Studying terminal boundary conditions of stellar evolution: Selected properties of white dwarfs and their environment (Vila Lanna April 14, 2014)

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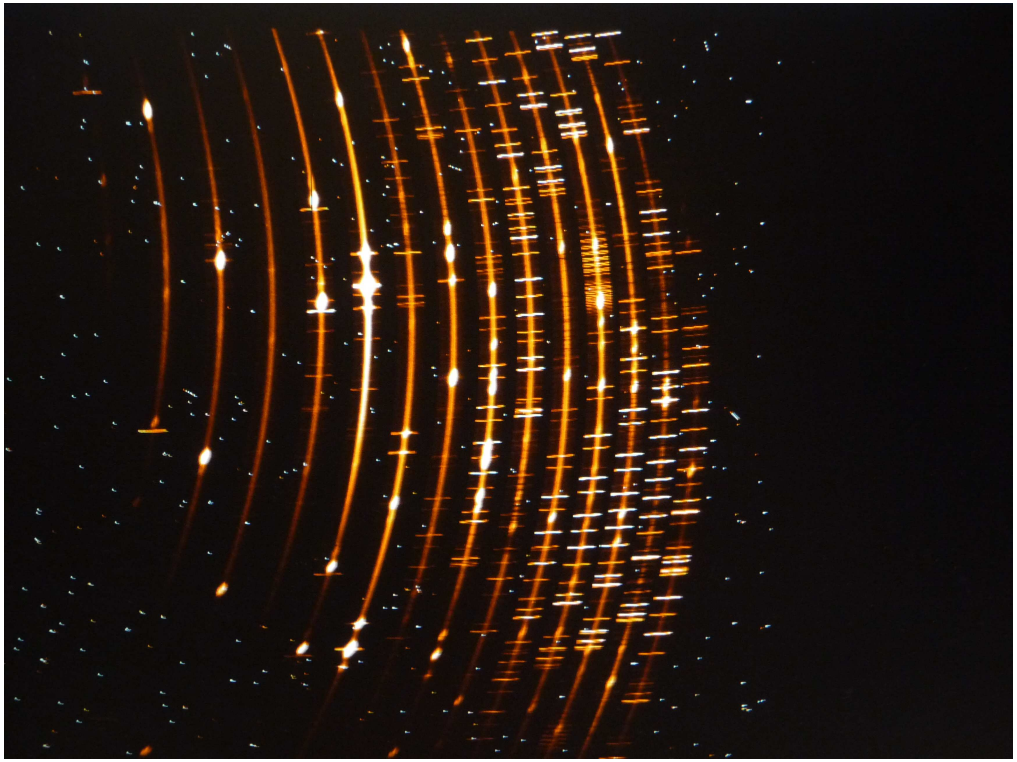
Overview

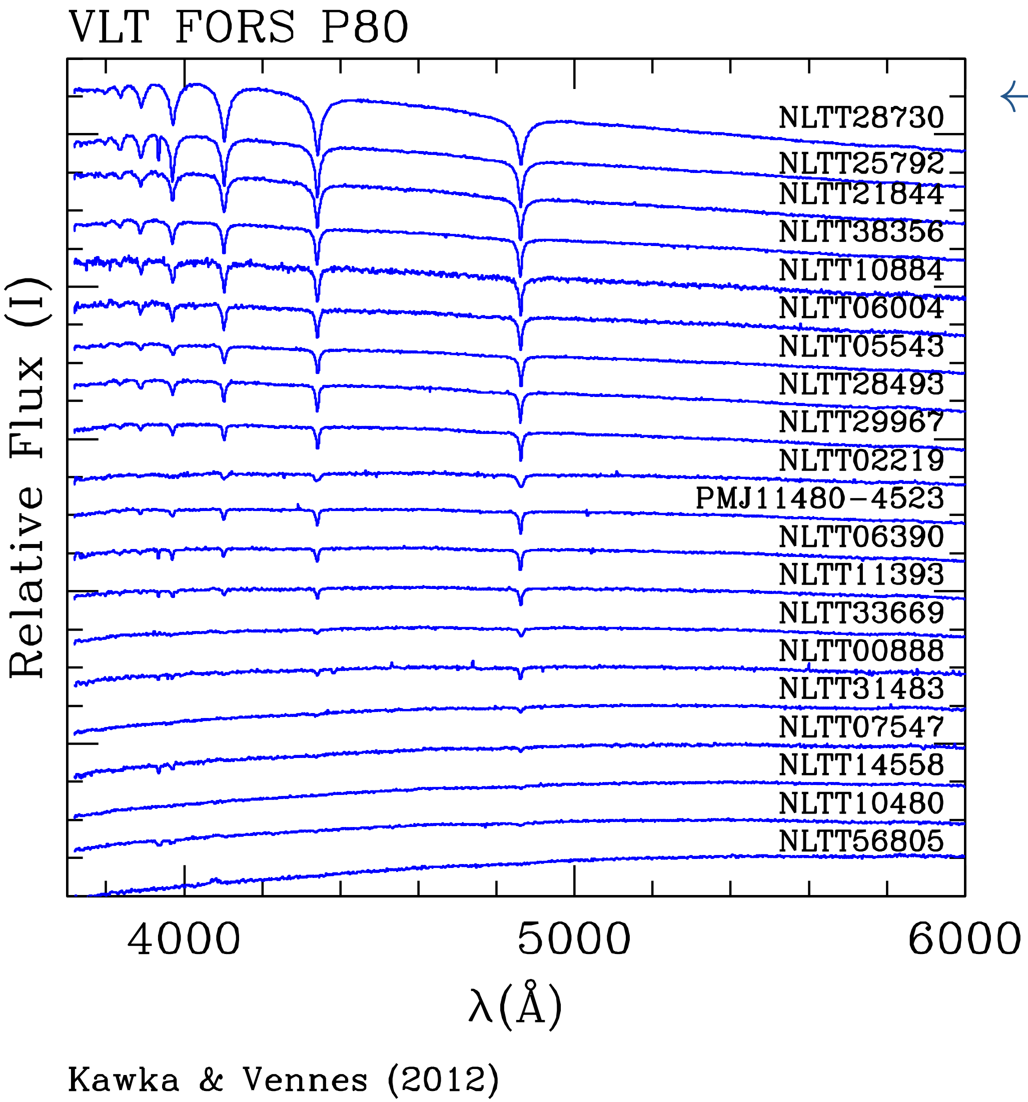
- In the end, most stars including the Sun (10 Gyr) only retain a degenerate CO core.
- We focus on detailed studies of white dwarf atmospheres (from P80 to P94) Spectroscopy with the ESO/VLTs: high R and S/N; also spectro-polarimetry:
  - FORS1: 0.33-0.62 μm, $R \approx 780$; FORS2: 0.58-0.73 μm, $R \approx 2140$
  - X-shooter: 0.3-2.4μm, $R \approx 9,000$, $m_{\rm AB} \lesssim 21$
- White dwarf surveys: proper-motion and IR/UV colours
- X-Shooter survey highlights:
  - Post-CE double degenerates
  - Magnetic field detections (kG to MG); post-CE? $\leftarrow$
  - polluted WDs and circumstellar discs $\leftarrow$
- Demise of planetary systems and abundance diversity: Accreting asteroids, planet/cores vs mantles?

ESO VLT/X-shooter — performance with white dwarfs



- Faint ($\lesssim 18$) white dwarf $\vec{\mathbf{B}}$, Z/H, binarity:
  - High S/N ≈ 100
  - $t_{\rm exp} \lesssim 6$ hrs, $R \approx 9000$.
  - $\vec{\mathbf{B}} \gtrsim 40$ kG (FORS: $\gtrsim 1$ kG)
  - $\mathrm{Ca/H} \gtrsim 10^{-12}$
  - $\Delta v \approx 2\,\mathrm{km\,s^{-1}}$
- Our sample:
  - NLTT 16249 (DA+DQ), NLTT 21913 (DA+DC)
  - NLTT 10480, 53908 (DAZH)
  - NLTT 888, 1675, 6390, 11393, 25792 (DAZ)

FORS/X-Shooter survey of white dwarfs



← VLT/FORS1 P80 (30 WDs)

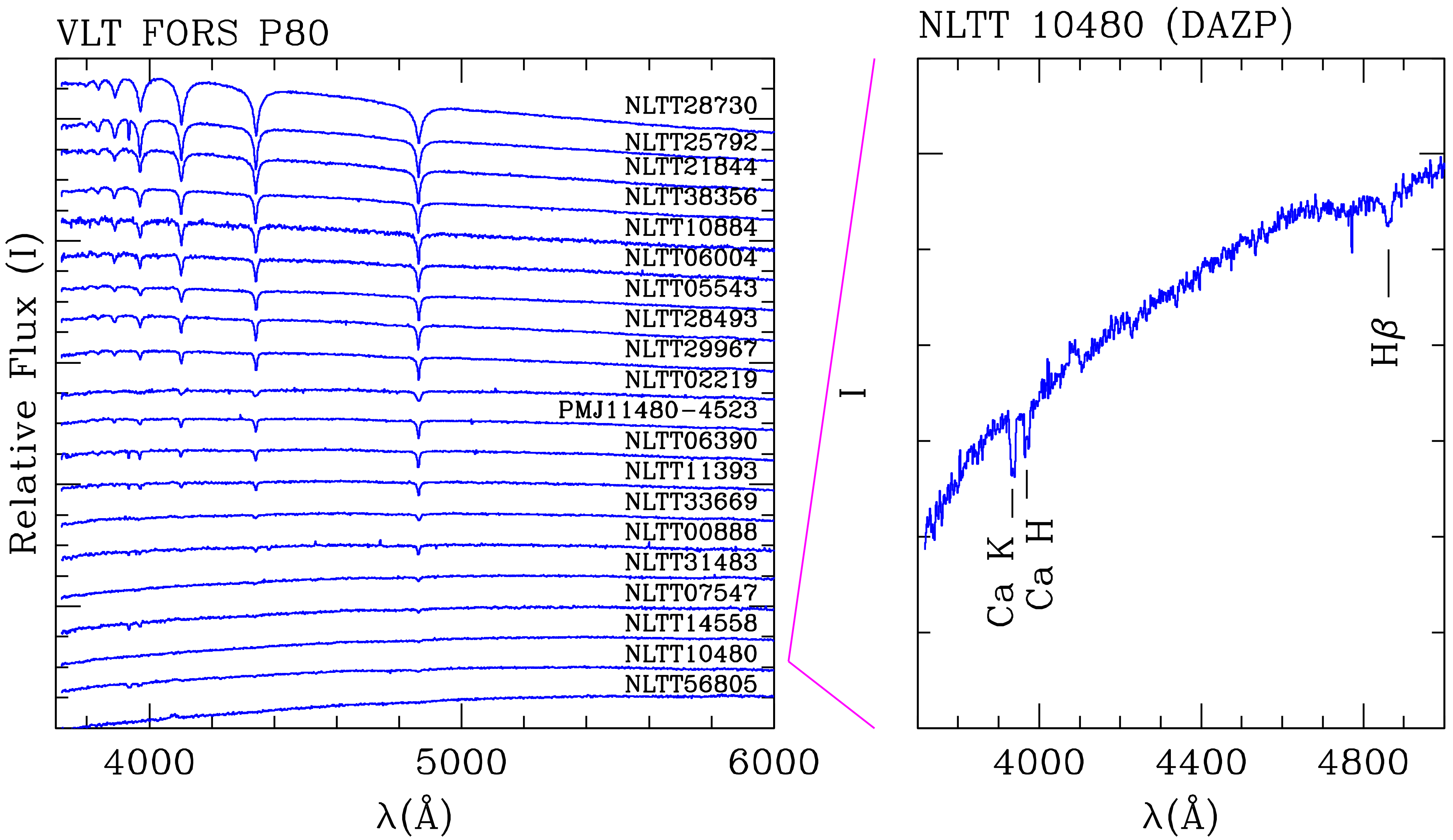
- High-SN, low-disp (gr. 600B, $\Delta\lambda \approx$6Å)
- 20 hydrogen-rich (DA)
- 10 helium-rich (DC, DQ)

• VLT/FORS2 P84 (40 WDs)

- High-SN, med-disp (gr. 1200R, $\Delta\lambda \approx$3Å)
- 40 hydrogen-rich (DA):

DD NLTT 11748 (Kawka & Vennes 2009), 12758 (Kawka &Vennes 2012)

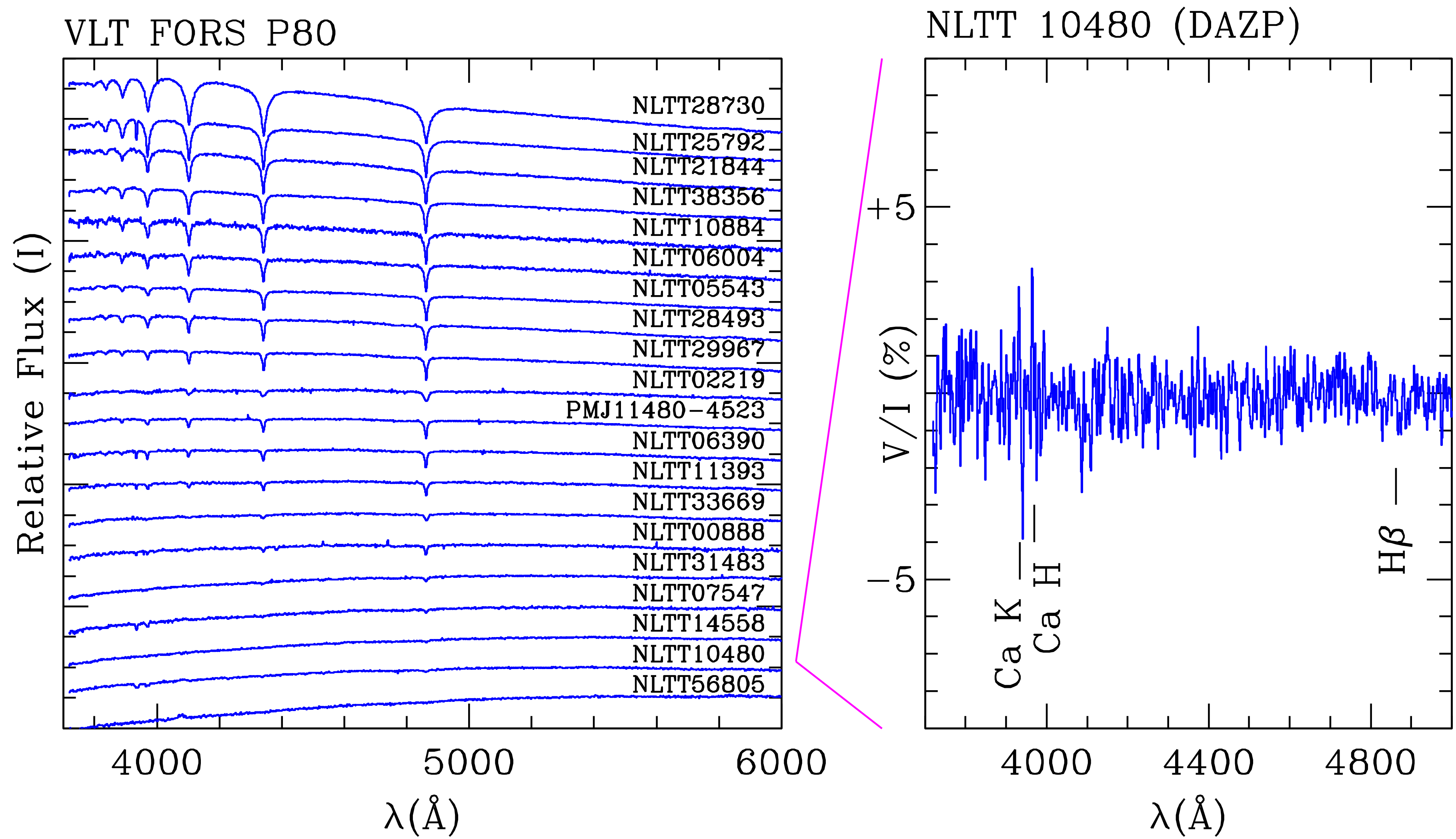
FORS/X-Shooter survey of white dwarfs



Kawka & Vennes (2012)

Kawka & Vennes (2011)

FORS/X-Shooter survey of white dwarfs



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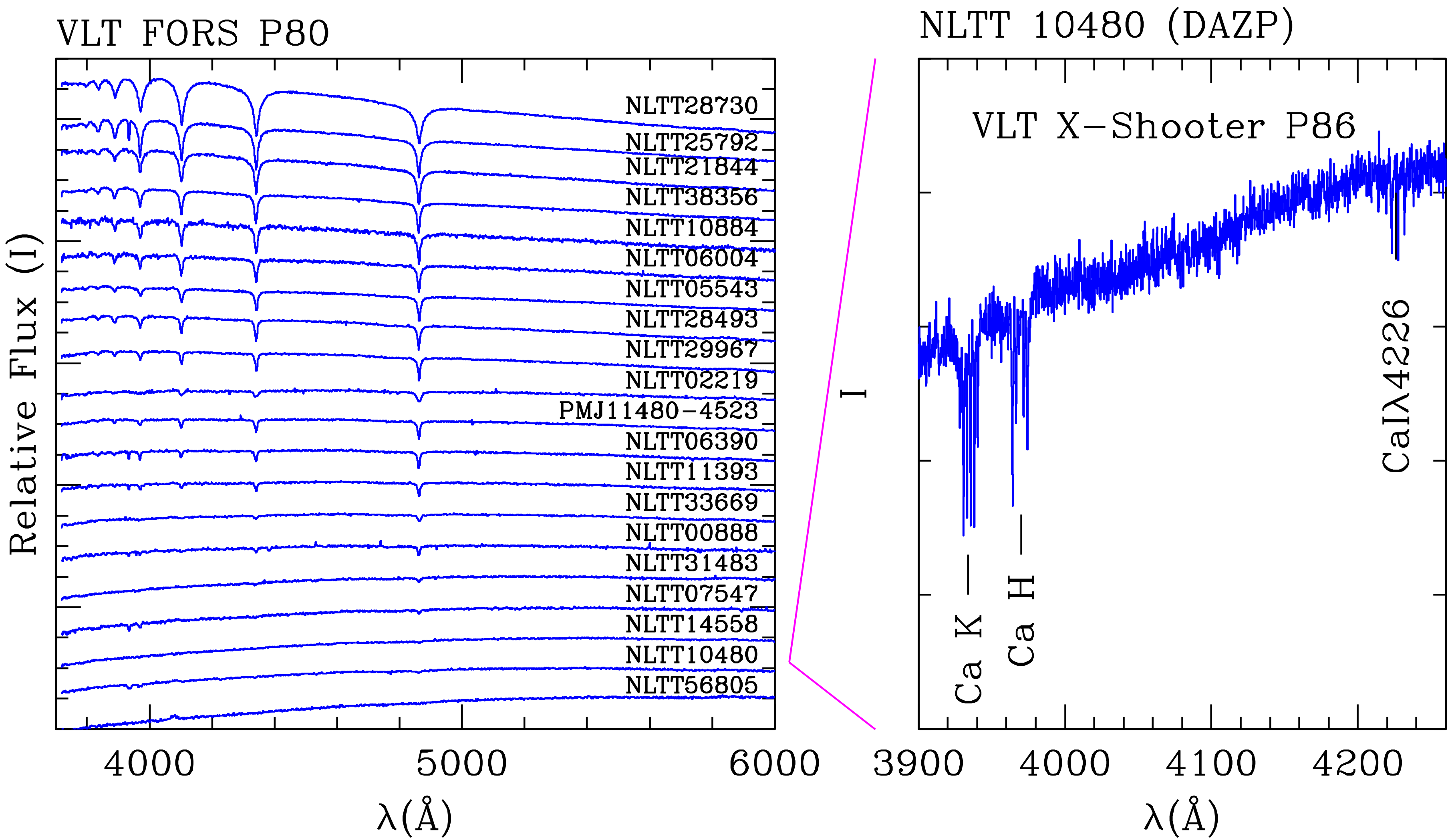

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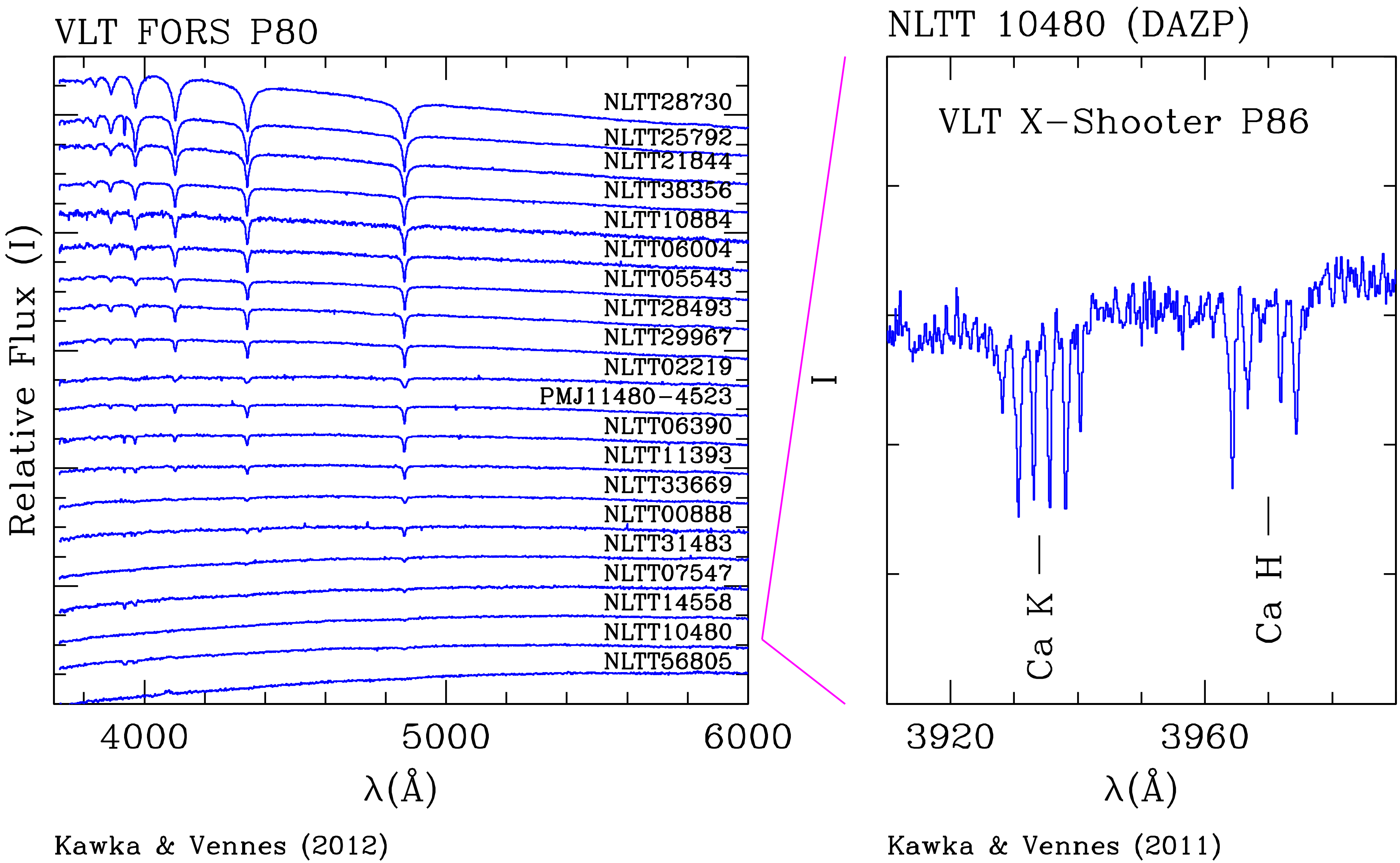

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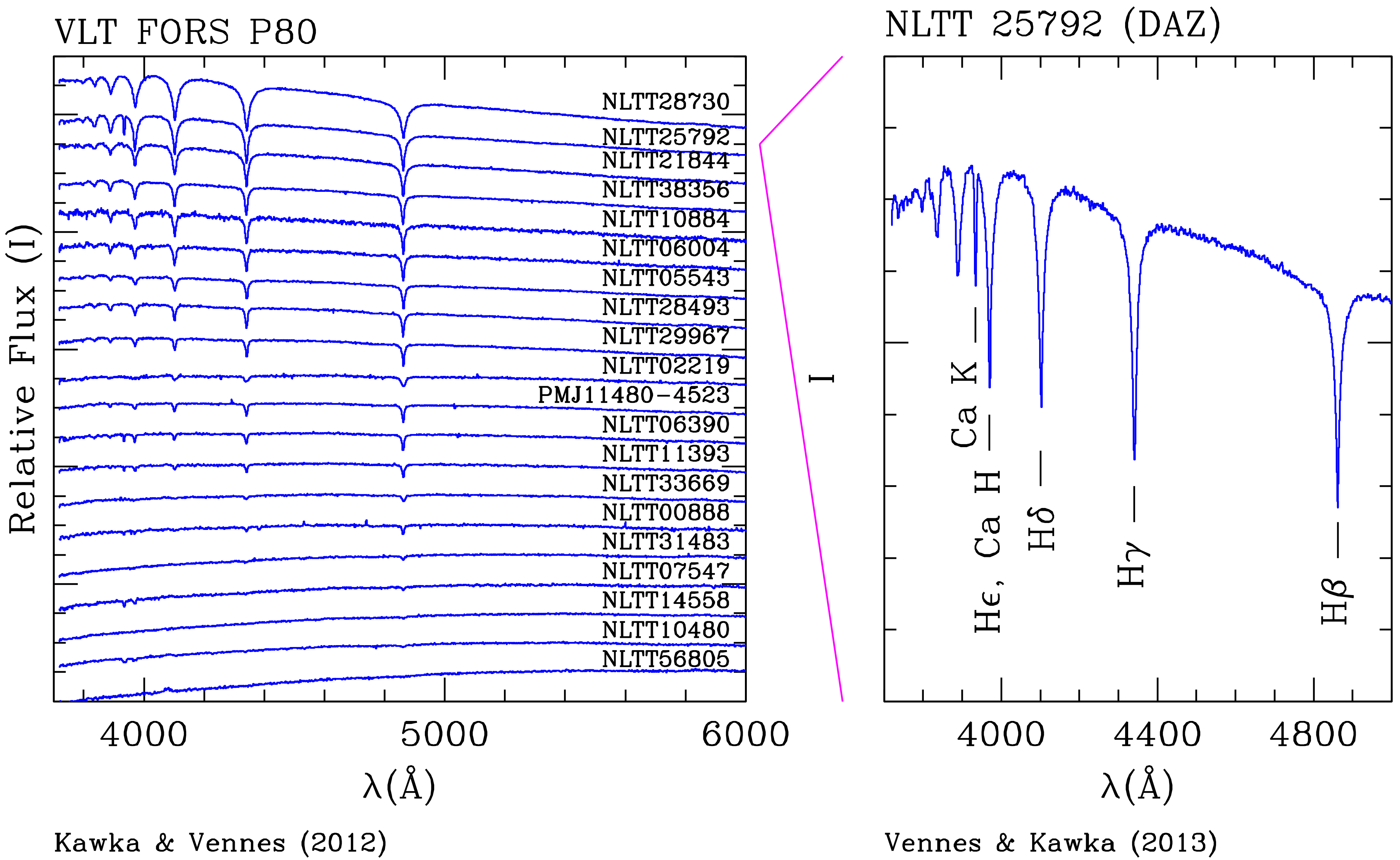
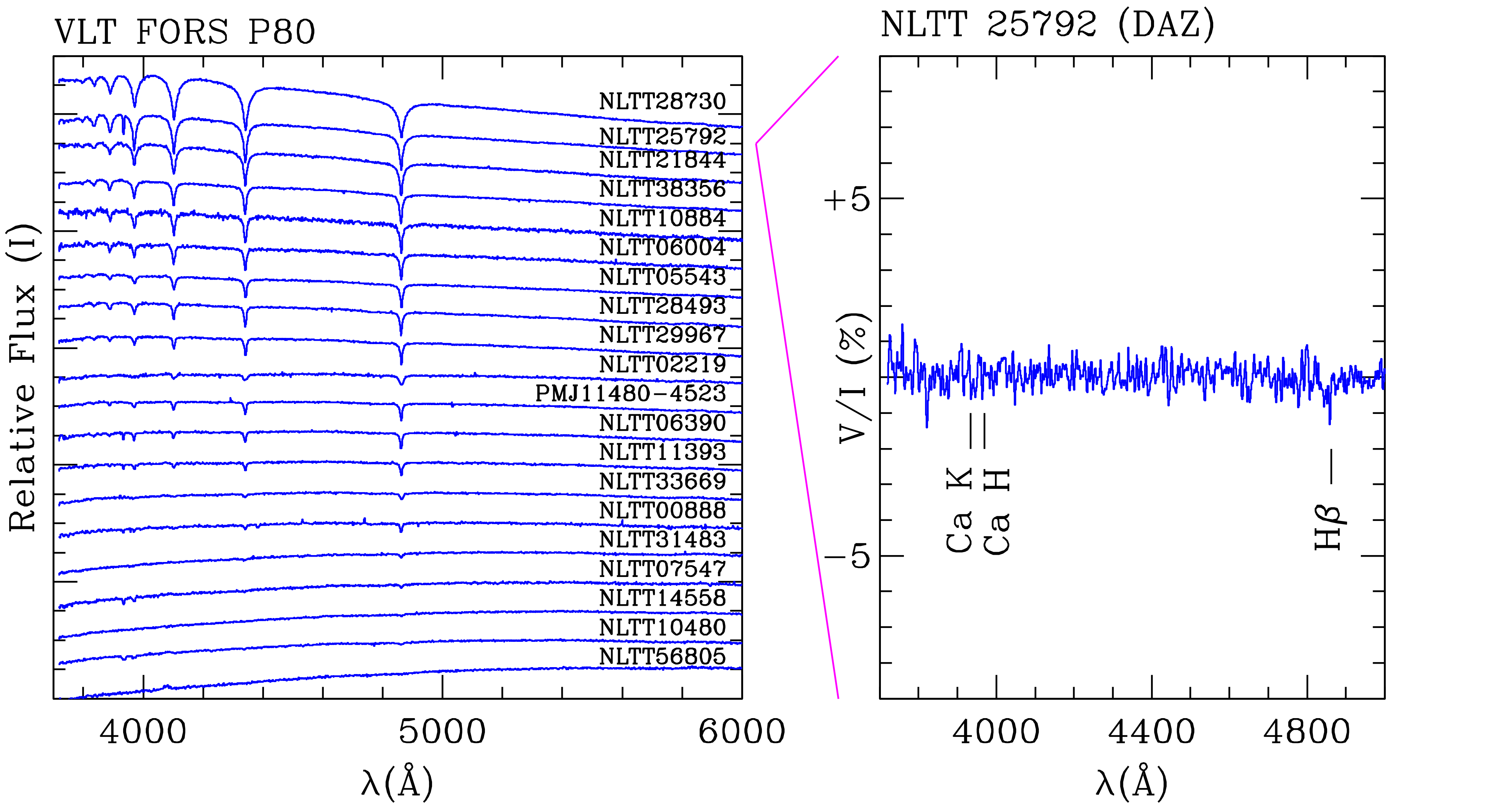


FORS/X-Shooter survey of white dwarfs



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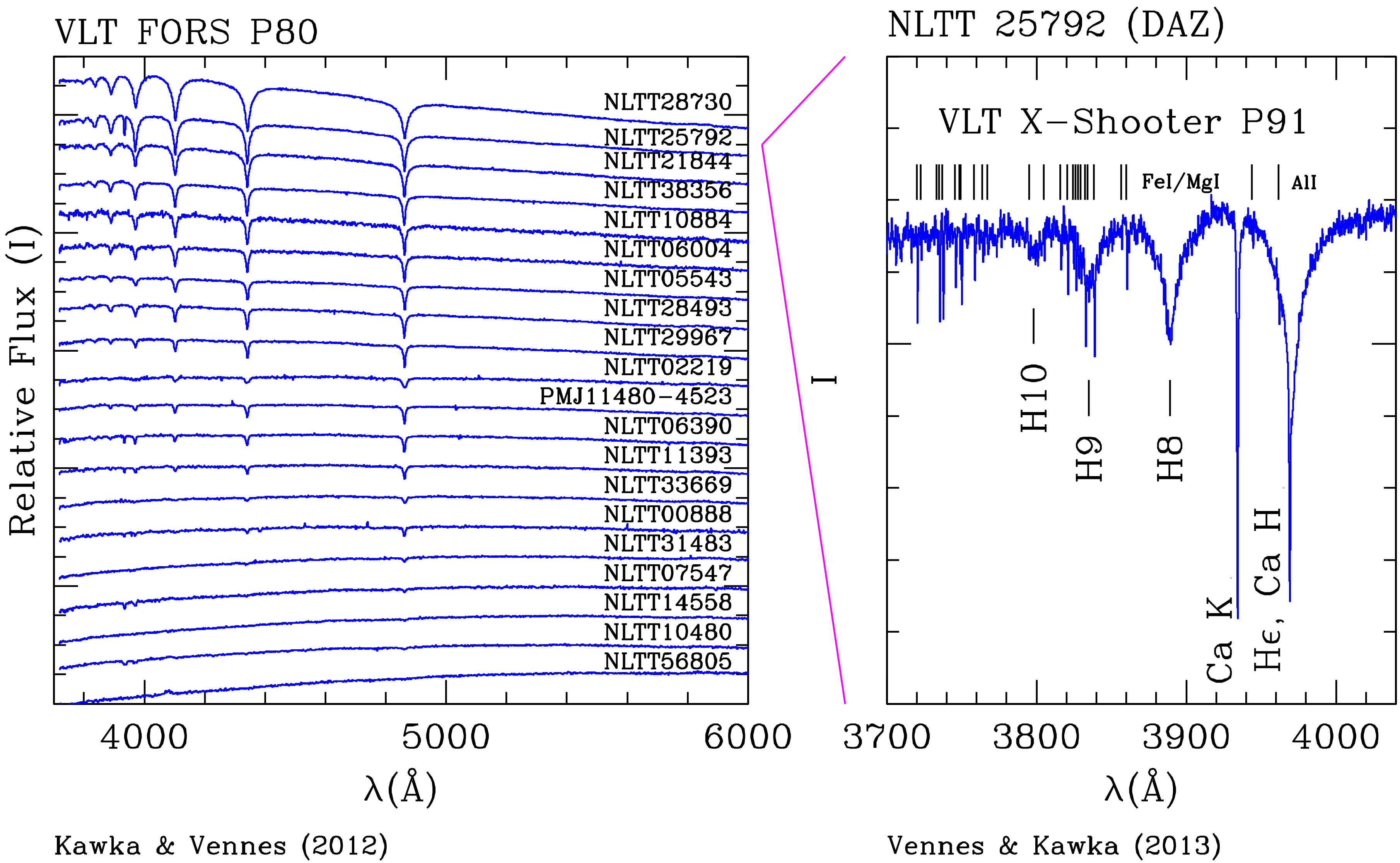
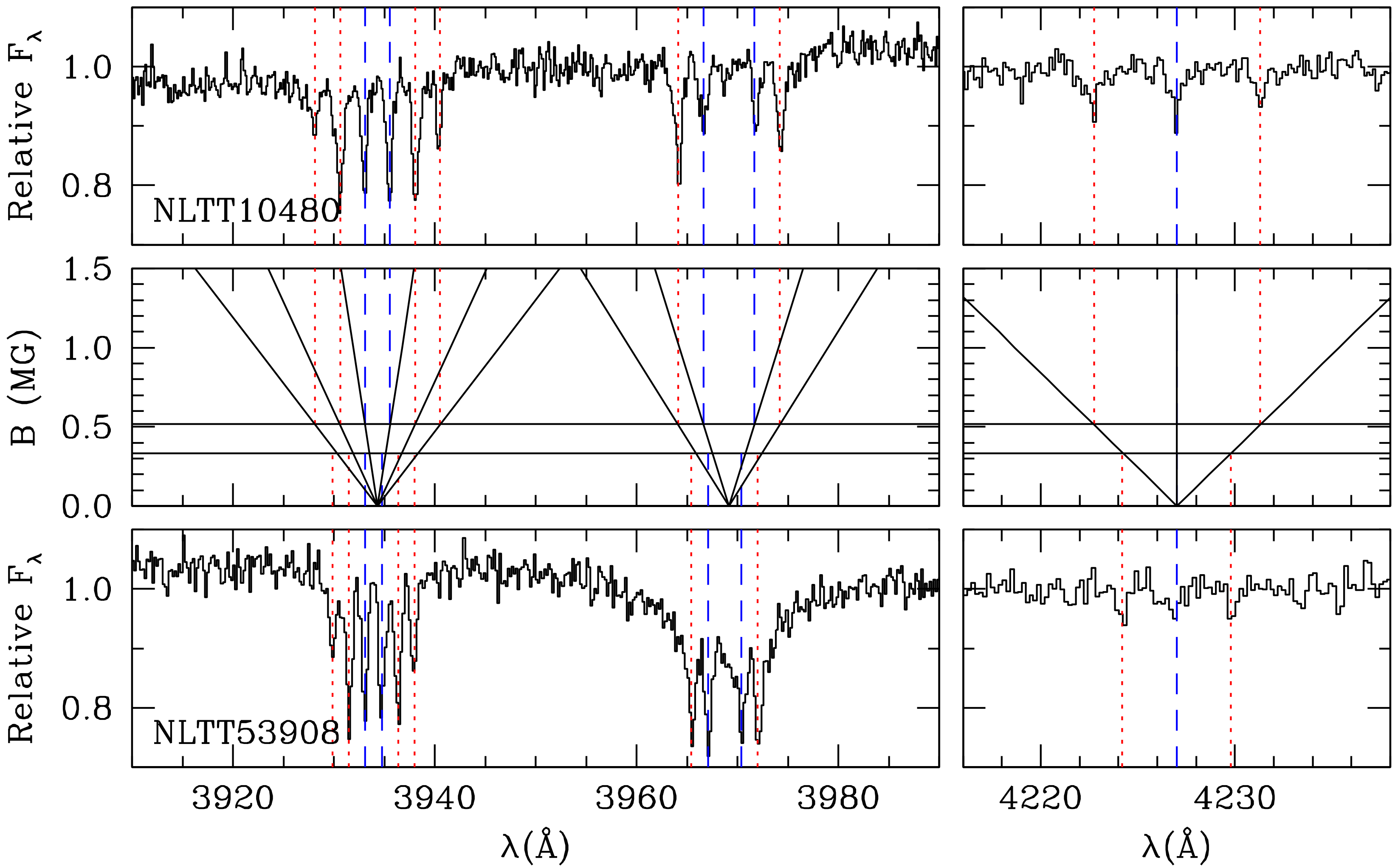
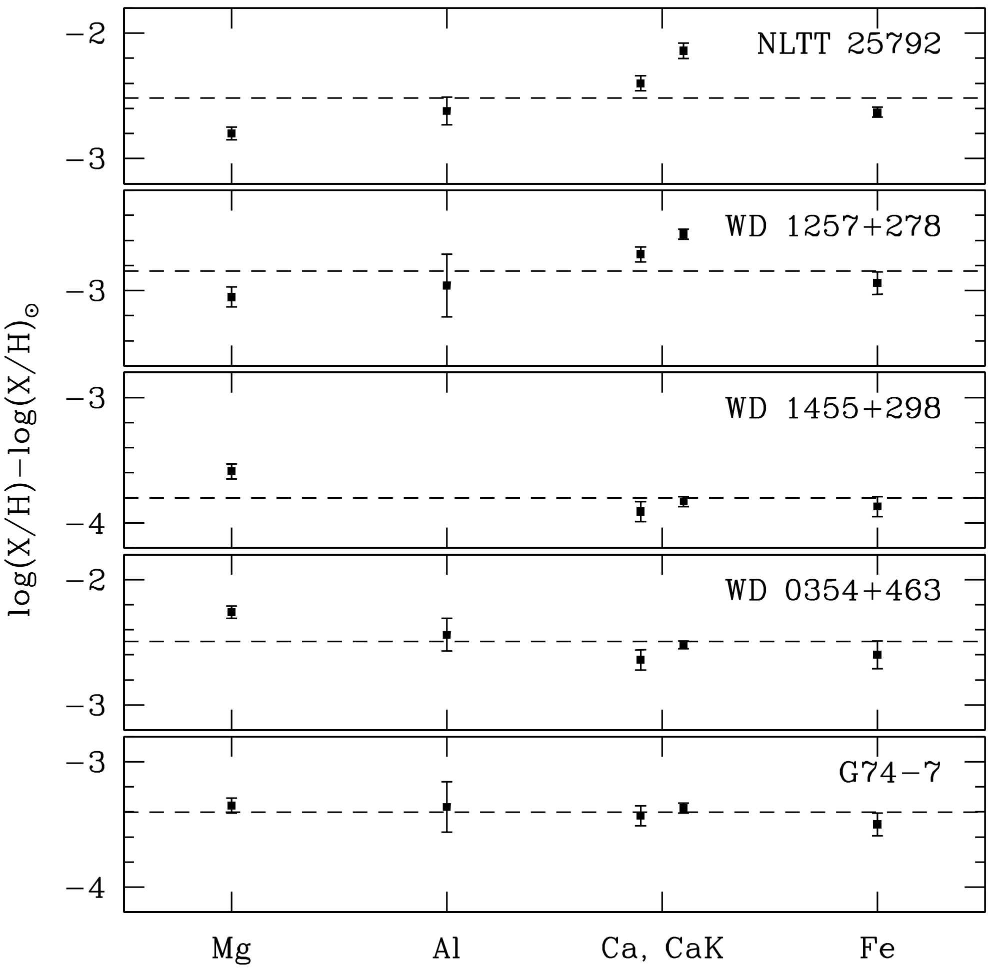


Z and $\vec{\mathbf{B}}$ (Kawka & Vennes 2011, 2014)



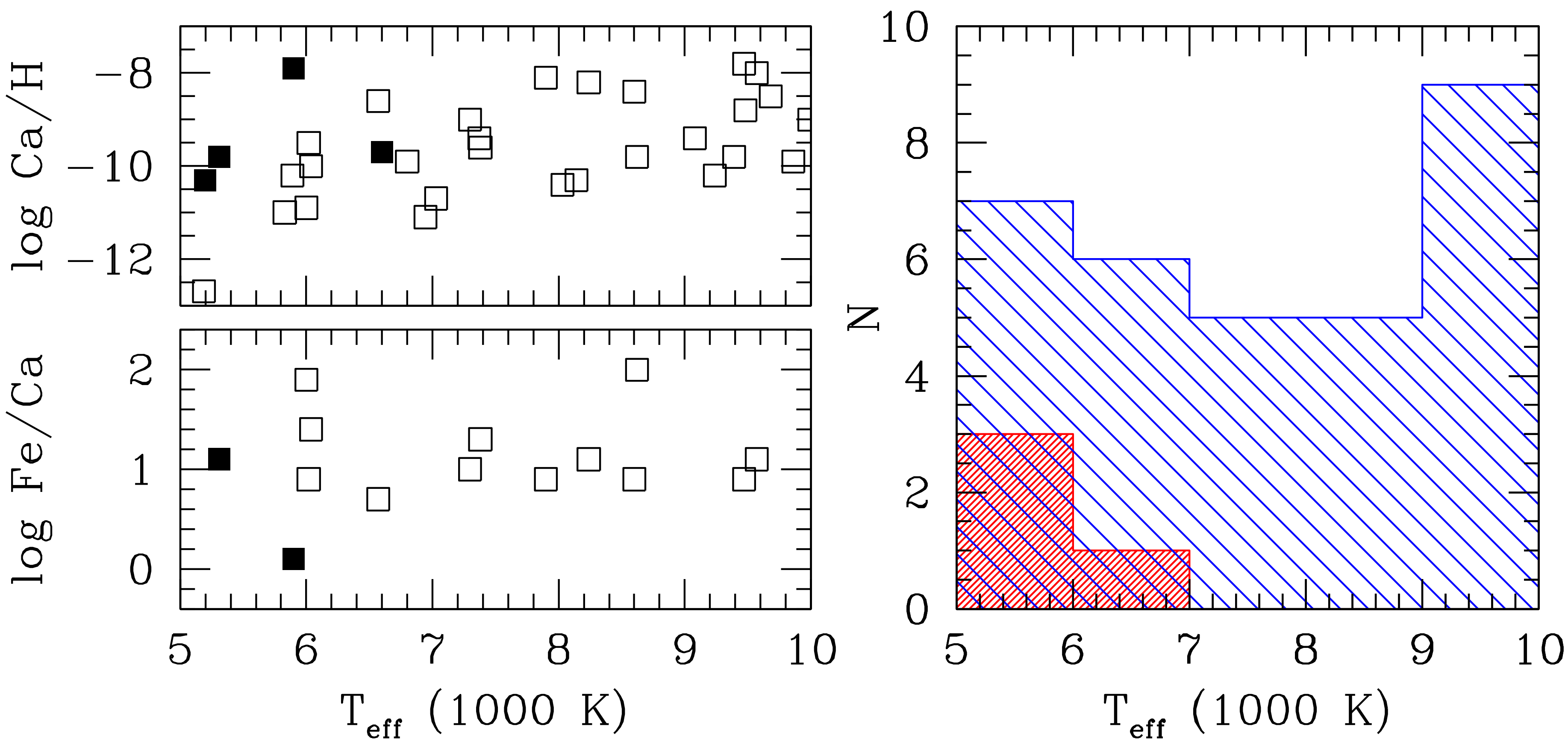
Average surface field, B_s, and longitudinal, B_l $\rightarrow$ field geometry.

Abundance diversity: Ca rich vs Mg rich ?



- On NLTT25792 (Vennes & Kawka 2013)
- Comparison with 4 DAZs (Keck). (Zuckerman et al. 2003, ApJ, 596, 477)
- WD0208+396 = G74-7: DAZ prototype (Lacombe et al., 1983, ApJ, 272, 660)
- WD0354+463: DA+dM7, wind accretion?
- WD1257+278: no disc
- WD1455+298: *WISE* W1/W2 excess

Abundance diversity: Ca/Fe ratio—mantle vs core?



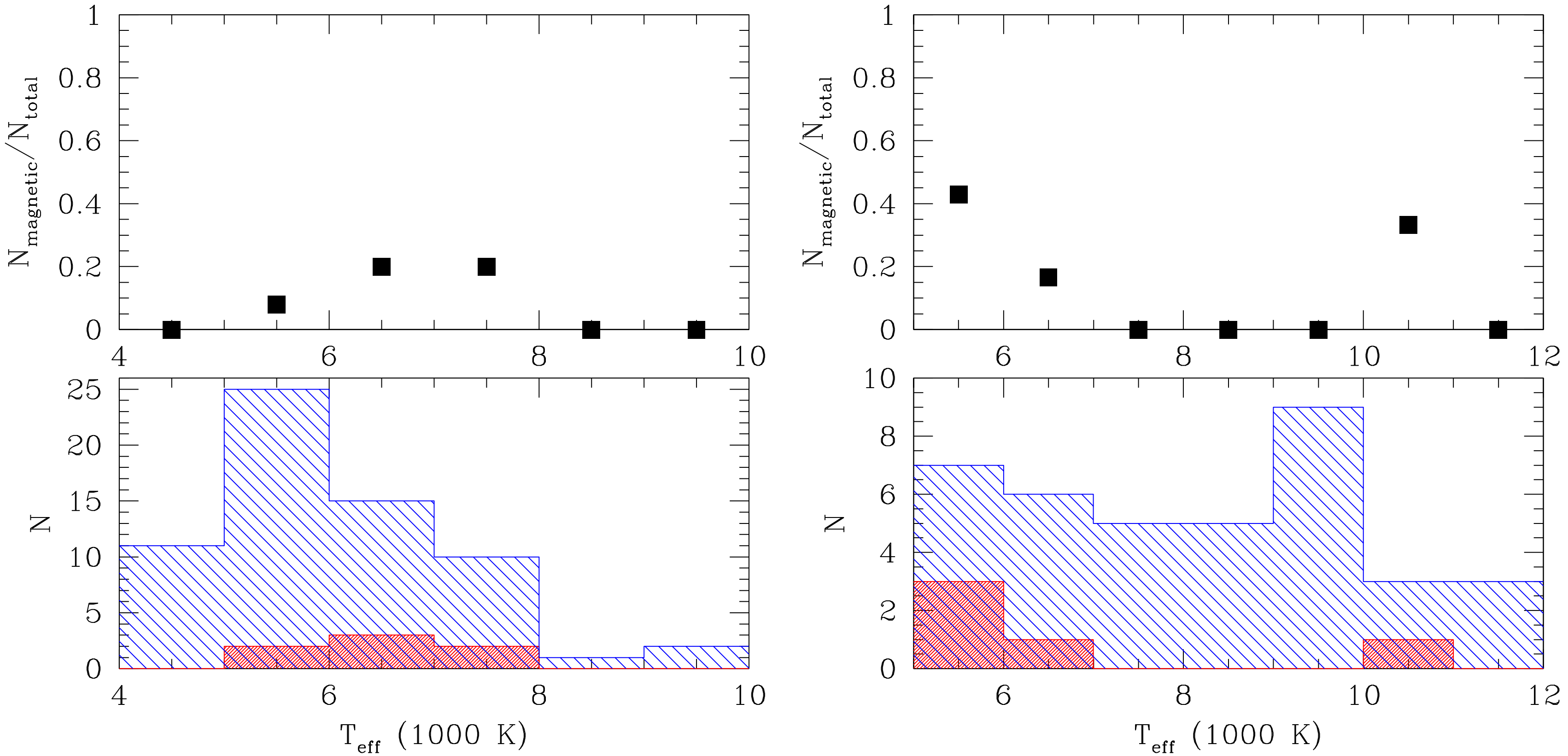
(black squares: magnetic, open squares: "non"-magnetic)

$T_{\rm eff} = 6000$, age=2.4Gyr, $\tau_{\rm diff} = 10^4$ years

$T_{\rm eff} = 8000$, age=1.0Gyr, $\tau_{\rm diff} = 10^3$ years

$T_{\rm eff} = 10000$, age=0.5Gyr, $\tau_{\rm diff} = 10^2$ years.

Metallicity and magnetic field: statistical argument



Field distribution versus effective temperature (i.e., age)

(Left) $\vec{B}$ identification in low-disp DA spectra from all cool WDs,

(Right) $\vec{B}$ identification in echelle spectra of cool polluted WDs.

Only 0.1% chance that samples drawn from same population.

Are Z and $\vec{B}$ correlated: early merger (Nordhaus et al. 2011, Tout et al. 2008)?

Summary

- FORS survey of high-proper motion stars still uncover important objects
- X-shooter spectroscopy optmizes SN ratio and spectral resolution
  - NLTT 10480 NLTT 53908 are new polluted magnetic WD
  - NLTT 25792 has anomalous Ca/Fe ratio with a rich Fe line spectrum
  - Cool DAZs show abundance variations suggesting source diversity
- Many but not all DAZs have a dust disc
  - Dust/gaseous discs are the key to accretion onto white dwarf
  - Collisions in post-AGB environment result in excursion within Roche lobe...
  - Gas pressure between star and dust disc pushes material in ...
  - Can direct impact occur too? yes.
  - Merger during CE may generate observed fields in DA white dwarfs