Abundance analysis of symbiotic giants

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Symbiotic stars

S(stellar)
normal giant
80%
$M_g \sim 10^{-7}\ M_{sun}/yr$
$P_{orb} \sim 1\text{-}15\ yr$

•Accreting white dwarf
majority

•Neutron star
•Disk-accreting MS star?
•Black hole?
a few

D(dusty)
Mira + dust evelope
20%
$M_g \sim 10^{-5}\ M_{sun}/yr$
$P_{orb} > 50\ yr$

CVs with very long orbital periods
Important tracers of late phases of stellar evolution
Promising "factory" of SNIa?

Symbiotic stars challenge binary evolution theory

e.g. Mikolajewska 2007; 2012

- Cannot be reproduced by PSM
- Stability of mass transfer in S-types with ellipsoidal light curves (at least 30%) and Mg/Mwd~2-3!!!)
- Asynchroneous rotation of the RG – theory predicts tsyn~100-1000yrs!
- Appearance of NBWDs – lack of SSXSs except systems with low metallicity (galactic halo & SMC)

All symbiotic giants have higher mass loss rates than single giants of the same spectral type

⇩

The symbiotic appearance and activity is triggered by the high mass loss of the giant

It is, however, not clear what triggers the high mass loss rates: Binarity and/or enhanced metallicity?

The link between SyS and other binaries involving red giants

Ba stars, CH-stars & Tc-poor S stars:

- WD companions and orbital elements similar to SyS
- enhancement of s-process elements due to pollution by material matter from the former TP-AGB companion

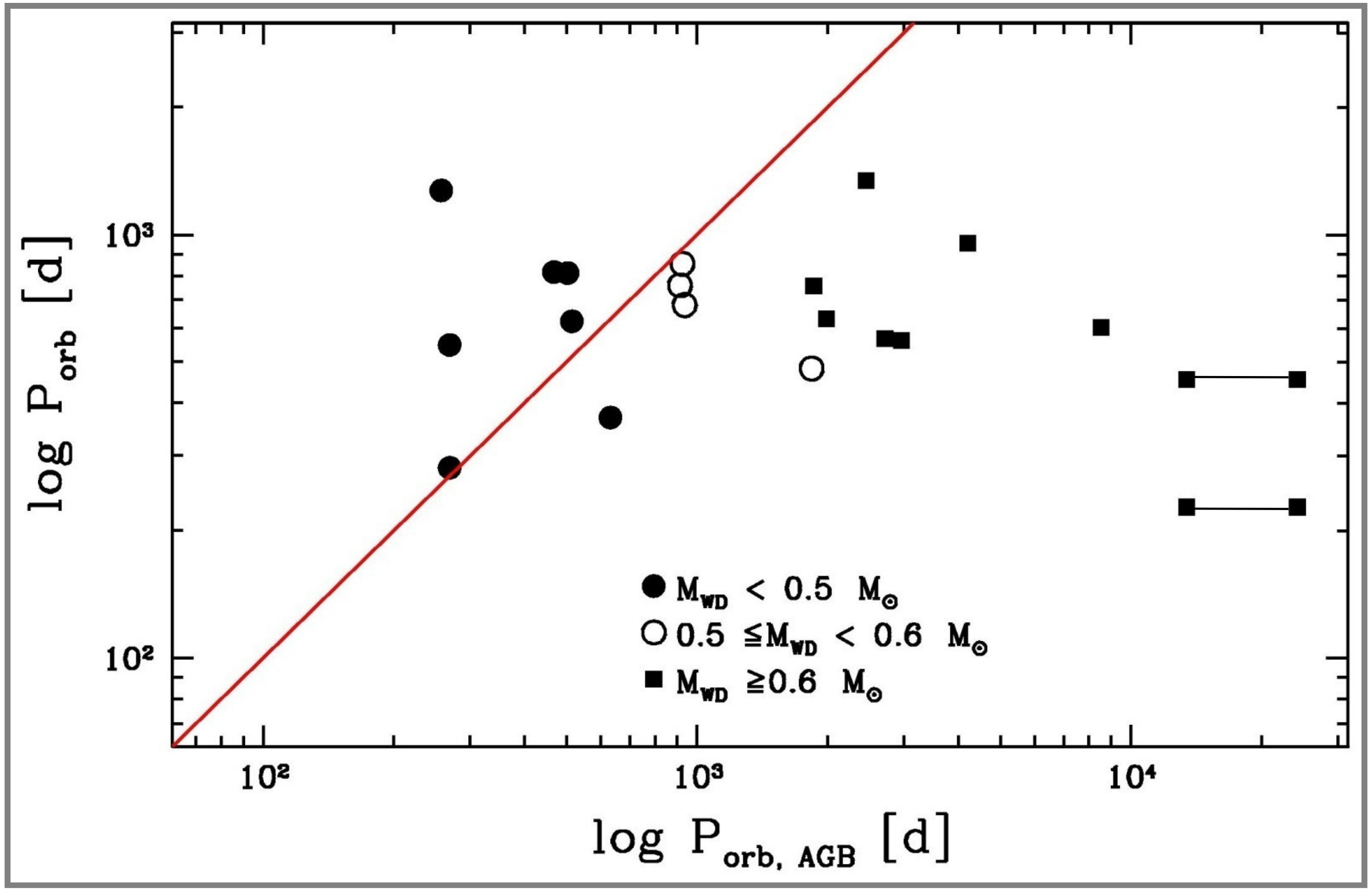
but

they usually do not exhibit symbiotic activity

probably due to their lower mass loss rates

Do SyS exhibit any evidence for pollution by material from the former TP-AGB companion?

The AGB progenitor of the HC



For all WD>0.6 Msun the present P_{orb} shorter than $P_{orb,AGB}$

What we know about chemical abundances of symbiotic stars?

UV emission line analysis of 24 SyS (Nussbaumer et al. 1988): relative CNO ratios place SyS among red giants.

Photospheric abundances:

- **AG Dra, BD-21 3873 & He2-467, yellow SYS, with K giants: metal poor with [Fe/H]<-1 & s-process overabundant (Smith et al. 1996, 1997; Pereira et al. 1998)**
- **HD 330036, AS 201 & StHA 190, D' systems with G giants & warm dust: high $v_g \sin i$, [Fe/H]~0 & s-process overabundant (Smith et al. 2001; Pereira et al. 2005)**

No evidence for s-process overabundances in red SyS... (Schmidt et al. 2005)

Why most of SyS don't exhibit s-process element enhancement as do Ba and S stars?

Possible answers:

- $M_{wd} < 0.45\ M_{sun}$ - maybe true in some SyS but not in most of them

- $Z > Z_{sun}$ - possibly: JHK colours similar to high Z giants in the Galactic Buldge (Whitelock & Munari 1992)

to be confirmed spectroscopically

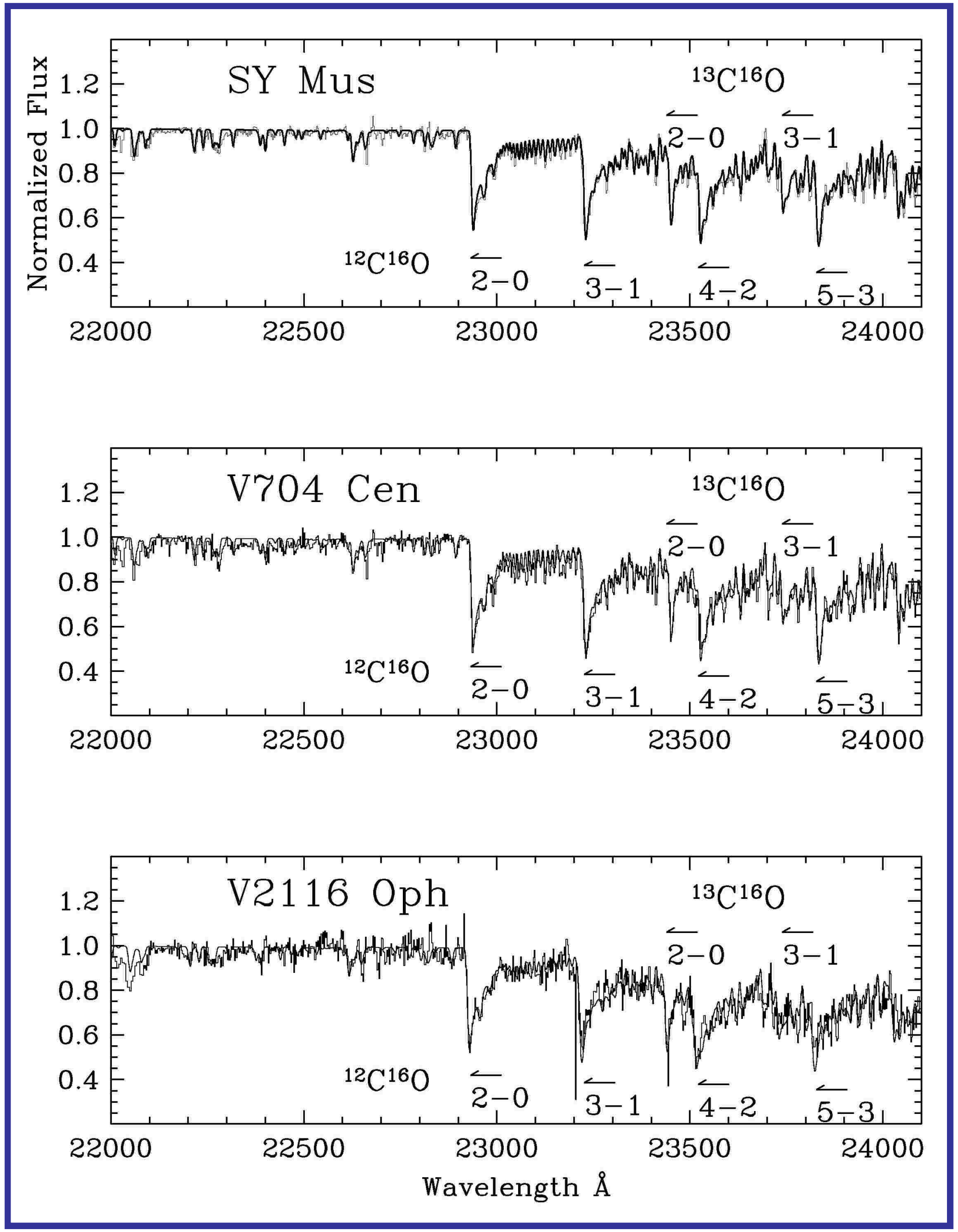
Data & method

High & medium resolution near-IR spectra:

- Phoenix at Gemini South: ~ 30 SyS
- IRSPEC at NTT: 10 SyS
- FTS at 4m KPNO: CH Cyg...

&

Standard LTE analysis and atmosphere models, and spectrum synthesis



NTT spectra

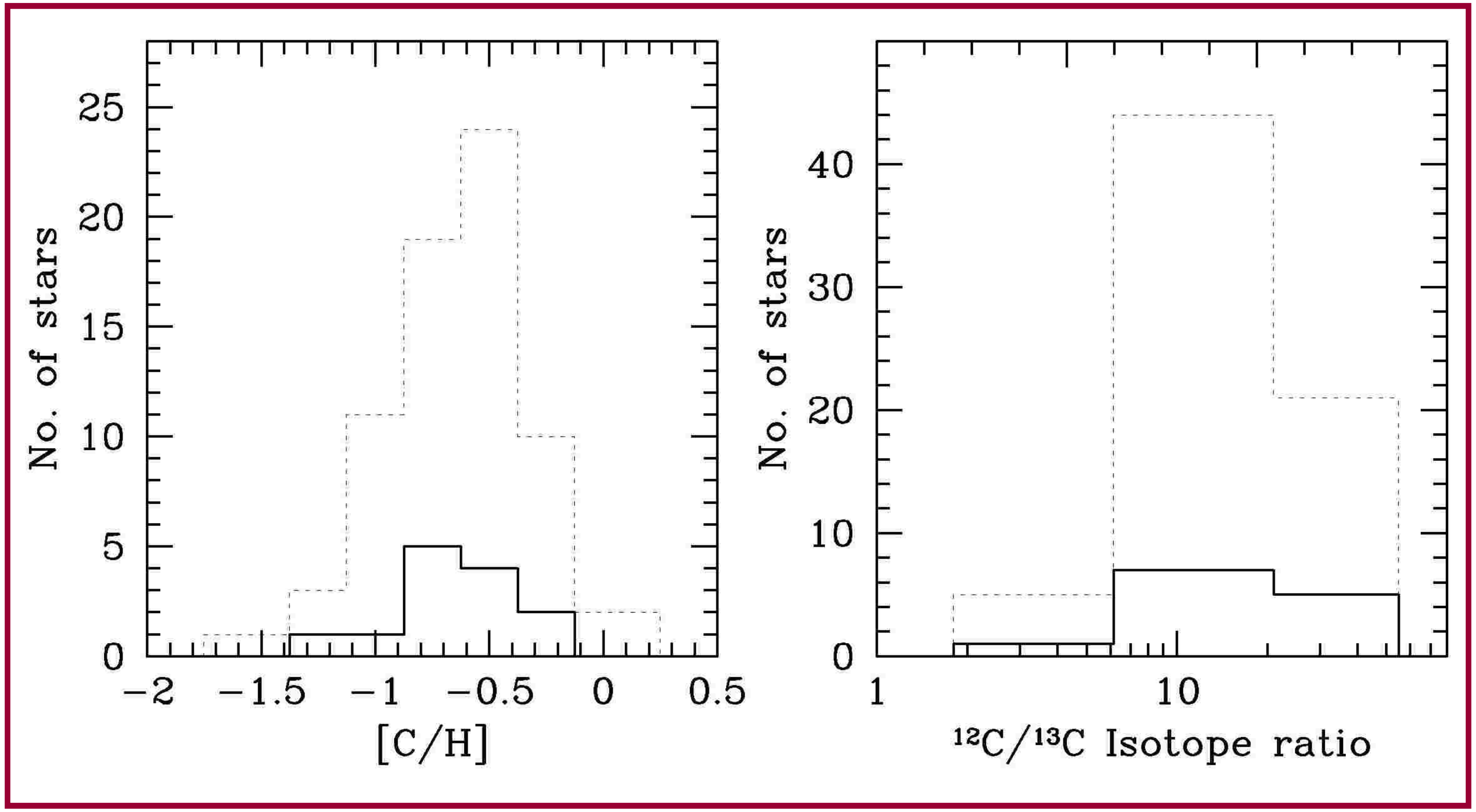
Normalized K-band spectra (thin lines) and synthetic spectra models (thick lines) (Schmidt & Mikołajewska 2003)

6 SyS (7studied) have 12C/13C<20

Also Schild et al. (1992)

4(6 studied) 12C/13C<~10

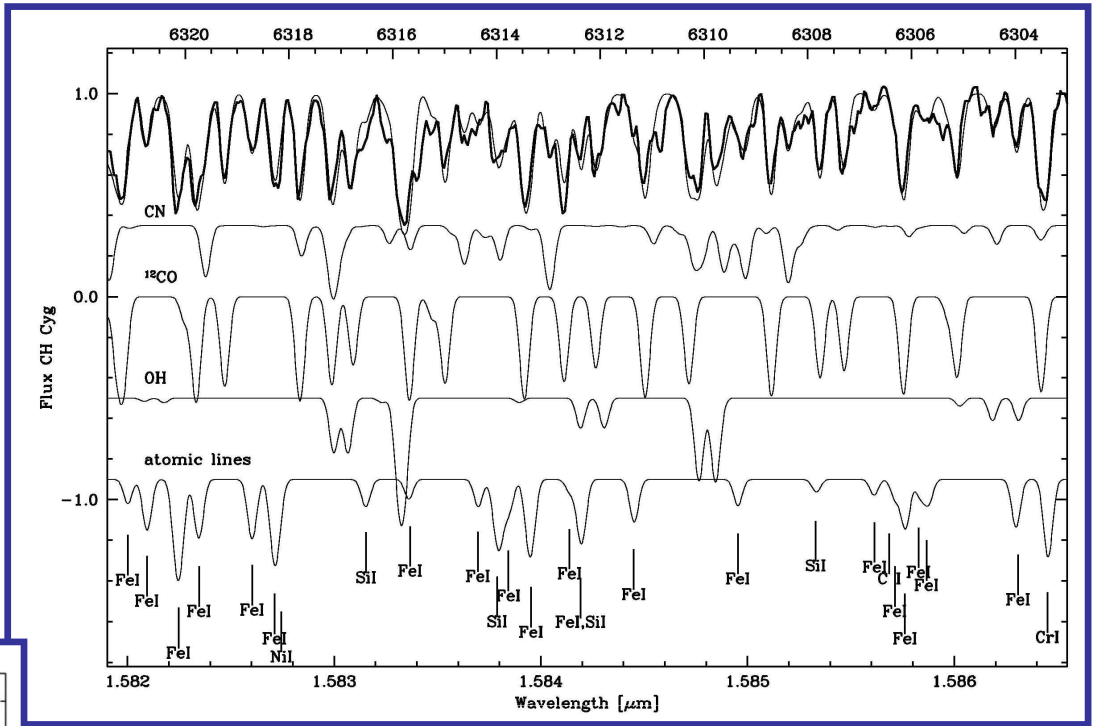
Carbon abundance

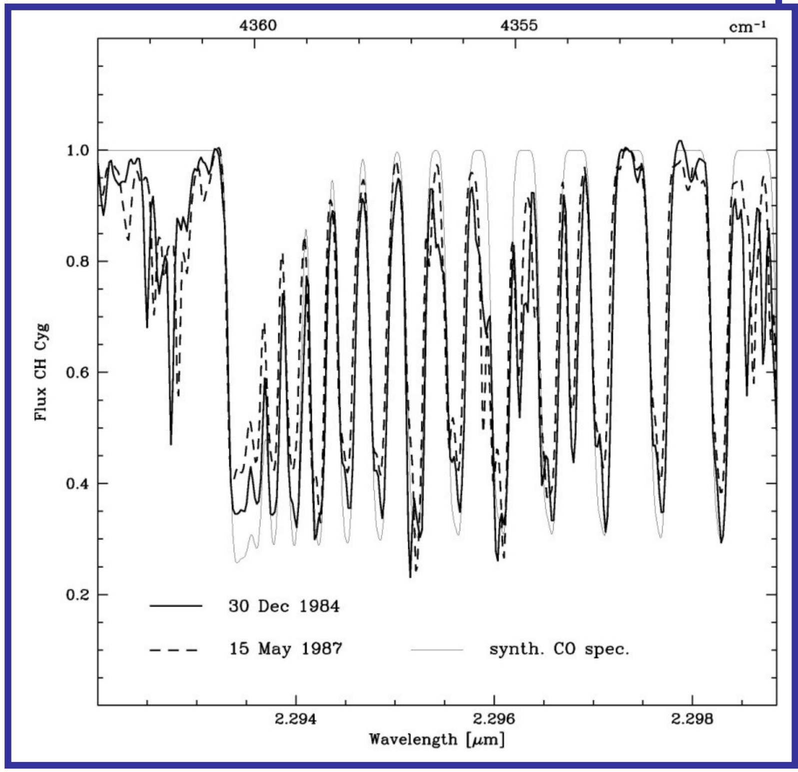


Comparison of symbiotic stars (thick lines) with single field M giants (dotted lines); from Schmidt & Mikołajewska 2003

CH Cyg

The first photosperic abundances for the M giant in S type SyS (Schmidt et al. 2005)





•[Fe/H]~0

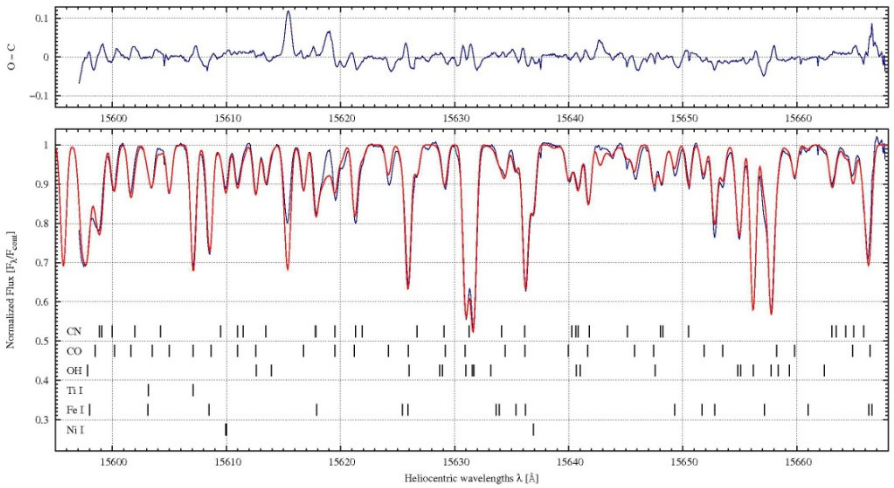
•[C/H]=-0.15; [N/H]=0.16; [O/H]=-0.07 like in single field M giants;

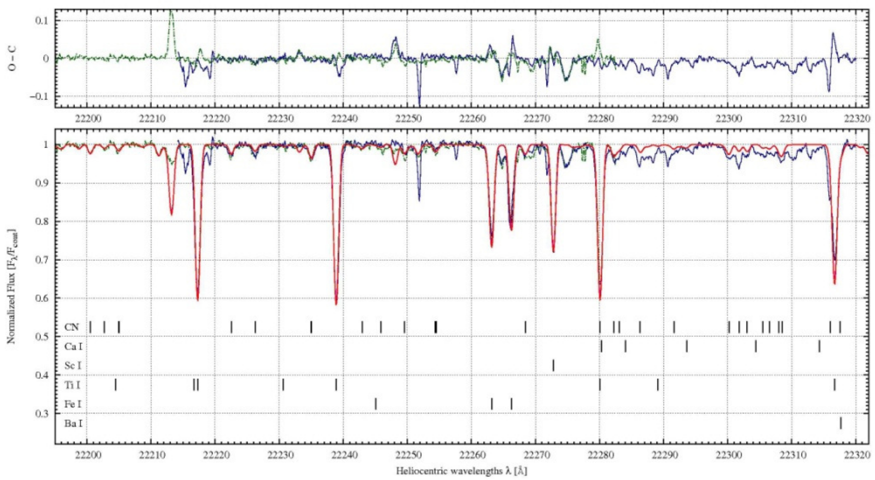
•^{12}C/^{13}C=18; ^{16}O/^{17}O=830 agree with giants experiencing the 1st dredge-up

•CNO ratios from emission lines
⇨ N overestimated by a factor of a few

Phoenix spectra of RW Hya

Mikołajewska et al. 2013, in preparation





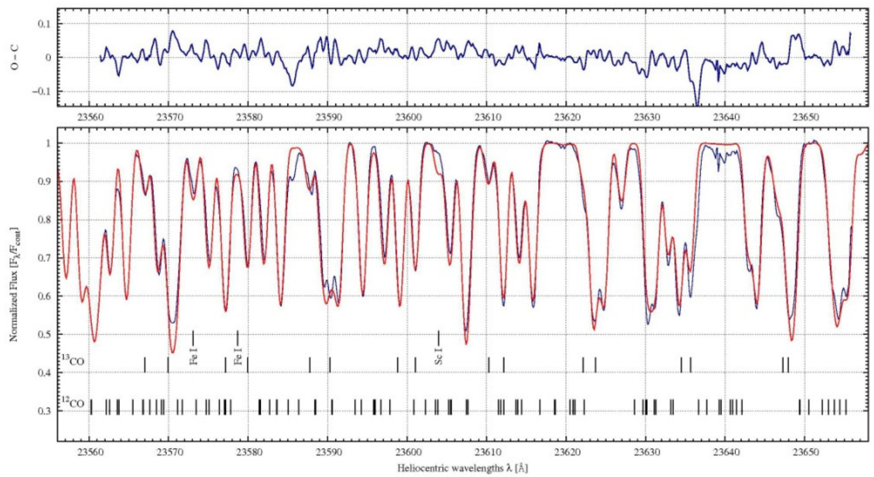


Table 3. Calculated abundances ($\log \epsilon(\chi)$) and errors (triple standard deviations) for RW Hya and SY Mus. Relative to the Sun [χ] abundances were estimated in relation to the Solar composition by Asplund et al. (2009). The numbers of lines (n) used in the analysis are also given.

	RW Hya		SY Mus		
χ	$\log \epsilon(\chi)$	[χ]	$\log \epsilon(\chi)$	[χ]	n
^{12}C	7.73 ± 0.08	-0.70 ± 0.13	8.10 ± 0.11	-0.33 ± 0.16	90
N	7.88 ± 0.13	+0.05 ± 0.18	8.11 ± 0.15	+0.28 ± 0.20	62
O	8.62 ± 0.08	-0.07 ± 0.13	8.58 ± 0.07	-0.11 ± 0.12	49
Sc	2.89 ± 0.29	-0.26 ± 0.33	4.02 ± 0.59	+0.87 ± 0.63	1
Ti	4.67 ± 0.33	-0.28 ± 0.38	5.13 ± 0.38	+0.18 ± 0.43	10
Fe	6.83 ± 0.12	-0.67 ± 0.16	7.39 ± 0.13	-0.11 ± 0.17	20
Ni	5.72 ± 0.21	-0.50 ± 0.25	6.36 ± 0.24	+0.14 ± 0.28	3
^{12}C/^{13}C	6.2 ± 1.0	...	8.0 ± 0.7	...	$\frac{88}{16}$ ⋆

⋆ The numbers of lines that have been used to estimate ^{12}C/^{13}C isotopic ratio: it was 88 lines for isotope ^{12}C and 16 lines for ^{13}C.

RW Hya (Otulakowska-Hypka et al. 2013):
Mg~3.5 Msun; Mwd=0.8 Msun

Concluding remarks

Short-period S-type symbiotics:

- **Low 12C/13C<10, [N/C]>0.5, [O/N]<solar**
- **Important for TNR modelling (novae, SSXS…)**

Ongoing:

ZrO, YO in the optical – evidence for pollution by the former TP-AGB companion?

Li-rich companions of massive WDs (SyRNe, other?)