Fluorine Abundances in Cool Extreme Helium Stars

Scenarios proposed as the potential sources of F

- Explosions of Type II supernovae (SNe), by the process referred to as v(nu)-process, can convert 20Ne into 19F (Woosley & Haxton 1988).
- Stellar winds from Wolf-Rayet (W-R) stars (Meynet & Arnould 2000).
- The third dredge-up of asymptotic giant branch (AGB) stars (Forestini et al. 1992).

- The reaction chain for F production in W-R stars and AGB stars is

  14N(α,γ)18F(β+)180(p,α)15N(α, γ)19F, where protons are liberated through 13C(α,n)160 followed by neutron captures, 14N(n,p)14C.
- To discriminate between the three possible scenarios of F production accurate measurements of F abundances in these objects are needed.
- Extreme helium (EHe) stars are suggested to have gone through AGB phase in its earlier evolution, hence, F should be present in their atmospheres.
- Presence of F in EHe’s atmosphere can serve as test bed for F production in AGB stars.

Measurements of F abundance

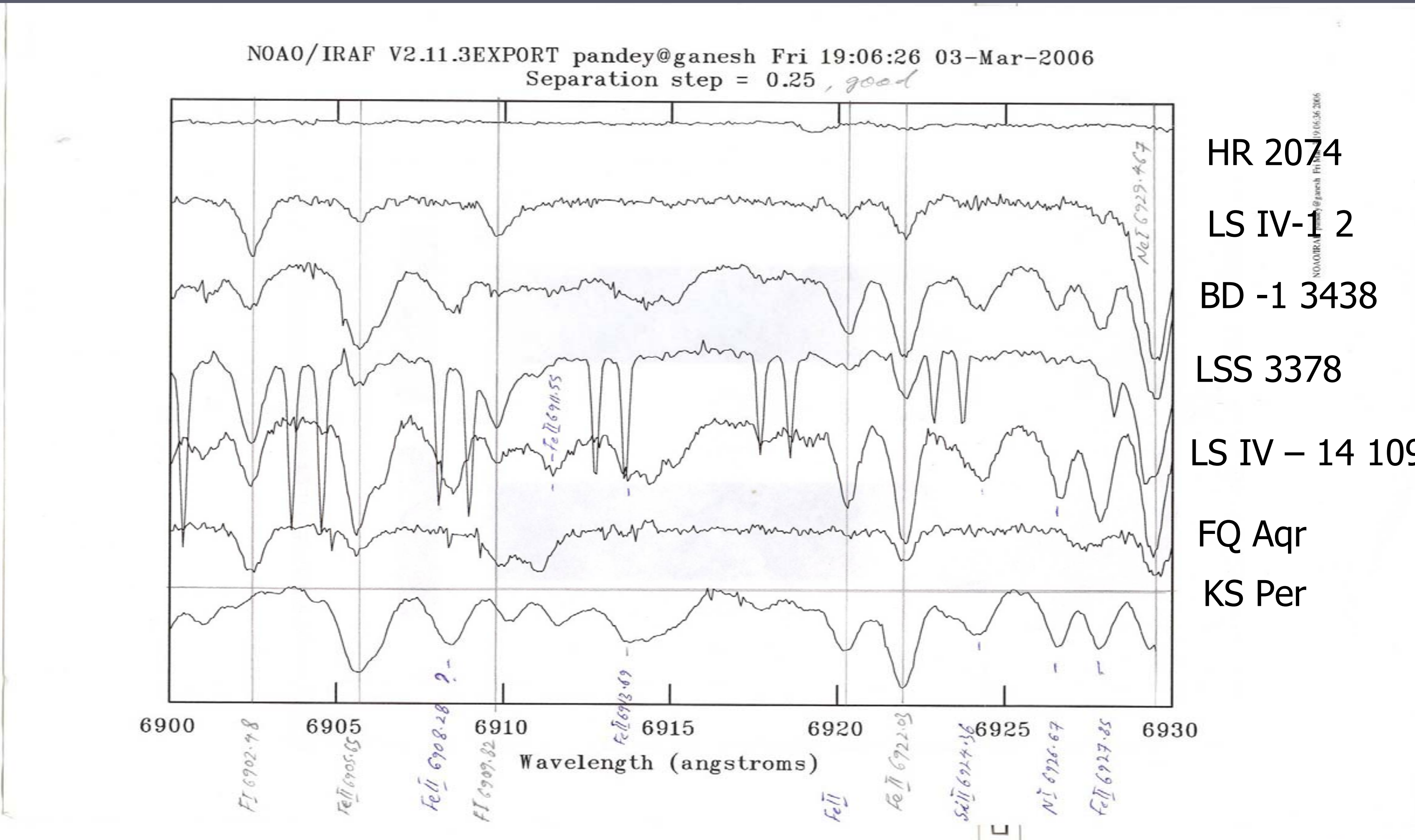
- Hall & Noyes (1969) measured F abundance from their identification of the fundamental vibration-rotation band of HF in sunspot spectra at 2.3μ .
- In red giants by Jorrissen et al. (1992), infrared HF vibration-rotation transition were used. They found enhanced F in C-rich stars, providing evidence of F production in AGB stars.
- Jorrissen et al's results were supported by observations of F V and F VI absorption lines in the far-UV spectra of hot post-AGB stars (Werner et al. 2005).

- F I λ955 interstellar absorption in two sight lines towards the Cep OB2 association using Far Ultraviolet Spectroscopic Explorer (Federman et al. 2005). No evidence of enhanced F resulting from the v(nu)-process in Type II SNe.
- Zhang & Liu (2005) determine F abundances from the [F II] λ4789 and [F IV] λ4060 nebular emission lines for a sample of PNe. F is abundant in PNe – evidence of F synthesis in AGB stars.

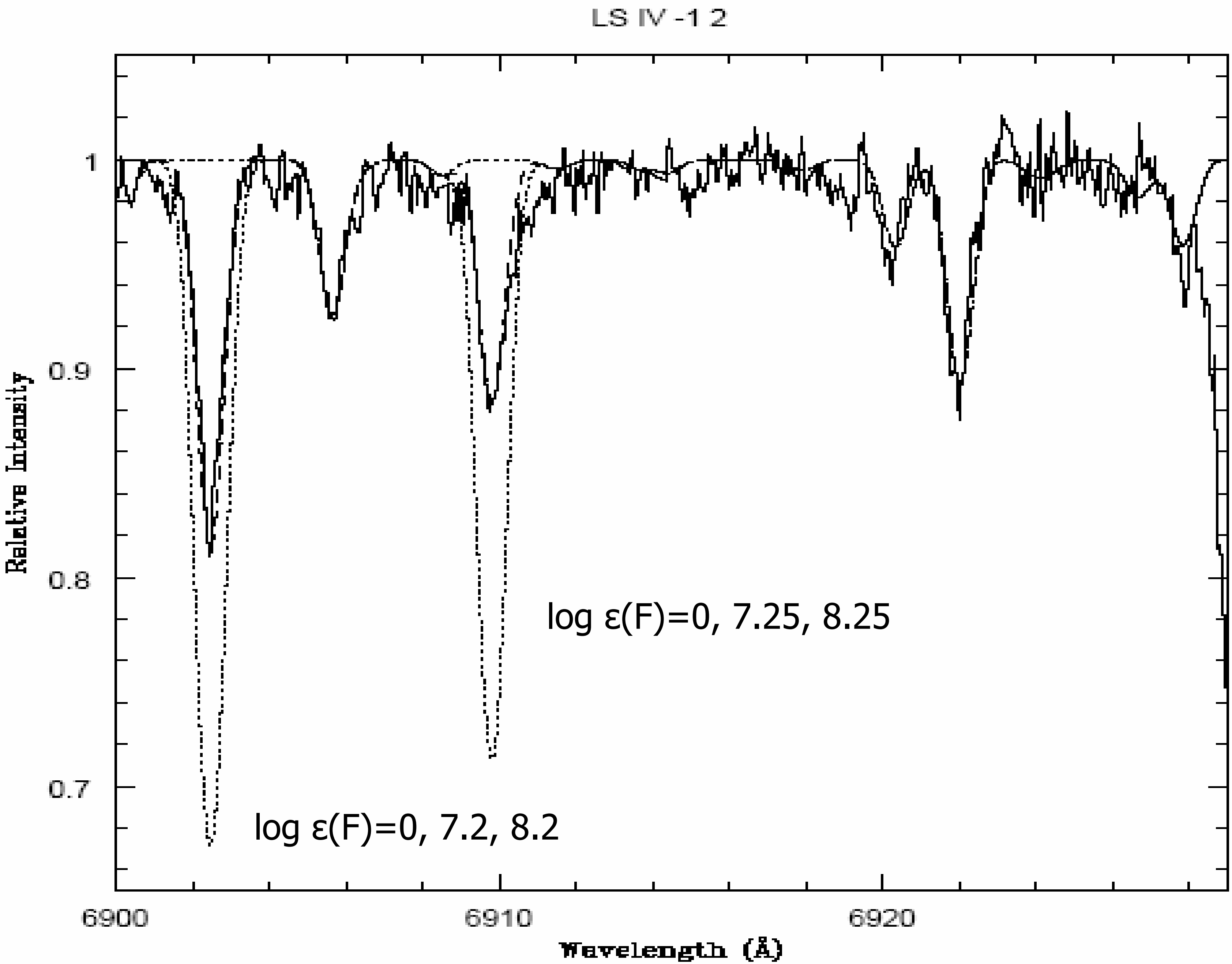
Searching For F I lines in cool EHes

F I lines from 3s - 3p transition array detected in the spectra of the analysed stars. The F I lines used in abundance determination for all the analysed stars are shown in bold

RMT	λ (Å)	χ (eV)	log gf	Contributors
1	**7482.72**	12.73	−0.66	F I, C I λ7483.445Å (red wing), Fe II λ7482.777Å (weak)
	7514.93	12.75	−0.96	F I
	7331.95	12.70	−0.11	F I, Fe II λ7332.115Å
	7425.64	12.73	−0.19	F I, Fe II λ7425.095Å
	7552.24	12.73	−0.34	F I
	7573.41	12.75	−0.34	F I
2	**6856.02**	12.70	+0.44	F I, Fe II λ6855.646Å
	6902.46	12.73	+0.18	F I
	6909.82	12.75	−0.23	F I
	6773.97	12.70	−0.40	F I, Fe II λ6774.473Å (red wing)
	6834.26	12.73	−0.21	F I
	6795.52	12.73	−1.09	F I
4	**7754.70**	12.98	+0.24	F I, Ti II λ7755.751Å (red wing)
	7800.22	13.03	+0.04	F I, Si I λ7799.996Å (weak), Fe II λ7801.235Å (red wing)
6	**7037.45**	12.98	+0.10	F I
	7127.88	13.03	−0.12	F I
	6966.35	12.98	−1.01	F I
	7202.37	13.03	−0.33	F I, C I λ7202.267Å

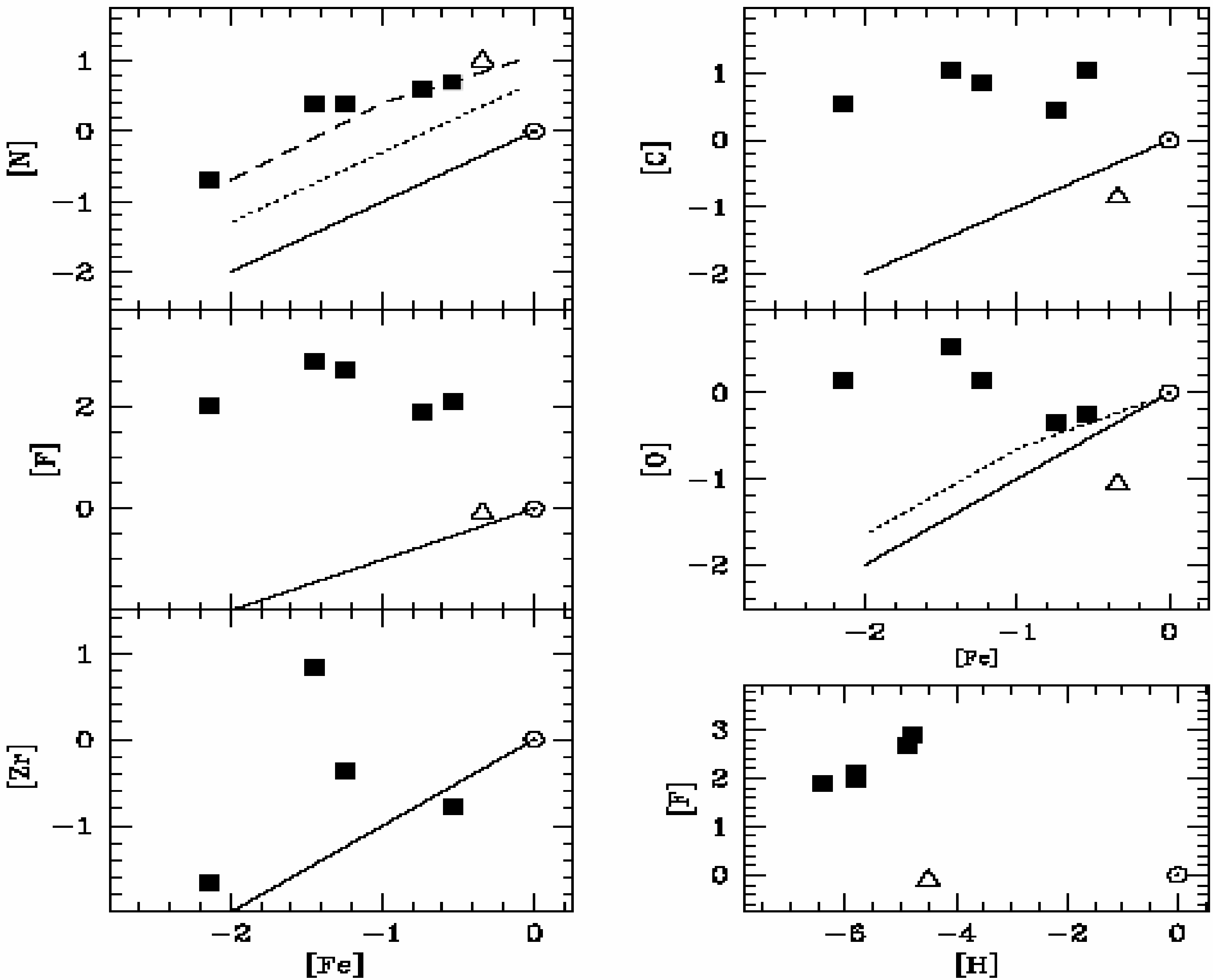


NOAO/IRAF V2.11.3EXPORT pandey@ganesh Fri 19:06:26 03-Mar-2006
Separation step = 0.25 , good
HR 2074
LS IV-1 2
BD -1 3438
LSS 3378
LS IV – 14 109
FQ Aqr
KS Per
6900
6905
6910
6915
6920
6925
6930
Wavelength (angstroms)


LS IV -1 2
Relative Intensity
1
0.9
0.8
0.7
6900
6910
6920
Wavelength (Å)
log ε(F)=0, 7.25, 8.25
log ε(F)=0, 7.2, 8.2

Final F abundances

FQ Aqr	6.5+/- 0.14
LS IV -14 109	6.6 +/-0.19
LSS 3378	7.4 +/-0.20
BD -1 3438	6.4 +/-0.14
LS IV -1 2	7.2 +/-0.10
KS Per	<4.4
Sun	4.53


[N]
[F]
[Zr]
[Fe]
[C]
[O]
[Fe]
[F]
[H]

- ^{19}F is synthesized and then dredged upto the surface during the He-burning thermal pulses.
- 19F abundances can in principle be used to probe the neutron source in EHes, since 19F(α,p)22Ne did not destroy 19F.
- The rate for 19F(α,p)22Ne is about 20 times faster than 22Ne(α,n)25Mg in the T_8 = 2.0 - 3.5K temperature range, 19F cannot survive in layers where neutrons are being liberated by 22Ne(α,n)25Mg.
- Hence 22Ne(α,n)25Mg is not the source of neutrons in cool EHes, instead, 13C(α,n)16O is the neutron source.

THANK YOU.