Fluorine and s-element abundances in carbon stars

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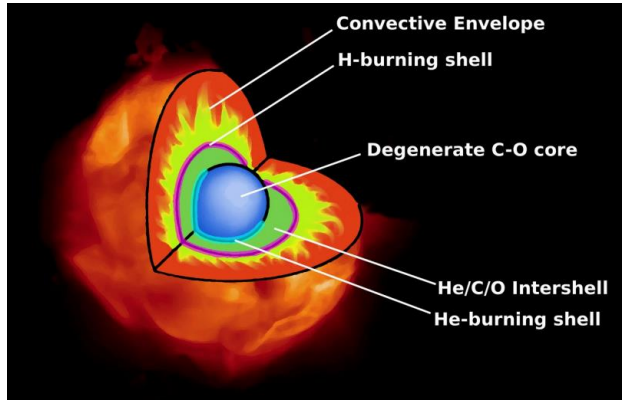


The dominant source of ^{19}F remains uncertain, and multiple production sites have been proposed:

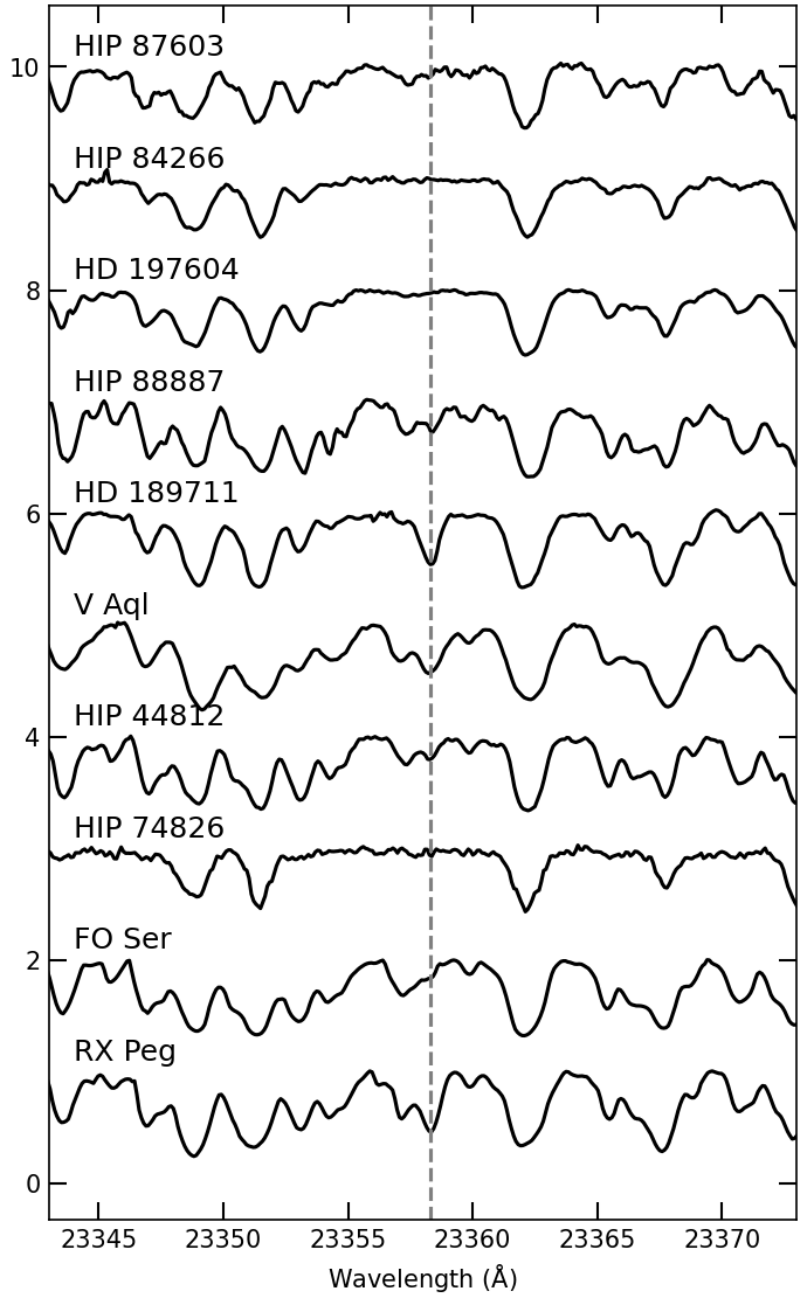
1. **<u>Thermal-pulsing asymptotic giant branch (AGB) stars</u>**
2. The v-process in core-collapse supernovae
3. Wolf-Rayet stars
4. Rapidly rotating massive stars
5. Novae

In the AGB phase, deep convective currents following thermal instability of the He-burning shell dredge up carbon, fluorine, and s-process elements.

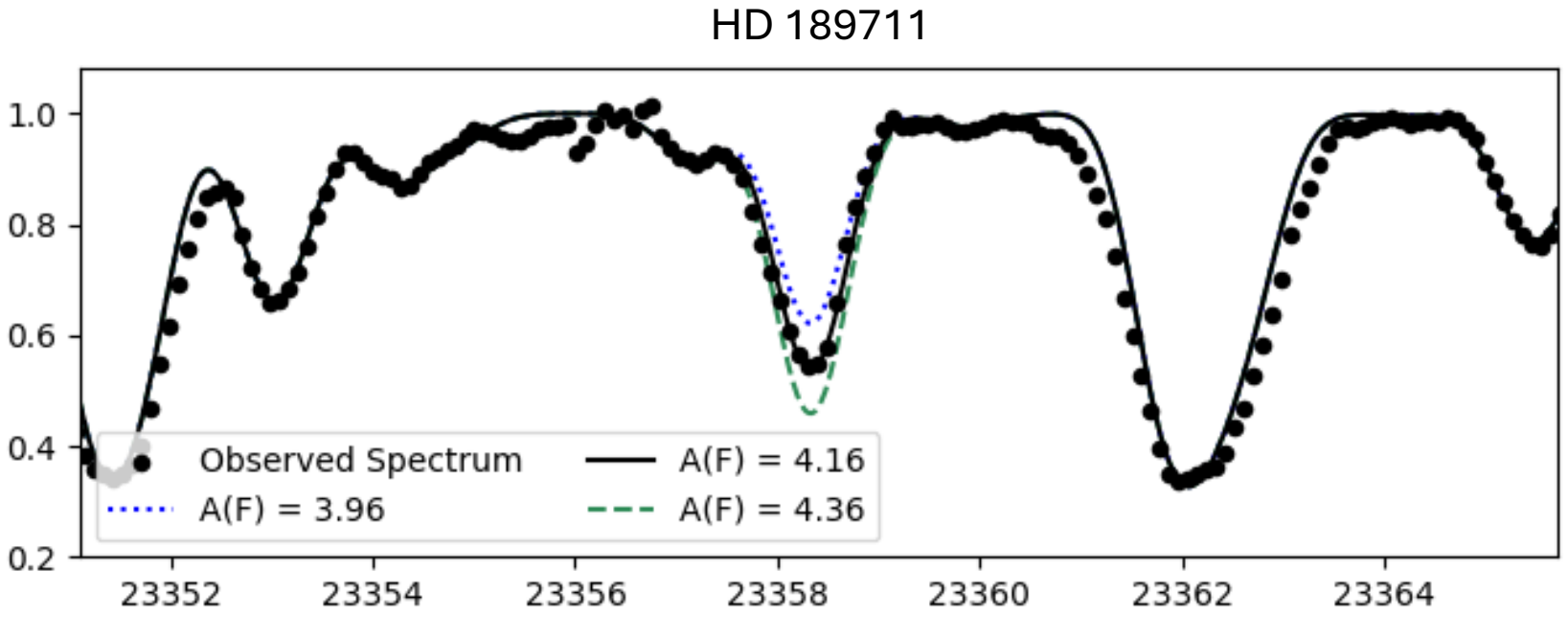
→ We investigate F abundances in 10 carbon-rich stars of spectral type N, R, and J at C/O ratios ≥ 1.1.

Carbon star sample

- High-resolution, near-IR spectra from the iSHELL spectrograph at the 3-meter NASA InfraRed Telescope Facility (IRTF)
- 10 carbon-rich stars with C/O ≥ 1.1
- The 23358.329 Å (1-0) R9 feature of HF was used for analysis



Analysis

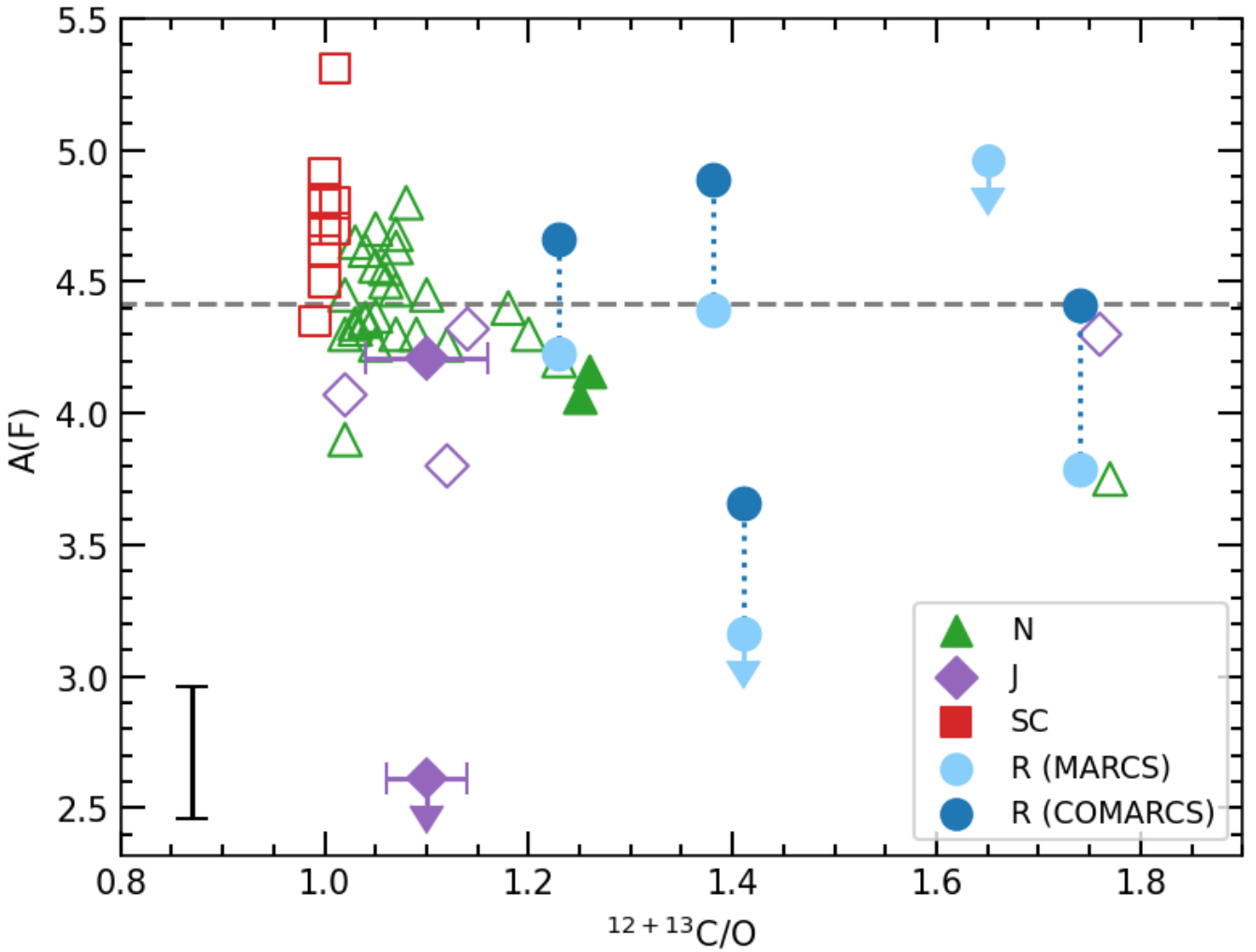


- Synthetic spectra computed using the spectral analysis code MOOG
- Model atmospheres:
  - COMARCS models (Aringer et al. 2009, 2019), selecting the model closest in temperature, log g, and C/O ratio
  - MARCS (Gustafsson et al. 2008) models for two stars with no available COMARCS models
  - For program stars with Teff > 4000 K, we also compute MARCS models for comparison

Results

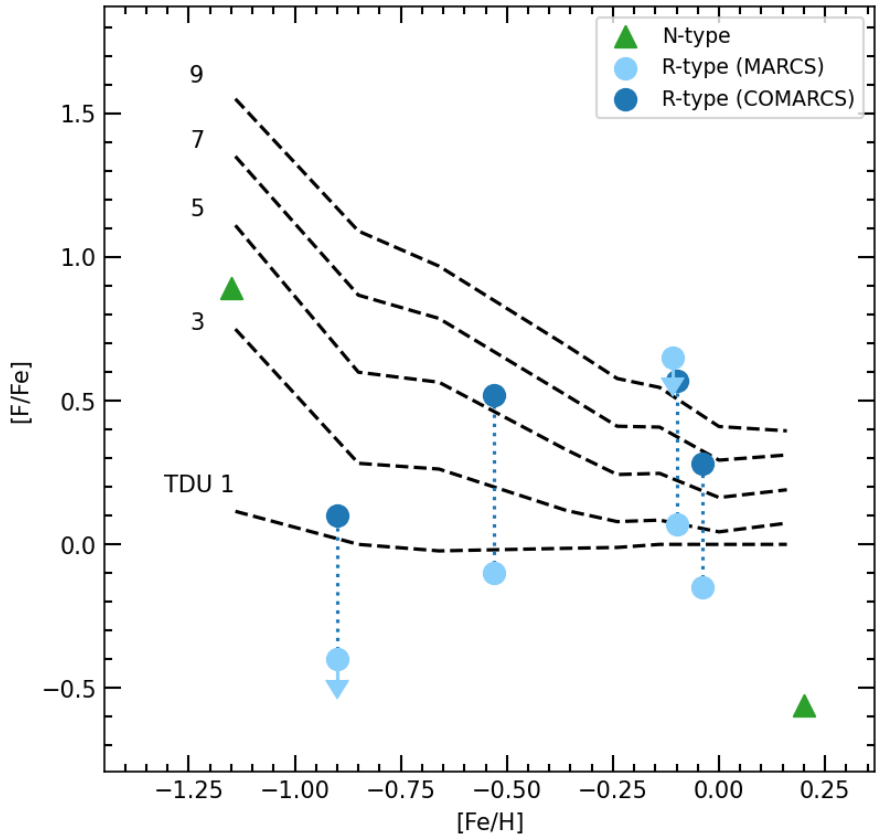
- **N-type**: the intrinsic consequence of C being dredged up in TDU
- **Early R-type**: origin uncertain; may be core-He burning stars (not on the AGB) with C enriched envelopes from a He-flash
- **J-type stars**: origin uncertain; may be descendants of R stars → they are AGB stars who do not experience TDU events due to their low mass (1–2 $M_{\odot}$)

Sequence of spectral types M-MS-S-SC-C(N-type)

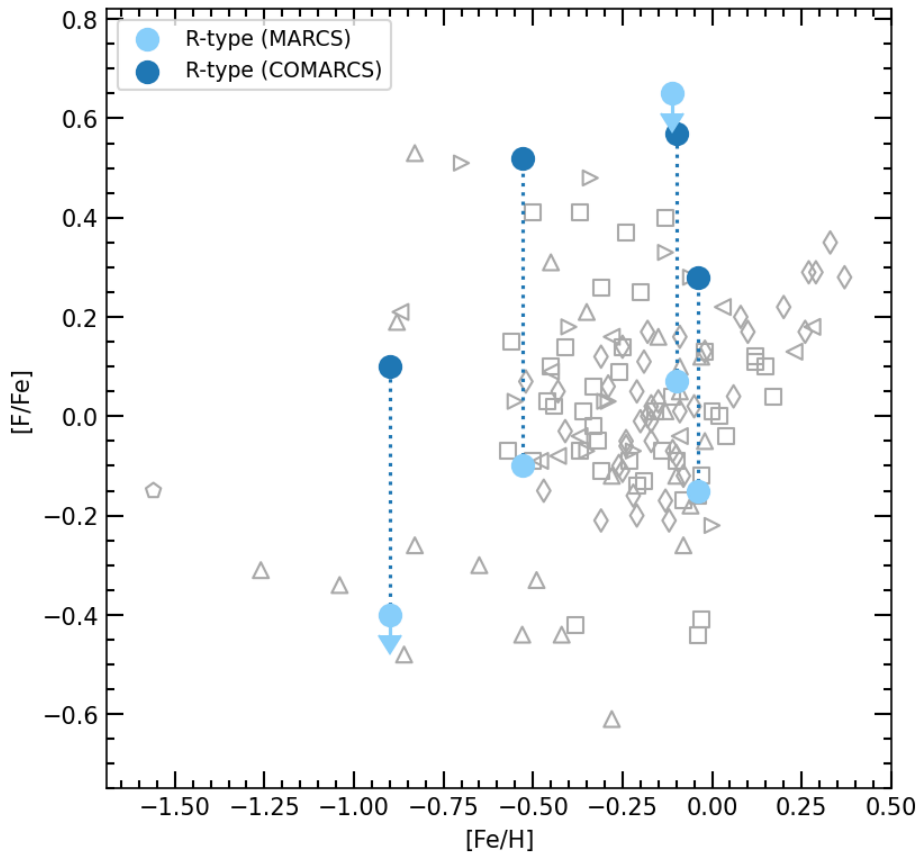


Results

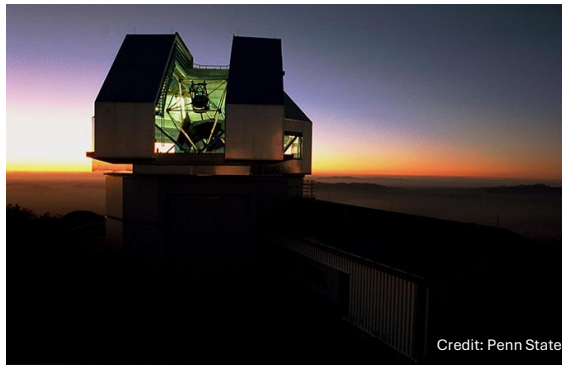
- Observed F abundances and FRUITY models (Cristallo et al. 2011, 2015)
- Low metallicity HD 189711 ([Fe/H] = −1.15): [F/Fe] = 0.89



- Derived F abundances vs. metallicity, compared to normal giants from the literature.
- The R stars in our sample may reflect the trends of the galactic evolution of F better than the [F/Fe] ratios anticipated from TDU events.



Future Work: s-elements with NEID spectra



Site	Kitt Peak National Observatory, Arizona, USA
Telescope	WIYN 3.5-m Telescope
Type	Radial Velocity Spectrograph
Wavelength range	380-930 nm
Spectral resolution	High-Resolution Mode: R ~ 120k High-Efficiency Mode: R ~ 70k

s-elements to measure: technetium (Tc) in R stars, Nb, Mo, Ce, and Pr

Other elements: Fe, Li, Ti, V, Sc, Cr, Mn, Co, Ru, Eu, Gd

→Construct plots of [F/<s>] vs. [<s>/Fe]