THE *GAIA* HR DIAGRAM OF S TYPE STARS

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1 INTRODUCTION

What are S type stars

- Late type giants? with **ZrO** and **TiO** molecular bands
- Transition objects between M and Carbon stars ➡ 0.5 ≤ C/O < 1
- Signatures of over-abundances of **s-process** elements

S type stars

Intrinsic
- Thermally Pulsing Asymptotic Giant Branch (AGB) stars
- Technetium-rich

Extrinsic
- Polluted binaries with a former AGB companion (now WD)
- Technetium-poor

2 SAMPLE SELECTION

Parallaxes from TGAS catalogue

We considered S stars with $\sigma_\omega \leq \omega/3$

High Resolution spectra from HERMES [1]

δ < -30 and V < 11

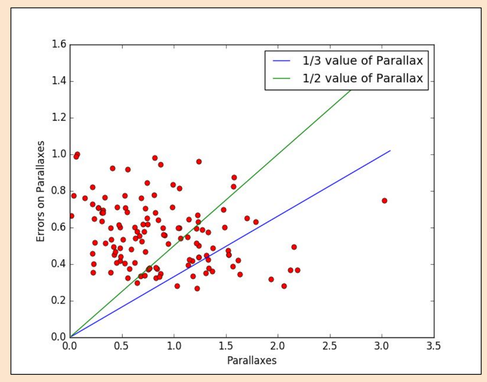


Figure 1 : Error on parallax vs Parallax from the TGAS catalogue for 124 S stars. The blue line separates the stars with $\sigma_\omega \leq \omega/3$ and the green line separates the stars with $\sigma_\omega \leq \omega/2$.

3 STELLAR PARAMETER DETERMINATION

Models

MARCS model atmospheres for S stars [2]
- $2700 \leq T_{eff}(K) \leq 4000$
- [Fe/H] = 0.0 and -0.5
- **$0.50 \leq C/O \leq 0.99$**
- $0 \leq \log g \leq 5$
- [α/Fe] = -0.4*[Fe/H]
- **[s/Fe] = +0,+1 and +2 dex**

The thermal structure of S stars is very sensitive to the C/O ratio .

Atmospheric parameters by spectral fitting

- Fitting observed spectra with synthetic spectra from MARCS models.
- Obtaining χ^2 for spectral regions of 200 Å width.
- Extracting parameters of the best fitting model (the one with least χ^2).

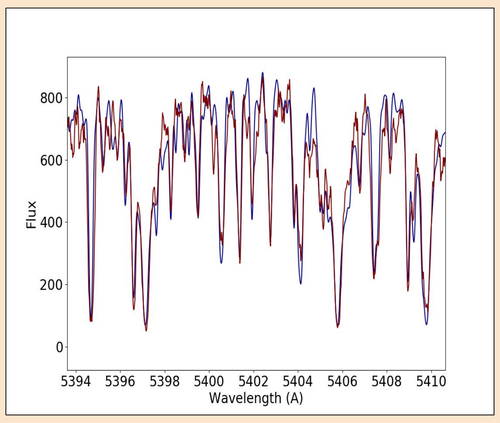


Figure 2 : An example of the agreement achieved from the χ^2 routine for Hen 4-137.Maroon: Observed spectra, Dark blue: Synthetic spectra

4 HR DIAGRAM

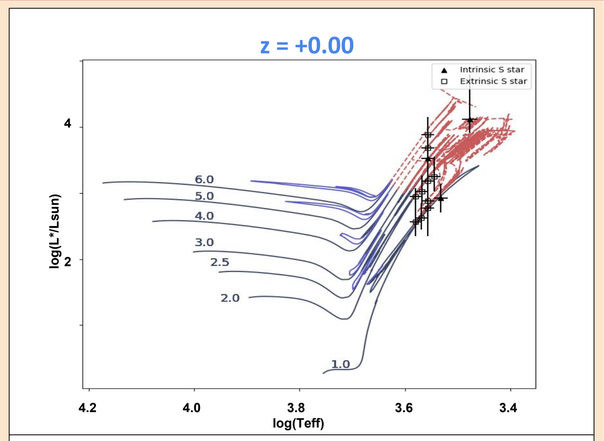
Tc rich S stars:

Cooler, more Luminous objects. In the Thermally Pulsing AGB phase

Tc poor S stars:

Hotter, Intrinsically fainter. Metal rich, on the tip of Red Giant Branch (RGB) or early AGB

Figure 3 : Comparison of the position of S stars in the HR diagram with the evolutionary tracks from the STAREVOL code [3]. Dark Blue represents the RGB phase, Light Blue represents the He burning Main Sequence phase, Dashed Pink represents the TP AGB phase

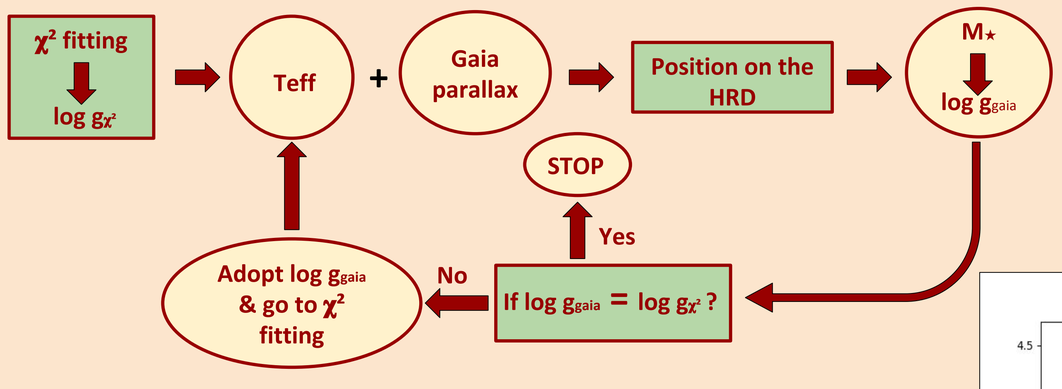


5 CONSTRAINING LOG G WITH *GAIA*

Comparison of log g obtained from the χ^2 fitting and from the position on the HRD (z=0.00) :

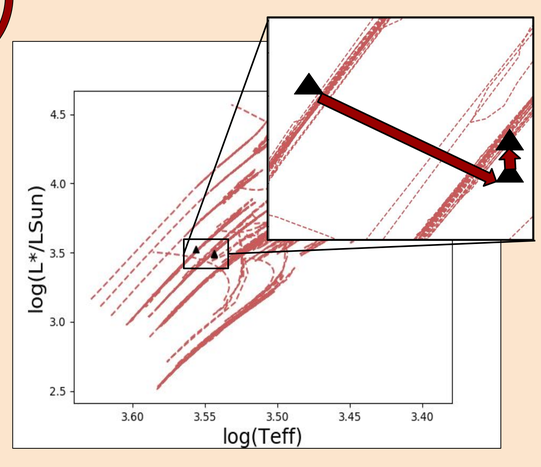
Star	log g : from χ^2	log g : from HRD
BD +69 524	2.0	1.0
BD +28 4592	2.0	1.4
NQ Pup	3.0	0.8
UY Cen	3.0	0.1

Gaia parallaxes can help us constrain log g by iterating on parameters from χ^2 fitting and HRD:



Iterations on parameters of NQ Pup to constrain log g:	Teff (K)	log g	[Fe/H]	C/O	
	3600	3.0	+0.00	0.971	➡ 3 $M_\odot$
	3500	0.0	-0.50	0.50	➡ 2 $M_\odot$
	3500	**1.0**	**-0.50**	**0.752**	➡ 2 $M_\odot$

Figure 4 : Evolution of the position of NQ Pup on the HRD (z=0.00) as it's stellar parameters are iterated to constrain log g



6 PRELIMINARY RESULTS & CONCLUSIONS

Derived parameters for following stars by spectral analysis

	Teff (K)	log g	[Fe/H]	C/O	[s/Fe]
HD 191589	3600	1.0	0.0	0.60	1.0
NQ Pup	3700	1.0	-0.3	0.50	1.0
UY Cen	3000	1.0	0.0	0.99	1.0

Conclusions:

- *GAIA* differentiates the population of intrinsic and extrinsic S stars.
- Fundamental parameter determination of S stars is crucial but is well constrained by the combination of high-resolution spectra, fine gridded models and *GAIA* parallaxes.
- Abundance determination of intrinsic S stars and comparison with theoretical predictions [4] is a work in progress.

References:
[1] Raskin, G. (2011). Astronomy and Astrophysics, Volume 526, id.A69, 12 pp.
[2] Van Eck, S. et al. (2017). A&A 601, A10: Refer to the poster of S. Van Eck.
[3] Siess L. ; Arnould M. (2008). Astronomy and Astrophysics, Volume 489, Issue 1, 2008, pp.395-402.
[4] S. Goriely and L. Siess, 2017 (A & A , In prep)