Probing AGB nucleosynthesis via S stars

Shreeya Shetye

Promotors:

Sophie Van Eck (ULB) and Hans Van Winckel(KUL)

Collaborators:

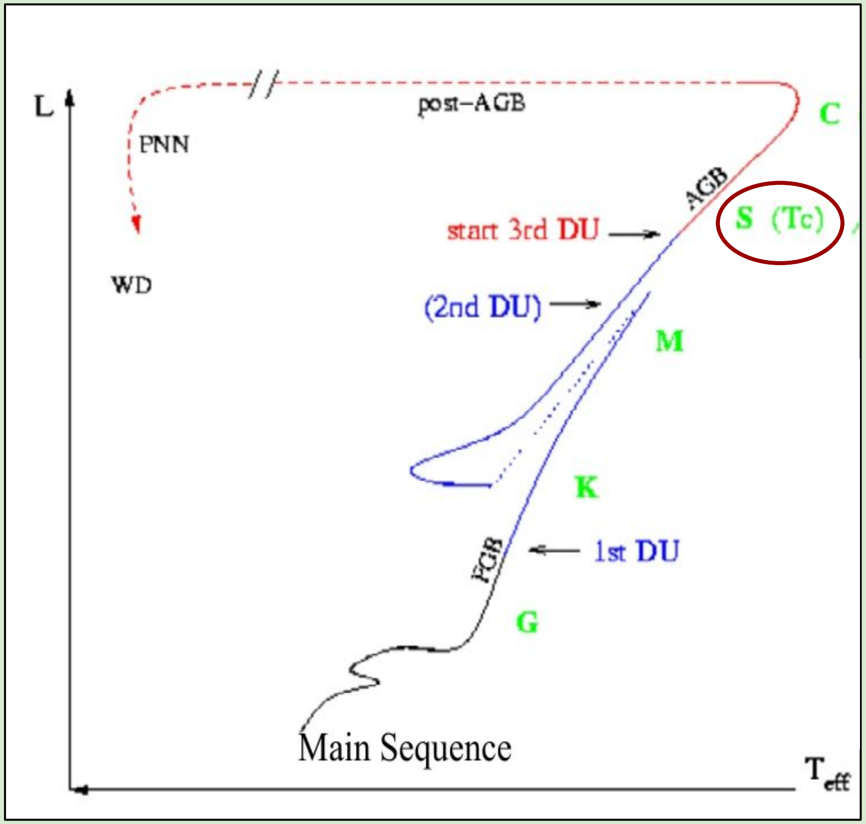
Alain Jorissen(ULB), Lionel Siess(ULB), Stephane Goriely(ULB)

S stars and their characteristics

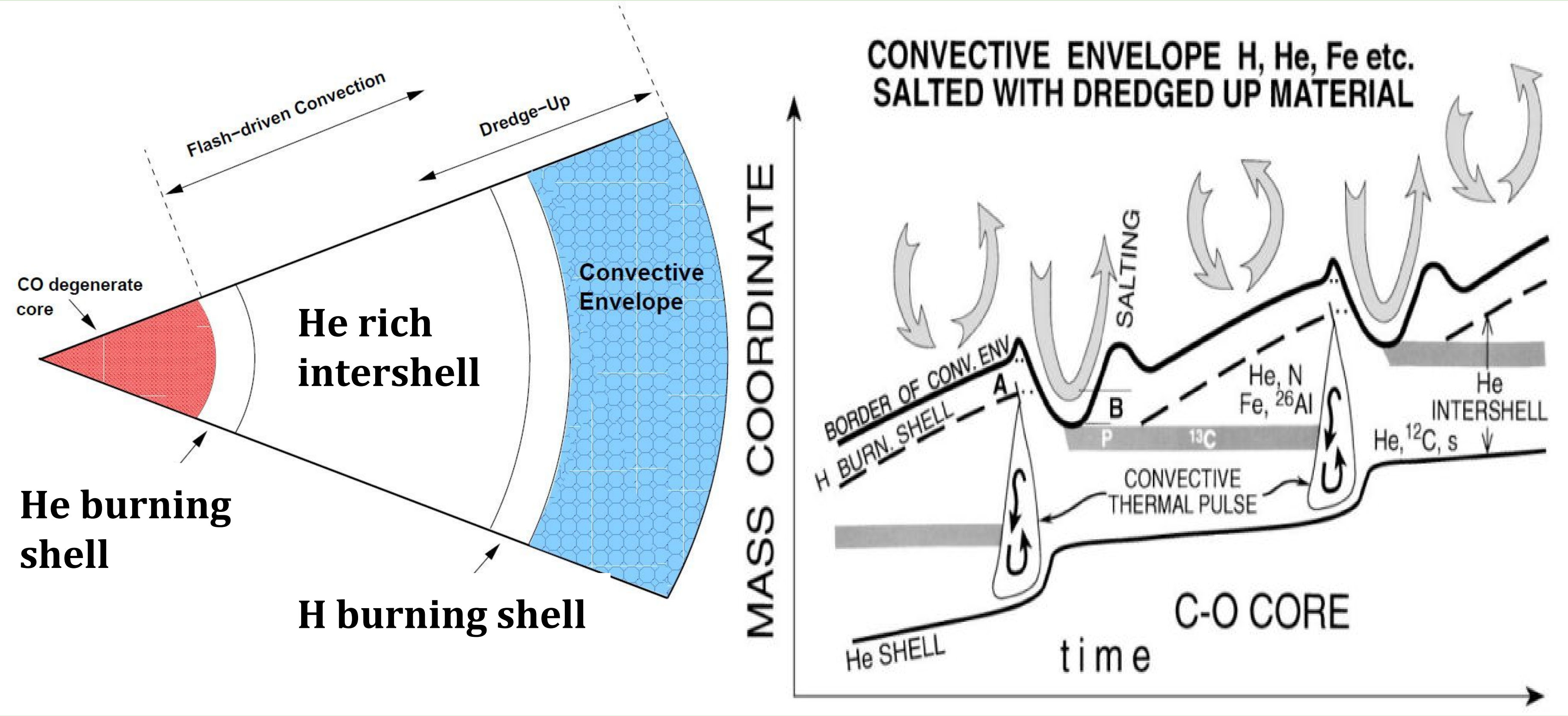
- Late-type giants with distinctive molecular bands of ZrO along with TiO bands. Effective Temperature from 3000K-4000K and log g from 0-1.
- Transition objects between M and C stars with $0.5 \leq C/O < 1$
- Their spectra show over-abundances of s-process elements

S stars and their characteristics

- S stars can be classified into:
  Intrinsic S stars : Pure TP - AGBs
  Extrinsic S stars : Polluted binaries



AGB nucleosynthesis



Picture credits (Left): Karakas A. , Lattanzio J. , Pols O. , 2002

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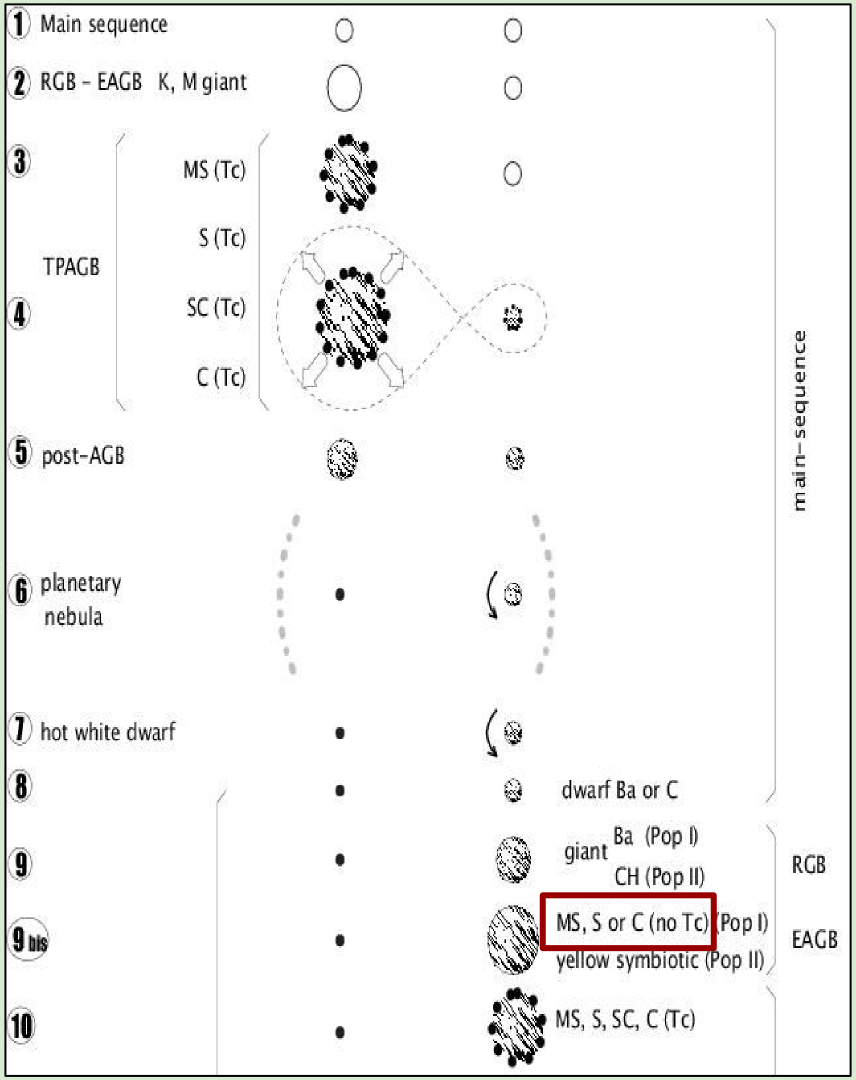
Remember talk by A. Escorza and D. Karinkuzhi ?



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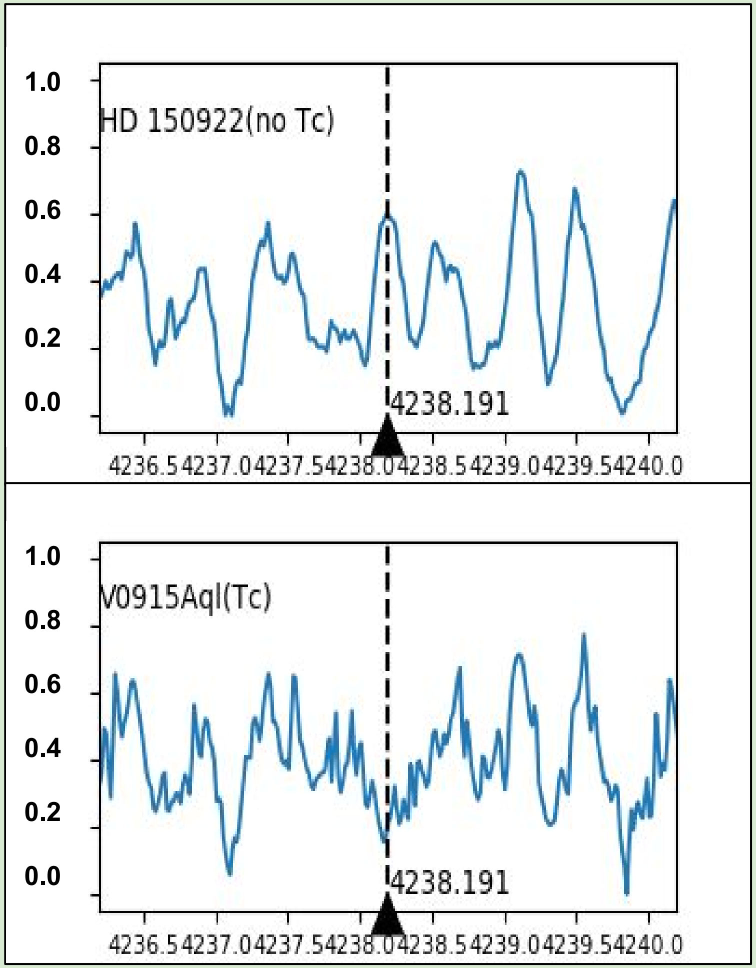
- Intrinsic and Extrinsic S stars can be distinguished by the presence or absence of **Tc** lines.
  (Tc^{99}, half life= $2.5*10^5$ yrs)



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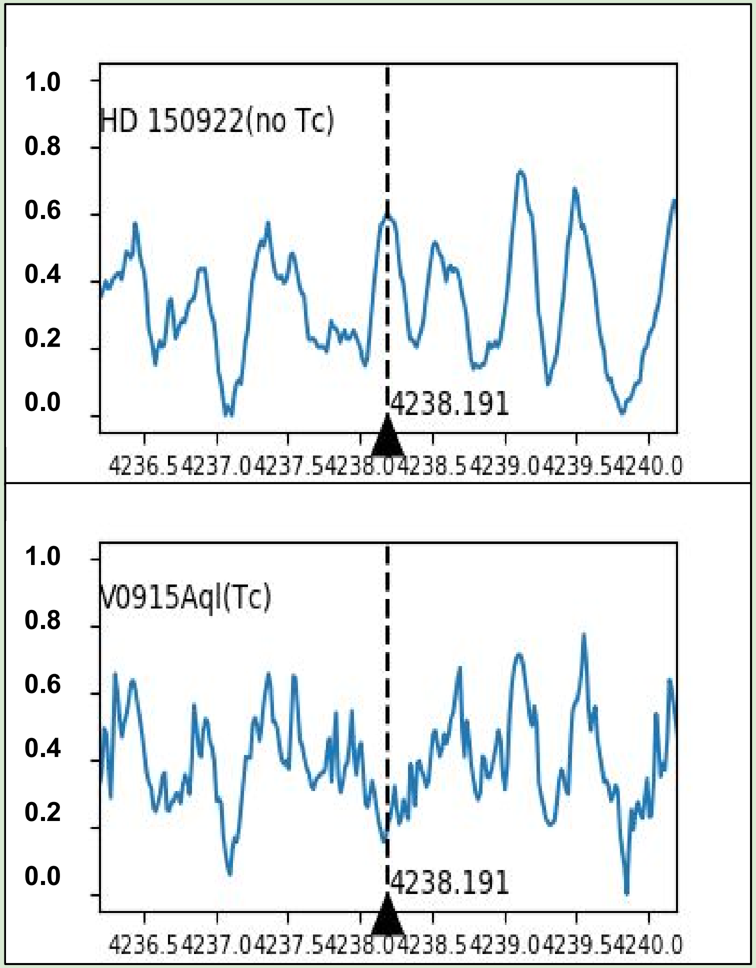


Why are the S stars important?

Because the intrinsic S stars are the first ones on AGB to have undergone Third Dredge-up

Sample Selection:

HERMES condition:

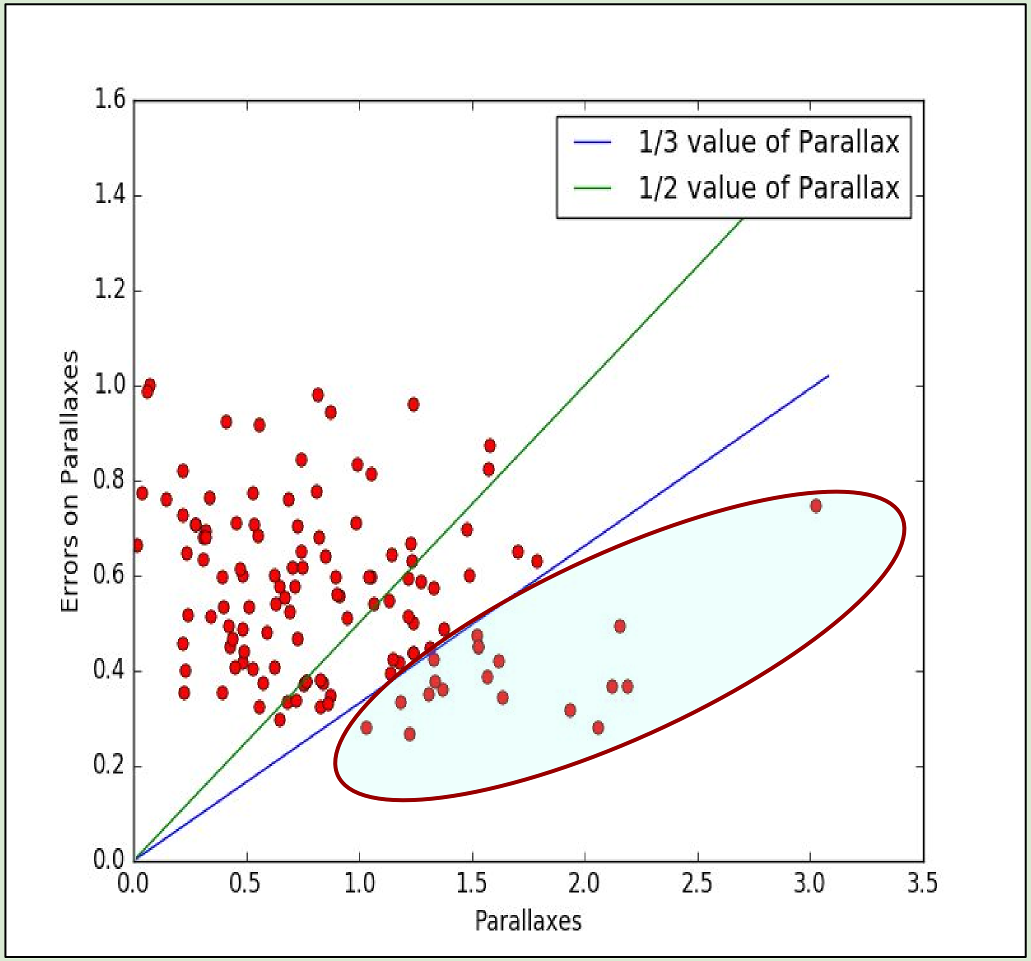
δ > -30 and V- band < 11

Parallax condition:

$$\sigma(\varpi) \leq \varpi/3$$

18 S stars with $\sigma(\varpi) \leq \varpi/3$

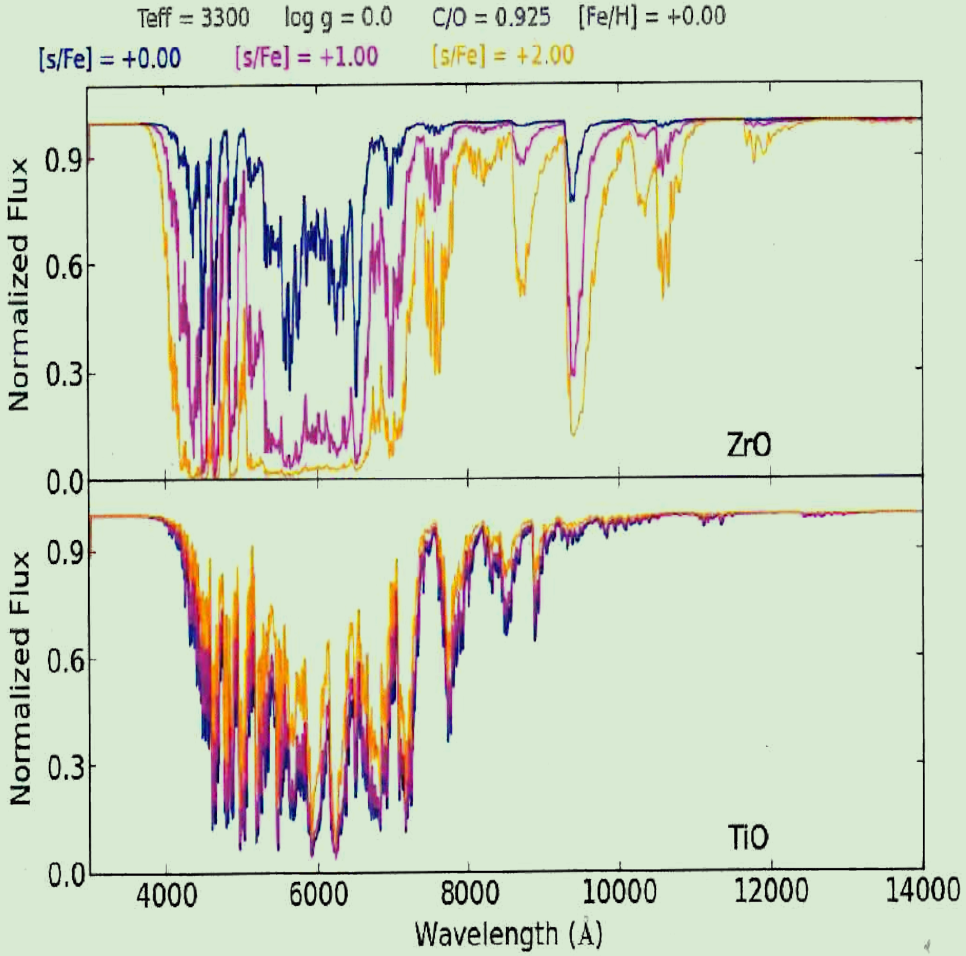
Picture credits: Peter Papics



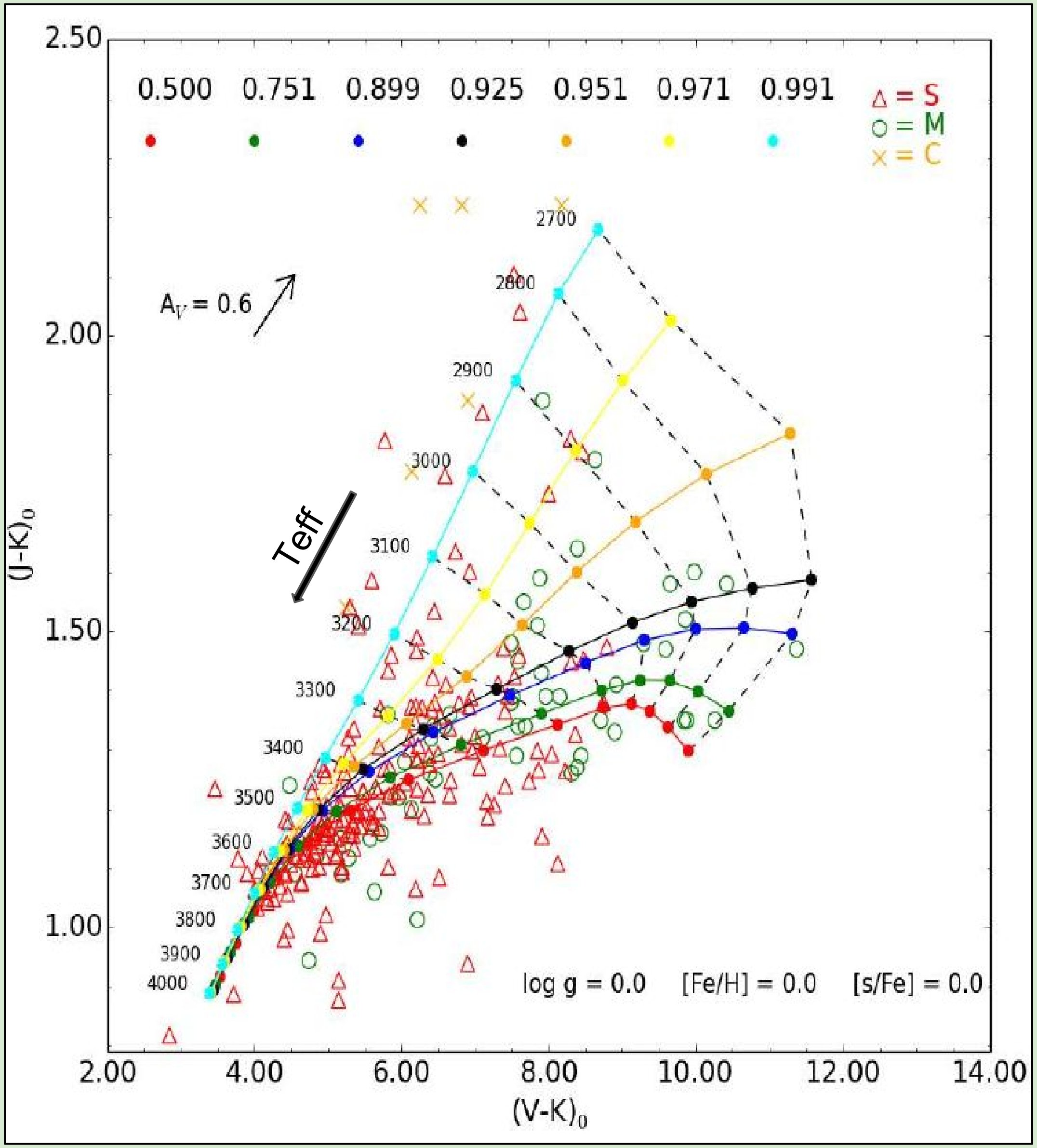
HERMES (KUL) spectrograph mounted on the 1.2m Mercator Telescope at the Roque de Los Muchachos Observatory, La Palma. Raskin G. et al, 2011

MARCS model atmospheres for S stars:

- $2700 \leq T_{eff}(K) \leq 4000$
- [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
- $M = 1\ M_{sun}$
- Microturbulence = 2 km/s



Models : S. Van Eck et al , 2017.Picture credits: P. Neyskens



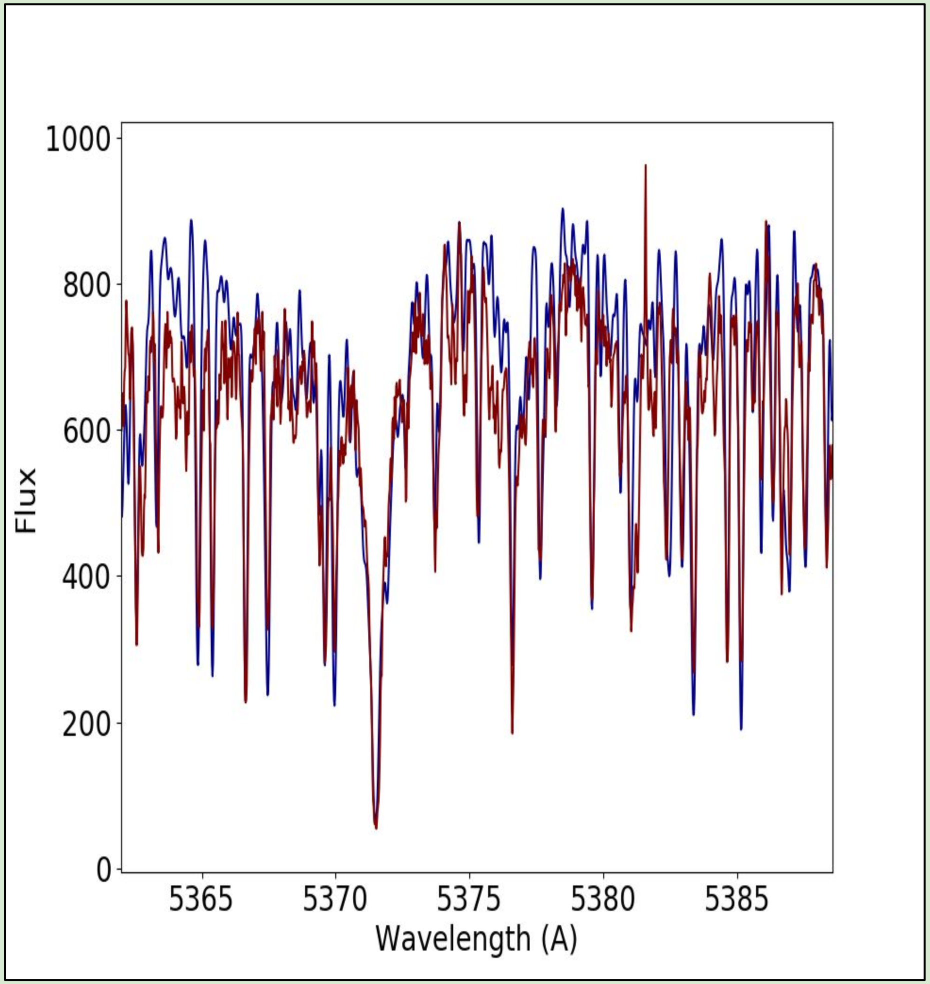
Temperature , C/O , [Fe/H] , [s/Fe]

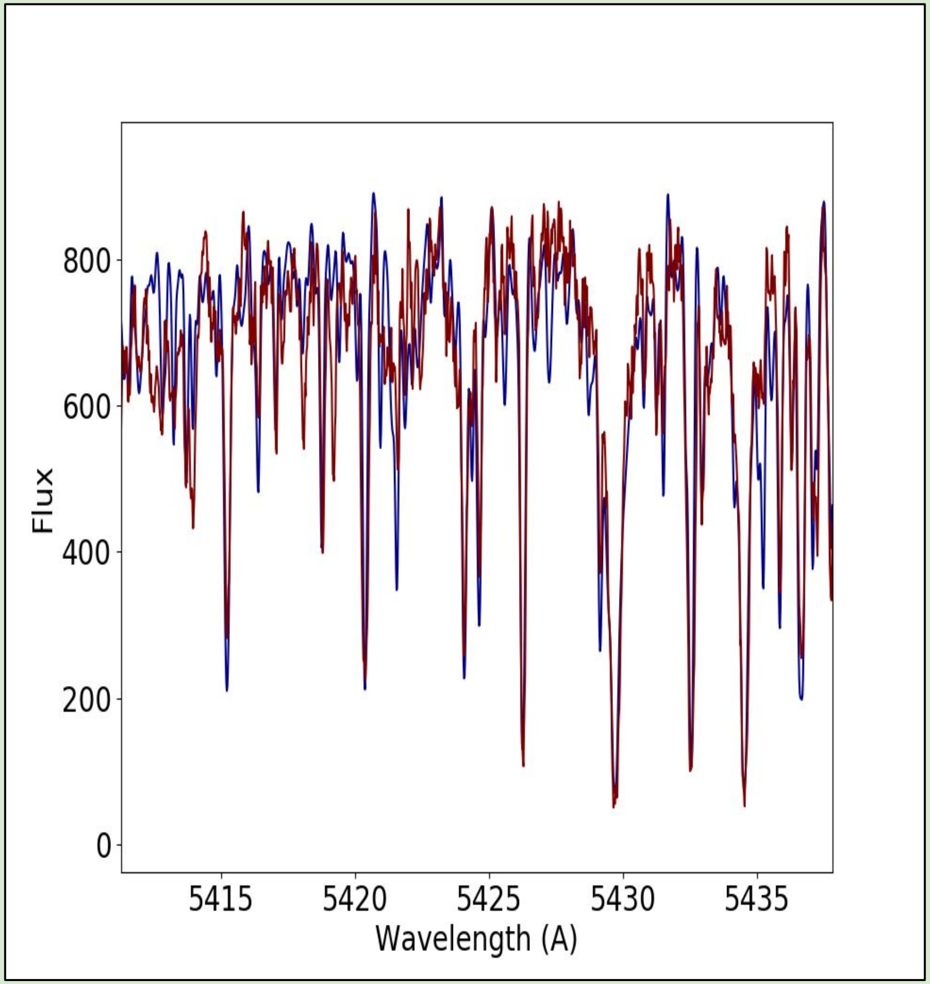
Photometric indices computed for each S star MARCS model atmosphere and compared with observations (S. Van Eck et al, 2017)

Atmospheric parameters by spectral fitting:

1. Grid of Synthetic spectra from MARCS models.
2. Selecting chunks of spectral regions with width 200A in between 4000 Å to 7200 Å ----> Fit (and normalise) the observed with the synthetic spectra.
3. Obtaining the χ^2 values for every spectral region.
4. Then can get the total χ^2 .

Example of χ^2 fitting:



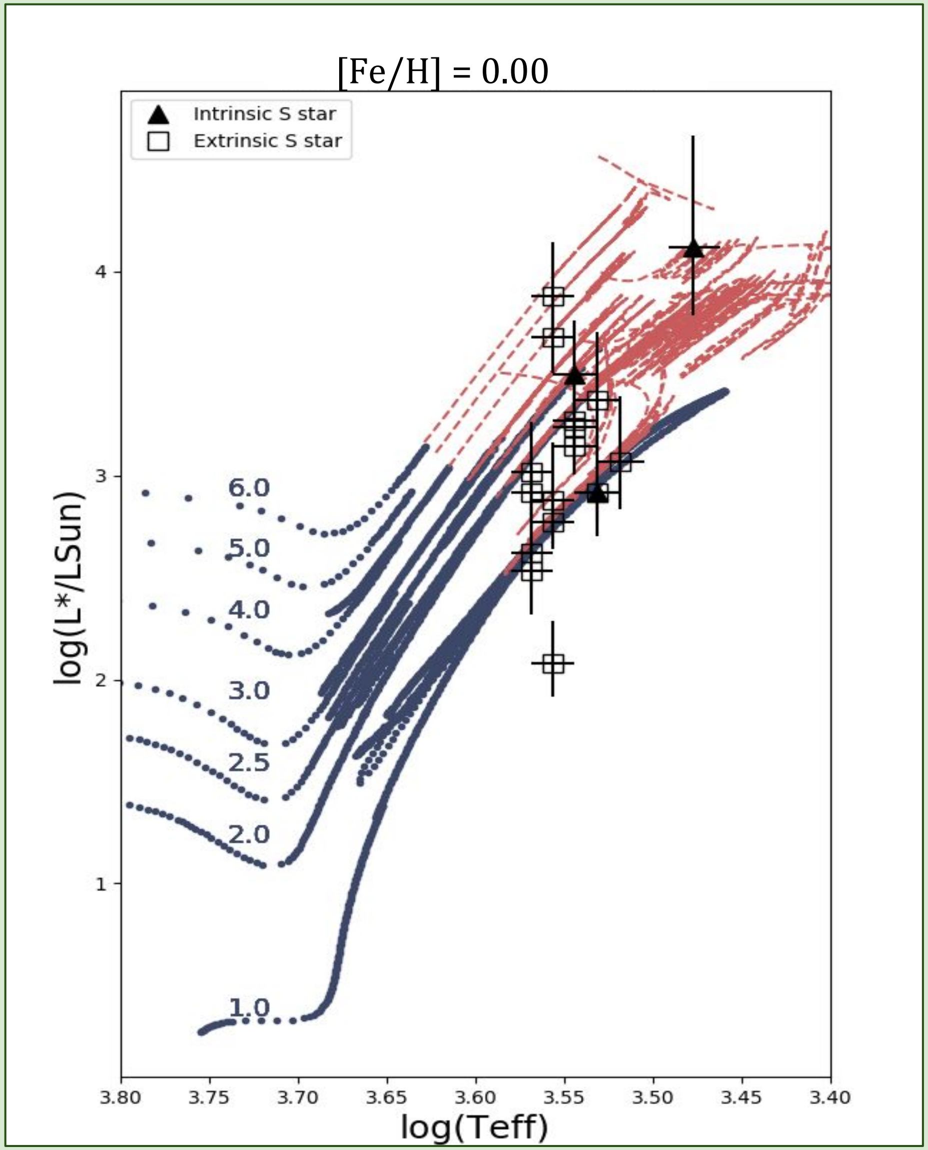


-Observed spectra

-Synthetic spectra

RESULTS:

HRD of S stars:



Intrinsic S stars - Cooler, more luminous objects.

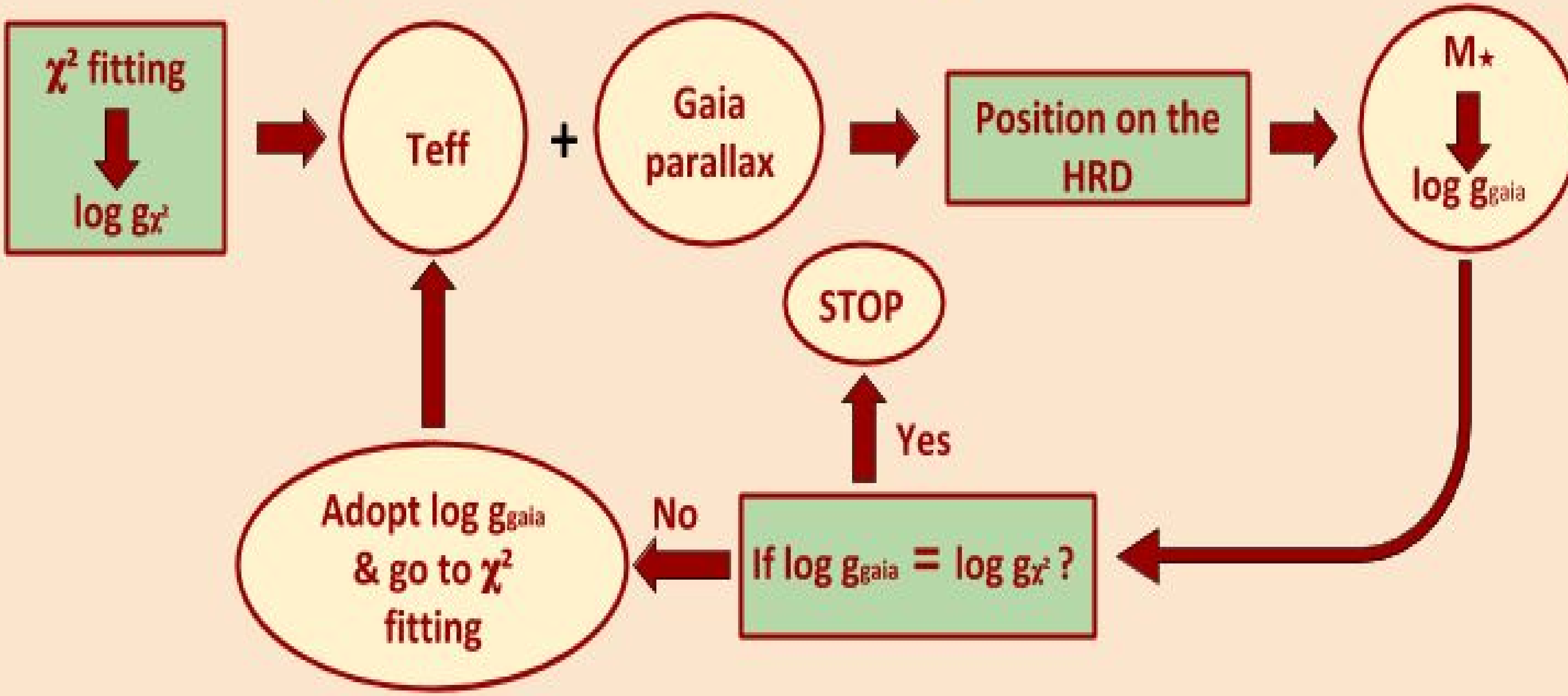
Extrinsic S stars - Hotter, intrinsically fainter

Error bars:

Temperature -- ± 100K
Luminosity -- from $\sigma(\omega)$

Evolutionary tracks from the STAREVOL code (L. Siess et al,2008)

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



Uncertainties in the HRD:

- S Stars with TGAS ($\sigma(\varpi) \leq \varpi/3$) + HERMES studied.

- Limitations of TGAS (missing targets) : Bright stars with G $\leq$ 7, sources close to bright stars, with high proper motion, **extremely blue and red sources.**

- Bias against the Intrinsic S stars.

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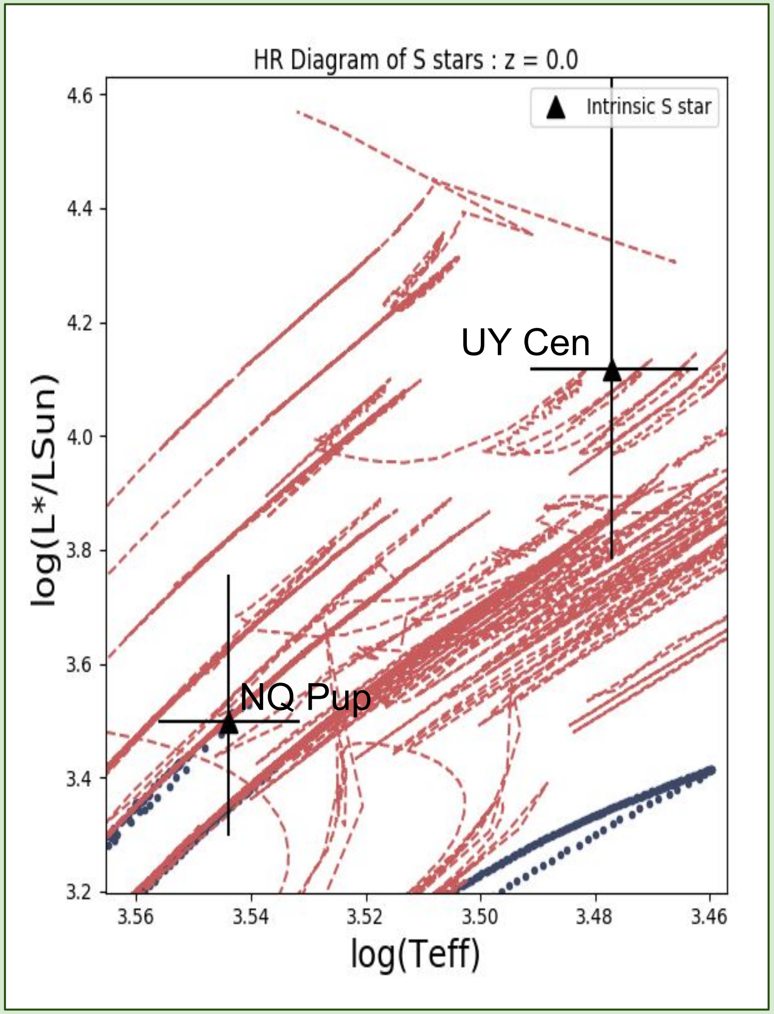
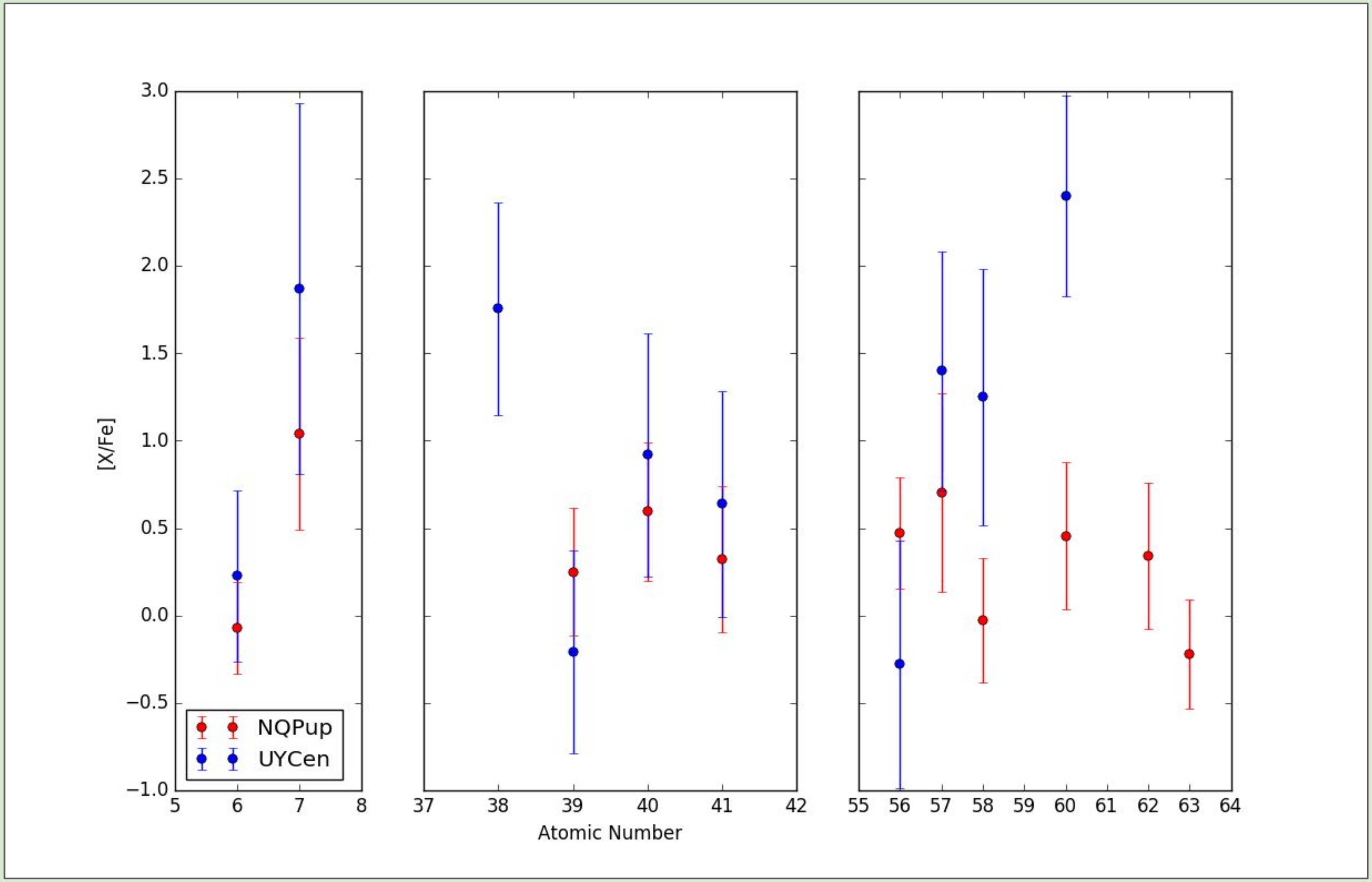
Expecting Gaia DR2 to release accurate parallaxes for more Intrinsic S stars !



Spectroscopically confirmed stellar parameters:

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

Comparison of chemical abundances of NQ Pup and UY Cen (Preliminary result)



Conclusions & Ongoing Work

- TGAS 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 is a work in progress.

THANK YOU