *TheoSSA*, Web Inerface.

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