

For a fistful of DZ and DZA white dwarfs (Haifa 07.03.17)

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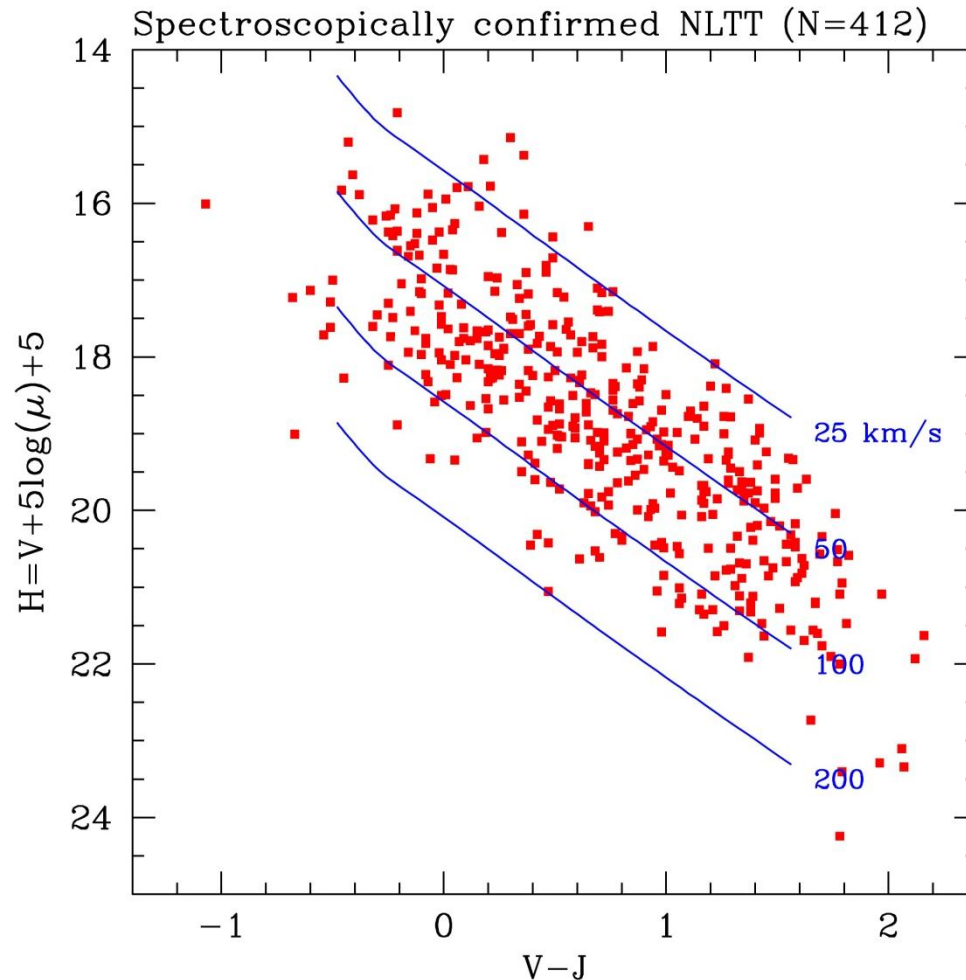
Czech Academy of Sciences

(in collaboration with A. Kawka, L.Ferrario,
S. Keller, M.S. Bessell, & SkyMapper)

Surveying the population

- Spectroscopic survey: exploring diversity.
- Selection criteria.
- Low-dispersion spectroscopic survey (CTIO, KPNO, ESO, SAAO, SSO) 2003-2017.
- Of DAZ, DAZP (Kawka), DZ, DZA ...
- High-dispersion follow-ups.
- Stellar parameters, abundances (H, Mg, Ca...).
- Environmental implications: The case of H.

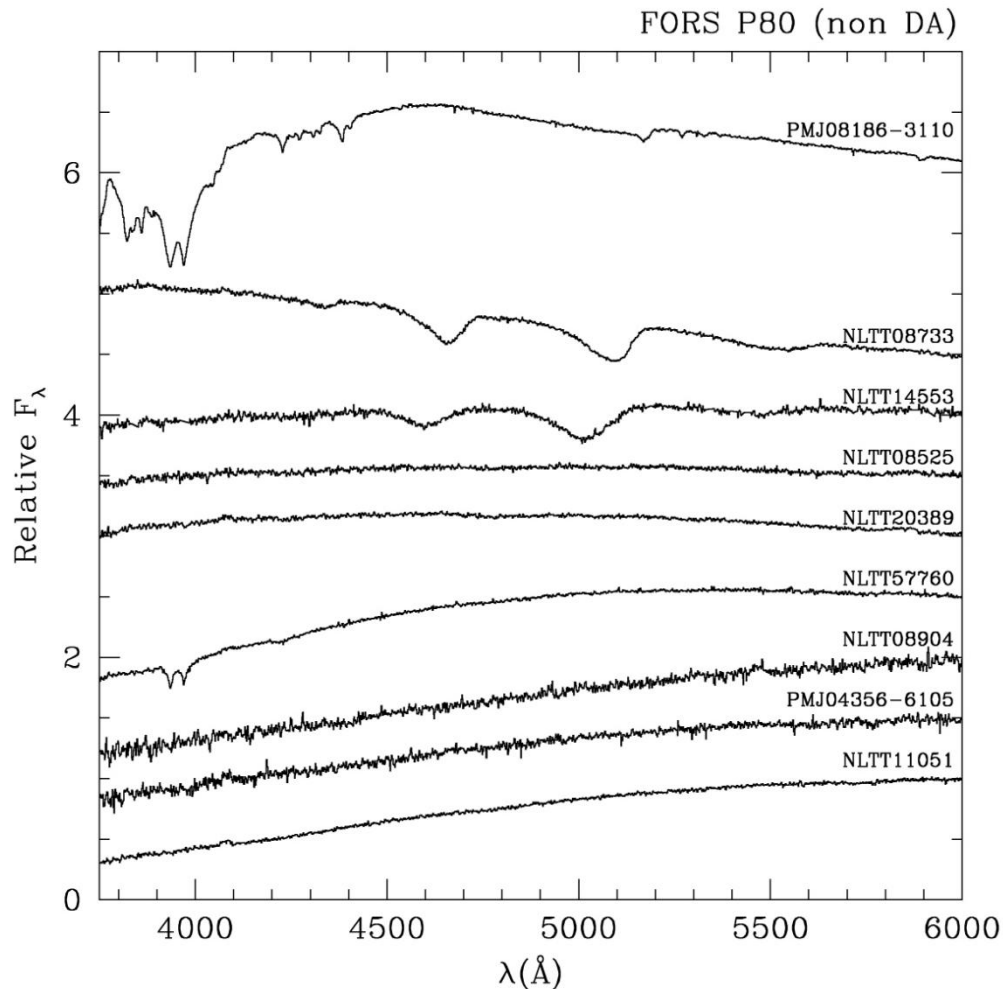
For a few polluted white dwarfs in an old survey (I) ...



Revised New Luyten Two-Tenths proper-motion survey (Salim & Gould 2002) 35,000 objects:

- WDs Spectroscopically confirmed (Kawka, Vennes et al. 2003-2017)
- Supplemented with LSPM, PMJ candidates (Lepine et al.)
- Kinematically selected ($V - J$ RPM)
- Colour selected ($V - J, J - H$)
- Properties: $T \sim 5,000\text{--}20,000\text{K}$, $v_T \sim 25\text{--}200\text{ km/s}$

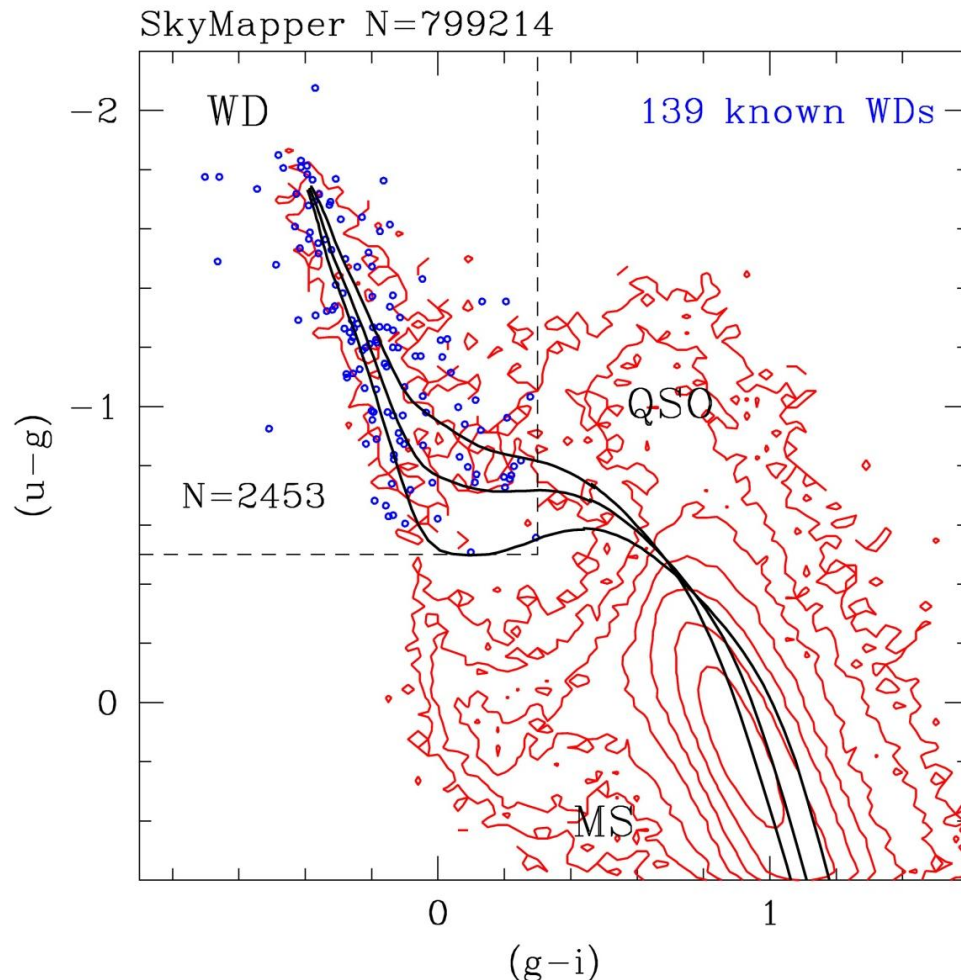
For a few polluted white dwarfs in an old survey (II) ...



Revised New Luyten Two-Tenths proper-motion survey (Salim & Gould 2002) 400+ WDs:

- Population break-down
H-rich 67%
He-rich 33% (DB, DQ
DC, DZ)
- Heavier elements:
All 8%, non-DA 15%
- Magnetic field
4% (14% in local sample)
- Low detection rate at low
field or low metallicity
(...under-reported at low-
dispersion)

For a few polluted white dwarfs in a new survey (I) ...

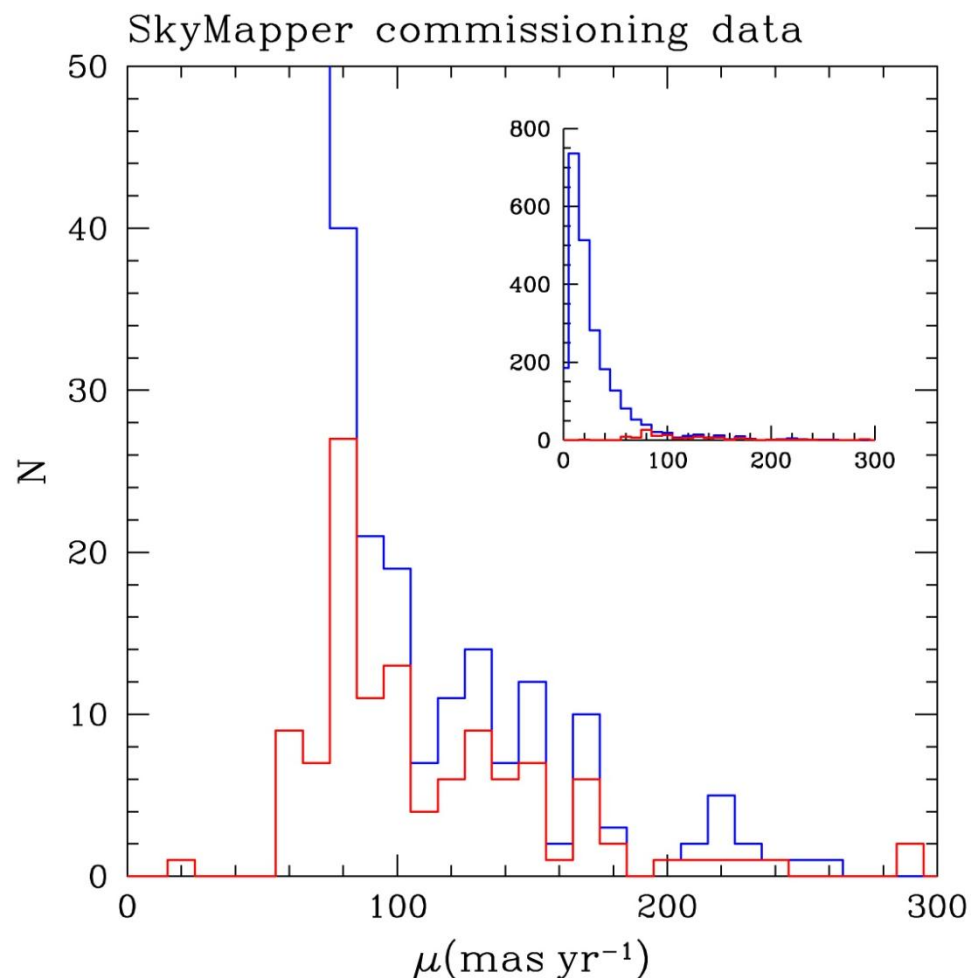


Sky-Mapper Short Survey (RSAA Mount Stromlo) is in progress ...

10^6 objects extracted from SkyMapper commissioning survey of extremely metal poor stars (EMP)

- Colour mix (Vega system): WD, QSO, MS
- Blue selection applied in $u-g$ versus $g-i$...
- Recovered 139 known southern WDs. 2200+ objects to go ...

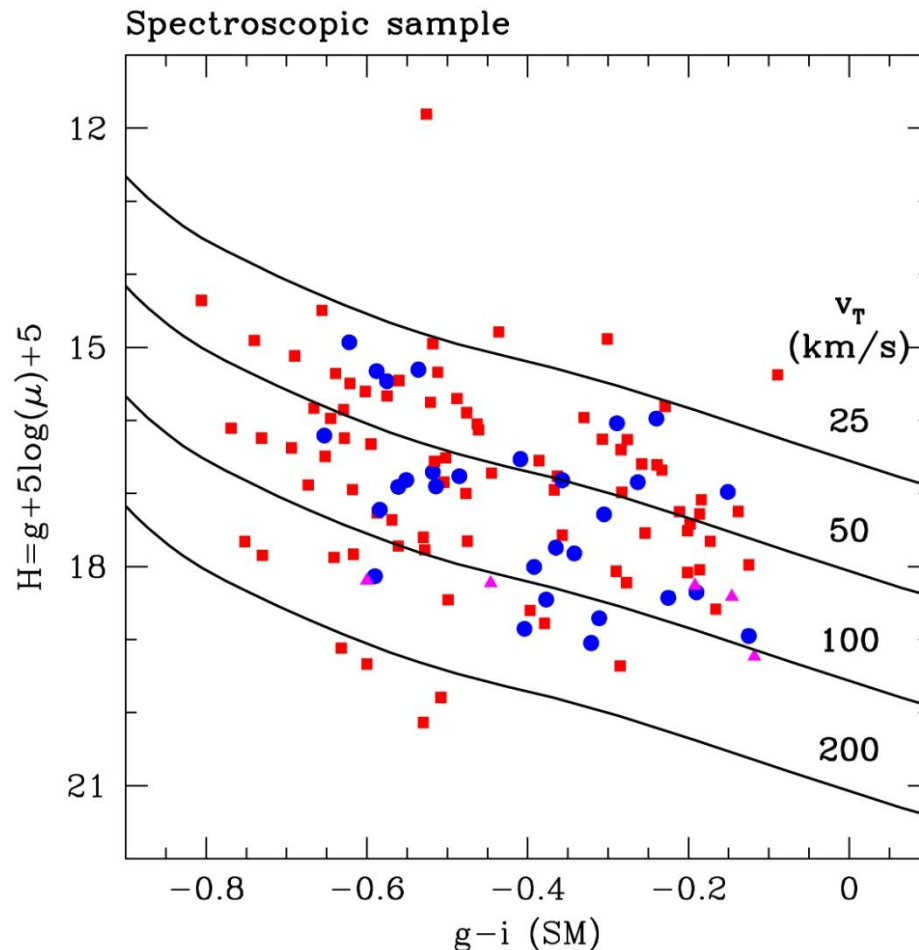
For a few polluted white dwarfs in a new survey (II) ...



Sky-Mapper Short Survey (RSAA Mount Stromlo) is in progress ...

- Additional criterion: proper motion; Adopted SuperCOSMOS Sky Surveys.
- (blue) All measurements
- Selected $\text{ppm} > 60 \text{ mas/yr}$
- (red) Spectroscopically confirmed : 116 objects.

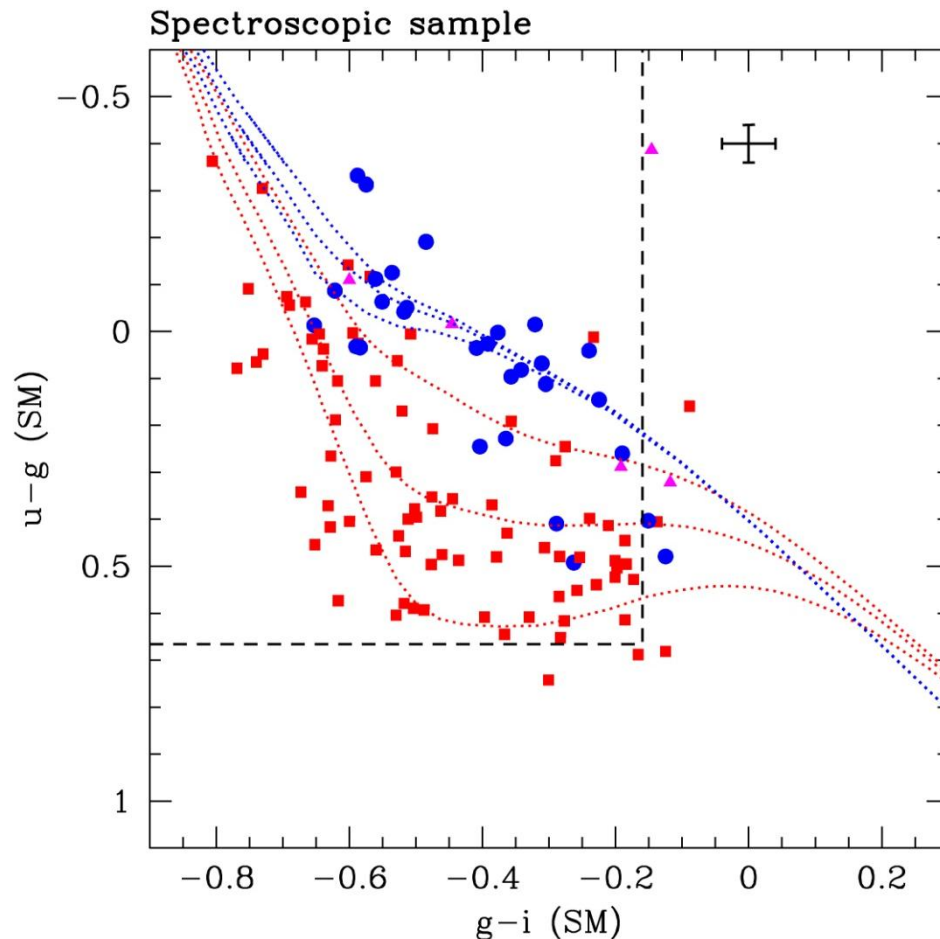
For a few polluted white dwarfs in a new survey (III) ...



Sky-Mapper Short Survey (RSAA Mount Stromlo) is in progress ...

- RPM diagram of new confirmed WDs
- High-velocity selection with halo candidates (primary objective)
- DA (red), non-DA (blue) no class distinctions
- Kinematics (transversal velocity v_T) estimated assuming $\log(g)=8$
- Colours calibrated using SMSS (AB system)

For a few polluted white dwarfs in a new survey (IV) ...

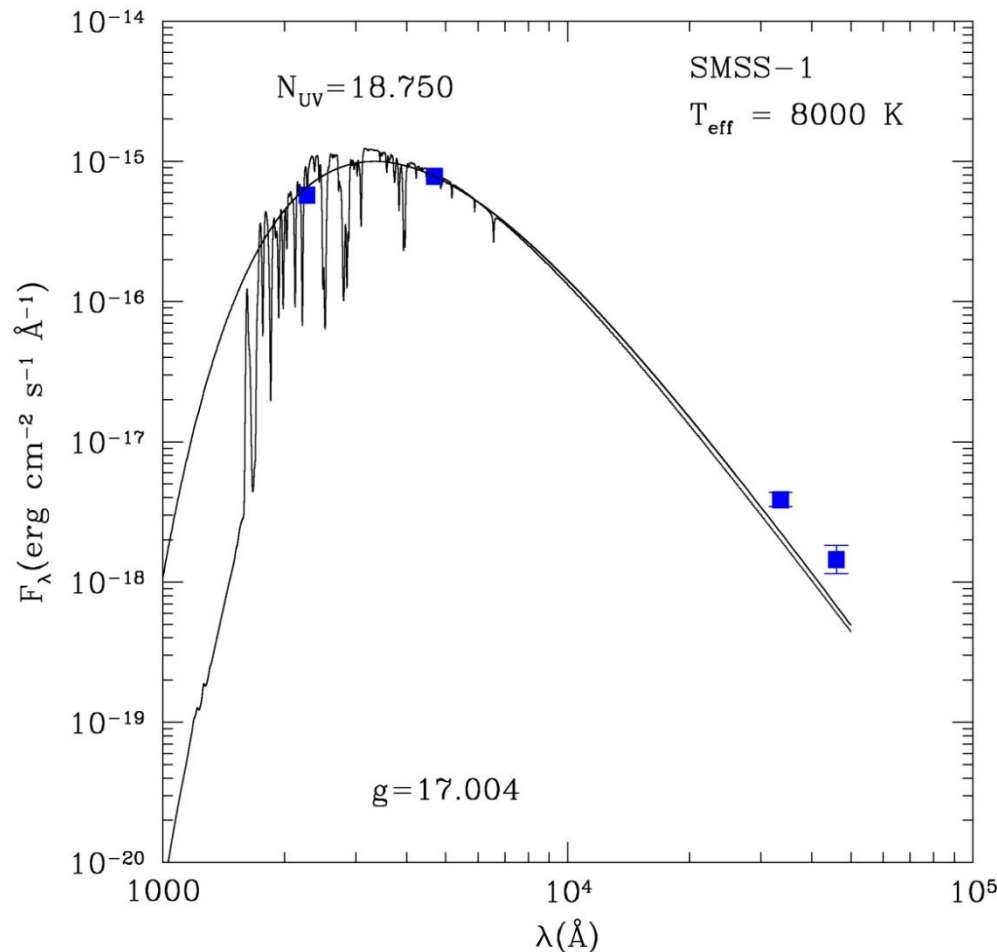


Sky-Mapper Short Survey (RSAA Mount Stromlo) is in progress ...

So far 116+ new WDs in SMSS/EMP

- Population break-down
(red) H-rich 72%
(blue) He-rich 28% (DB, DQ, DC, DZ)
- Heavier elements:
all 4%, non-DA 15%
- Magnetic fields:
<2% ($B > 500$ kG)
- low-detection rate at low field or metallicity ...

For a few polluted white dwarfs in a new survey (V) ...

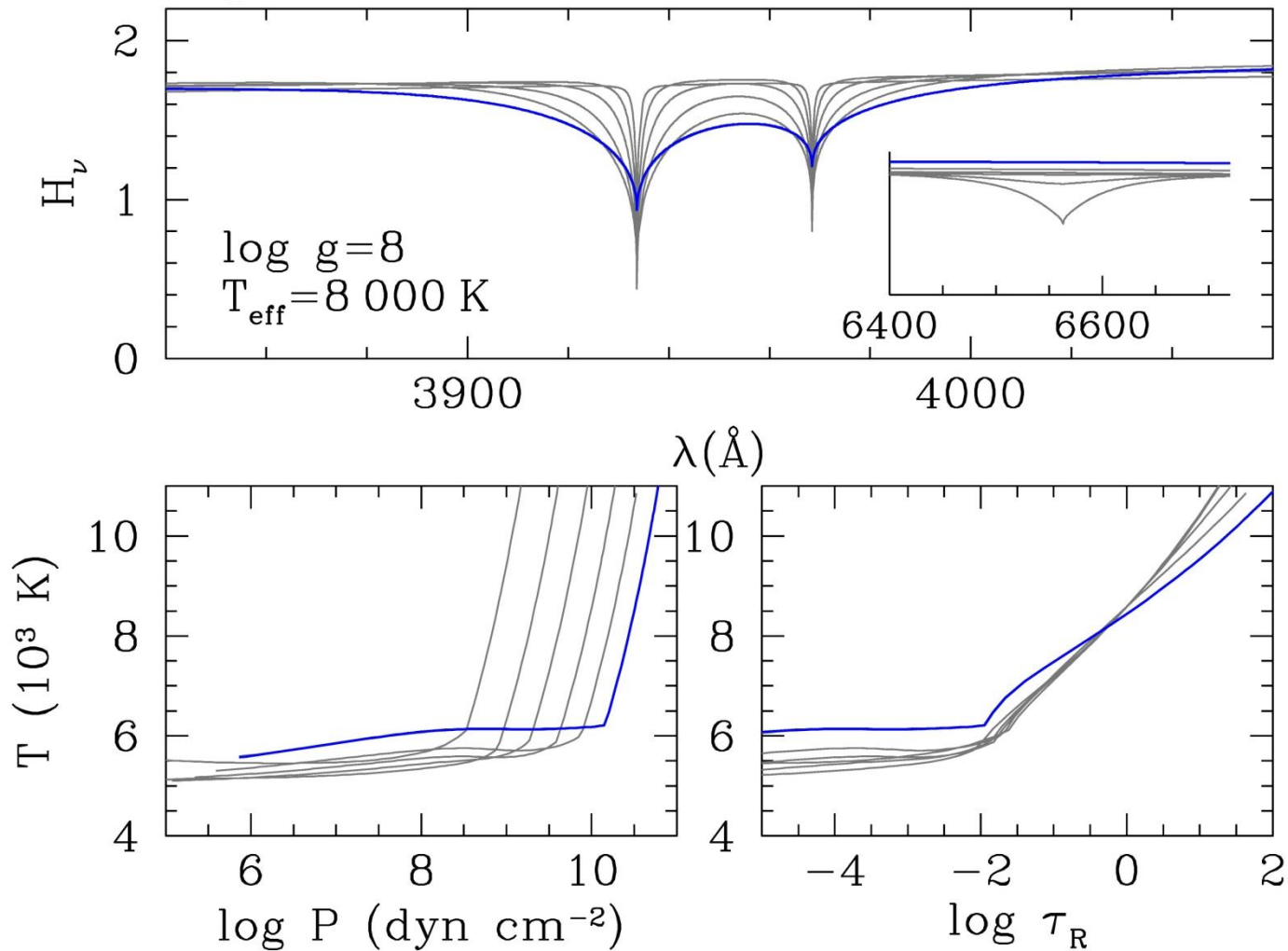


Sky-Mapper Short Survey (RSAA Mount Stromlo) is in progress ...

- Developing the SEDs: here GALEX NUV, Gaia g, and WISE W1 & W2
- Developing the models: pure He versus high-Z
- Computing synthetic colours for data analysis.
- Here, a preview of SMSS-1, a new DZA at 8,000K. IR excess?

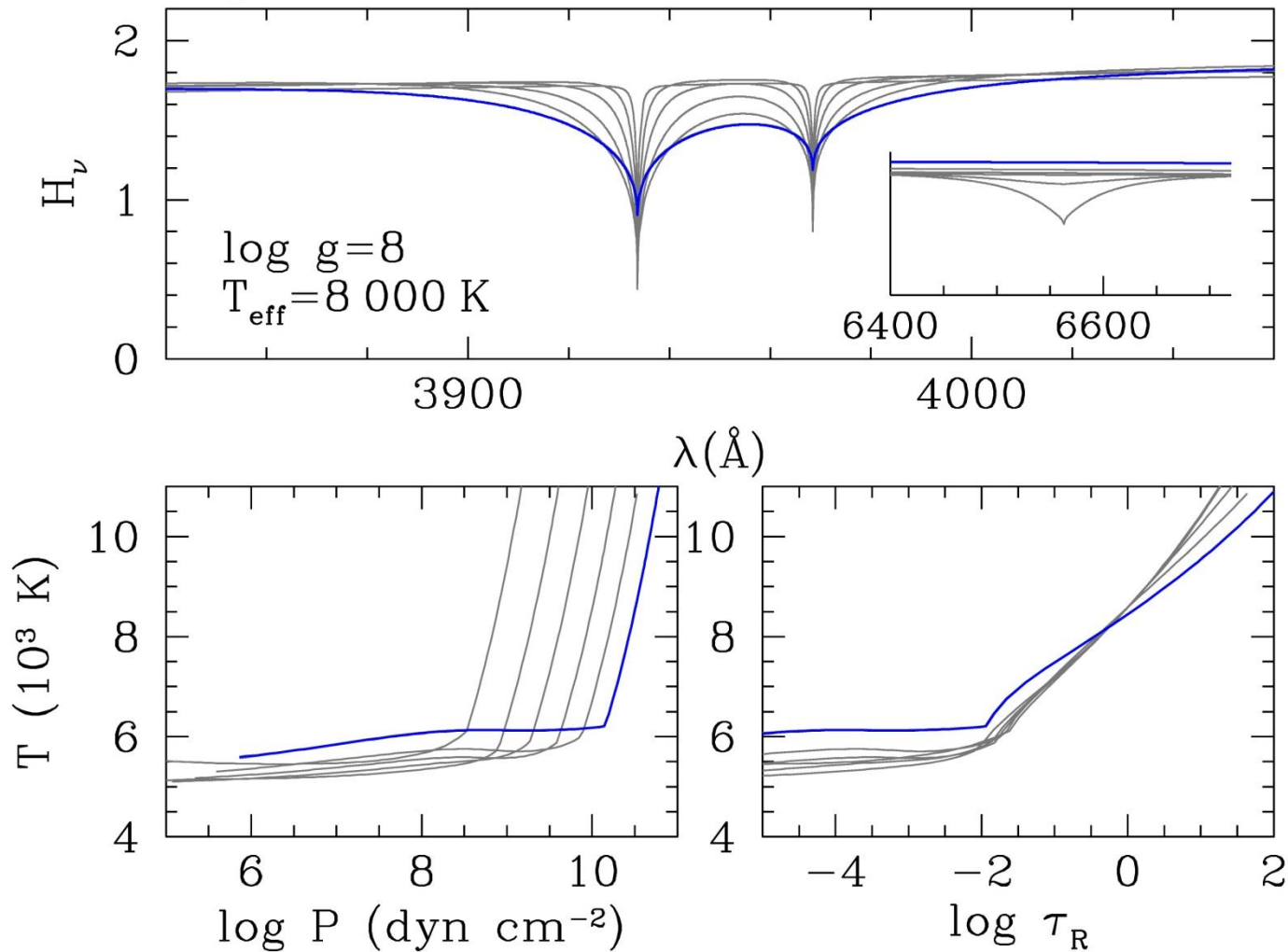
Structure & spectral synthesis

$\log \text{He}/\text{H} = 19$

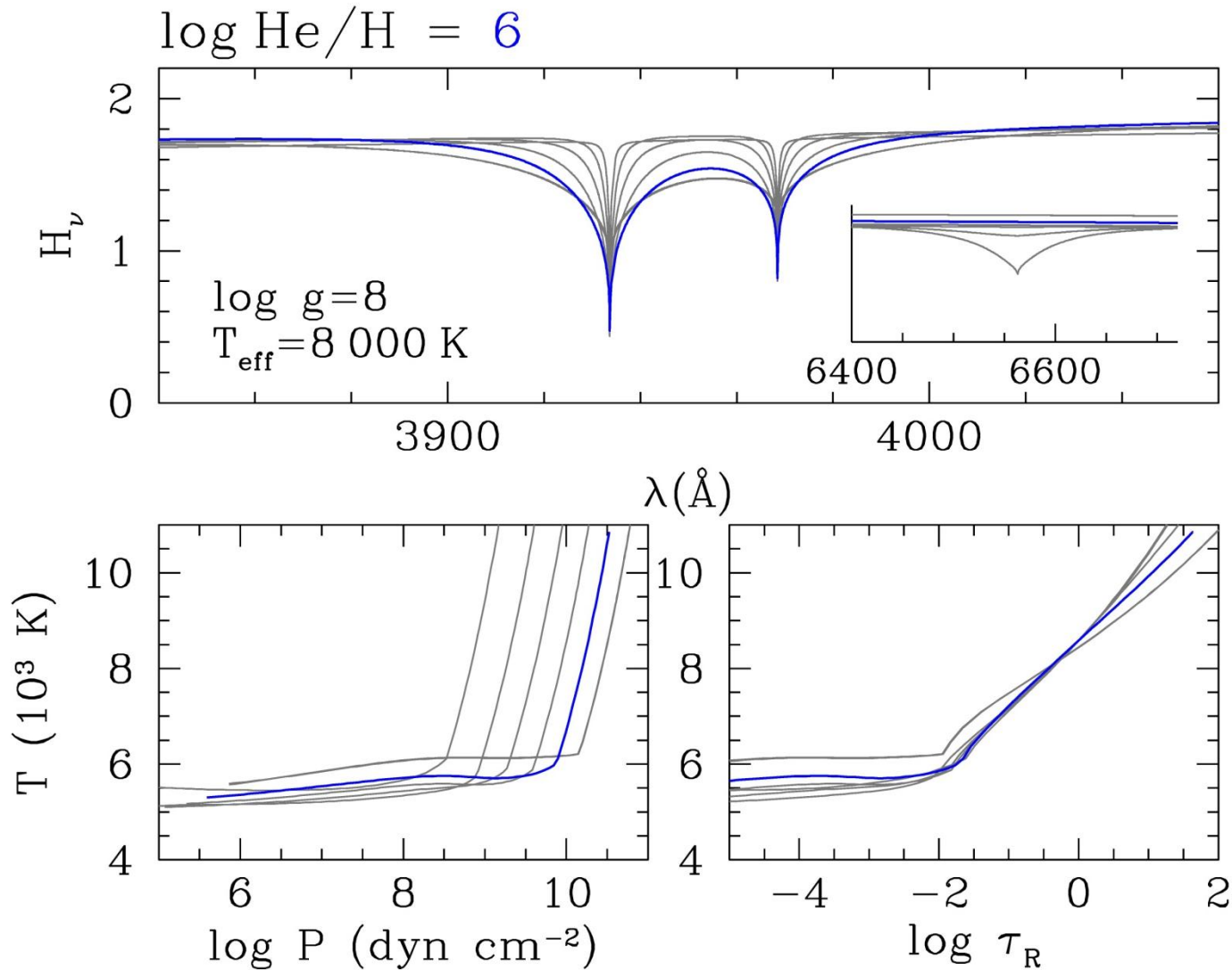


Structure & spectral synthesis

$\log \text{He}/\text{H} = 9$

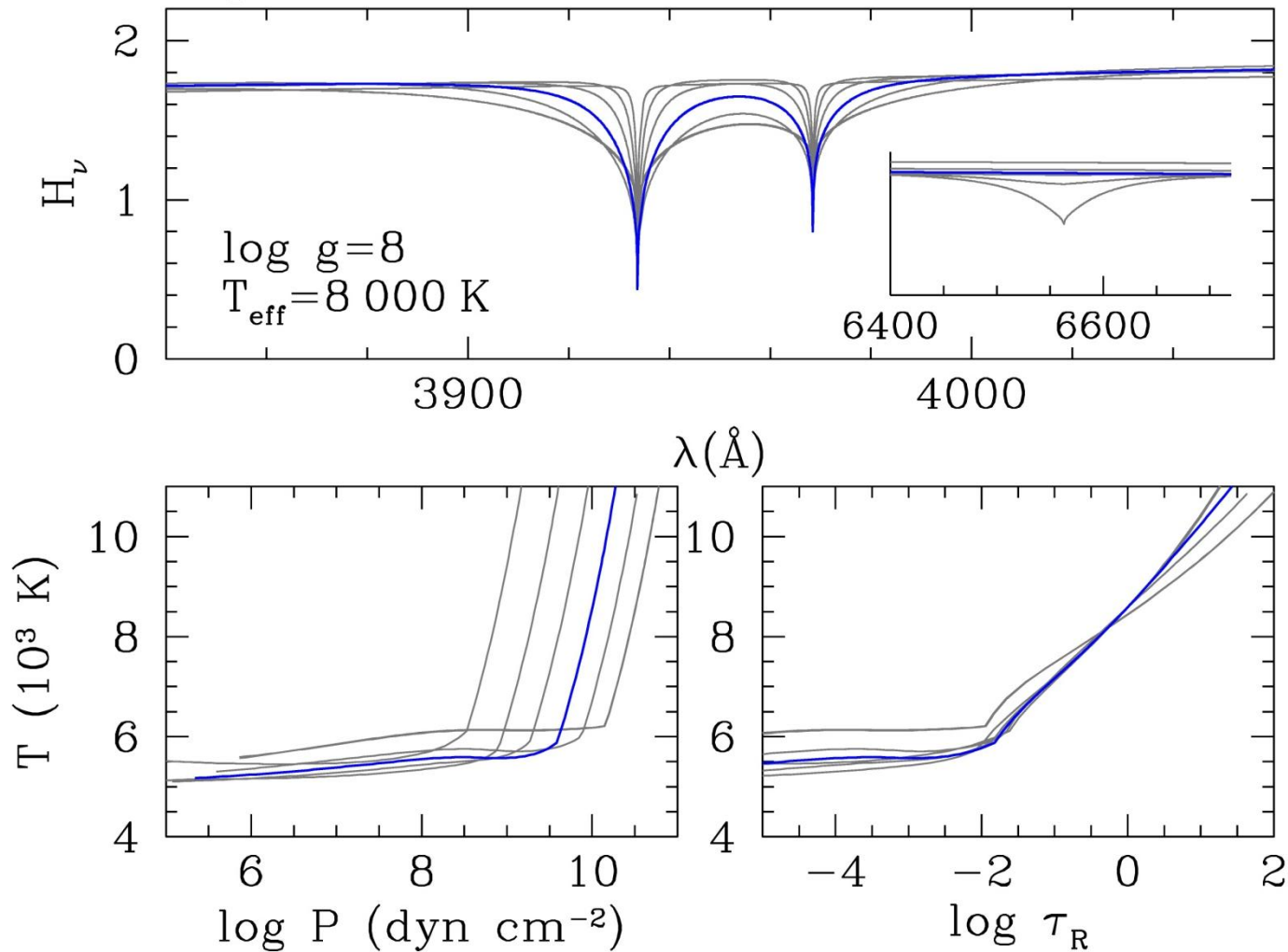


Structure & spectral synthesis

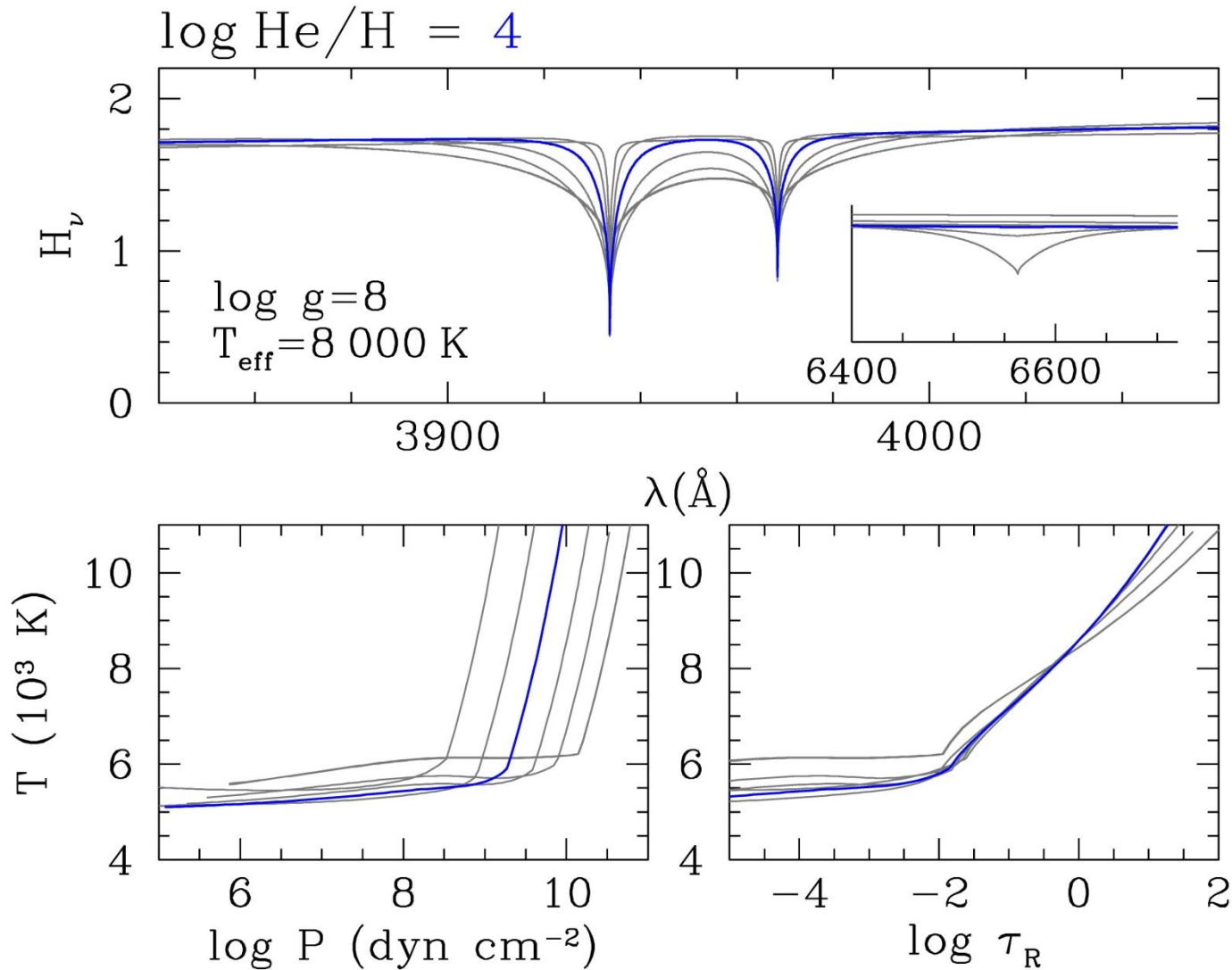


Structure & spectral synthesis

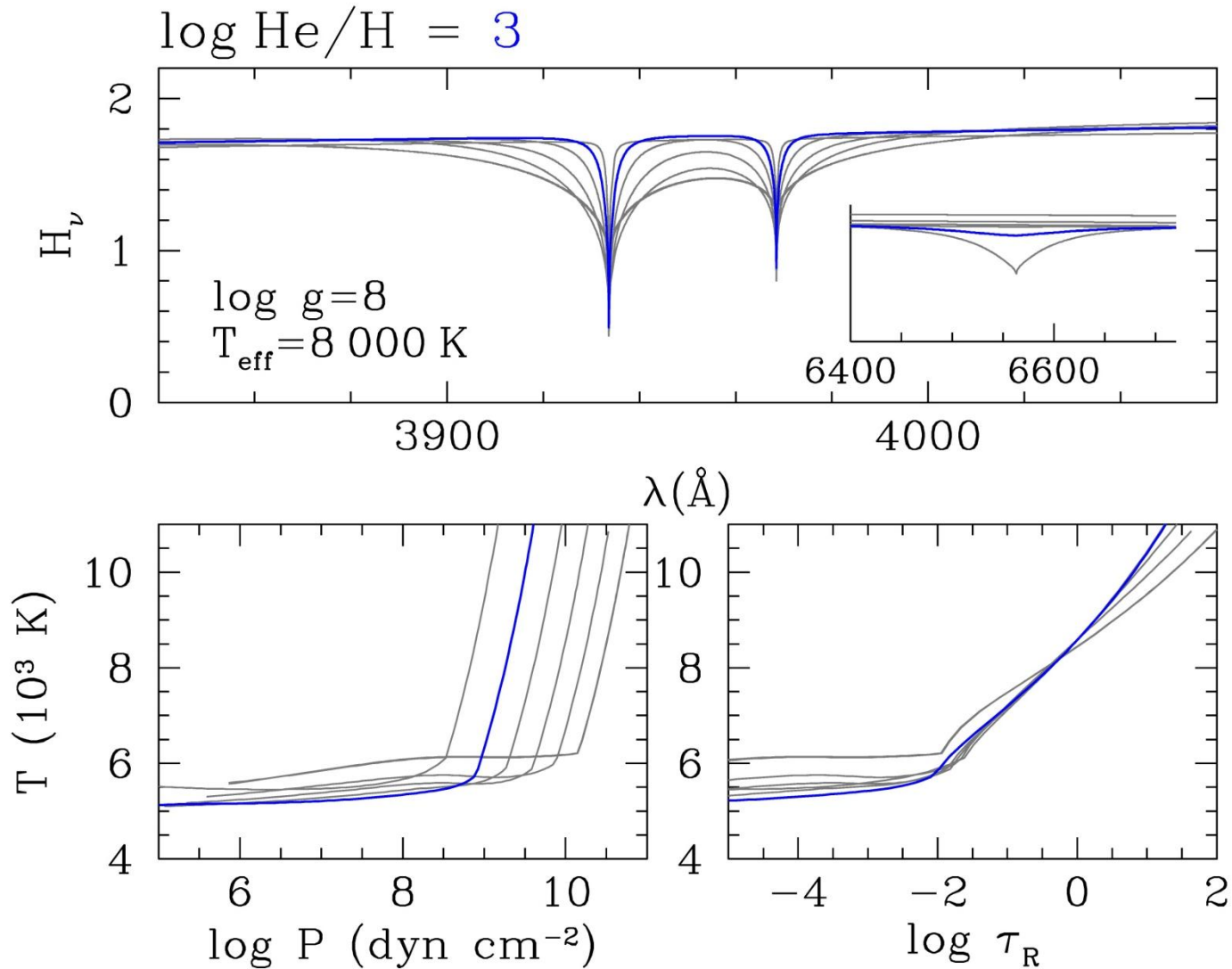
$\log \text{He}/\text{H} = 5$



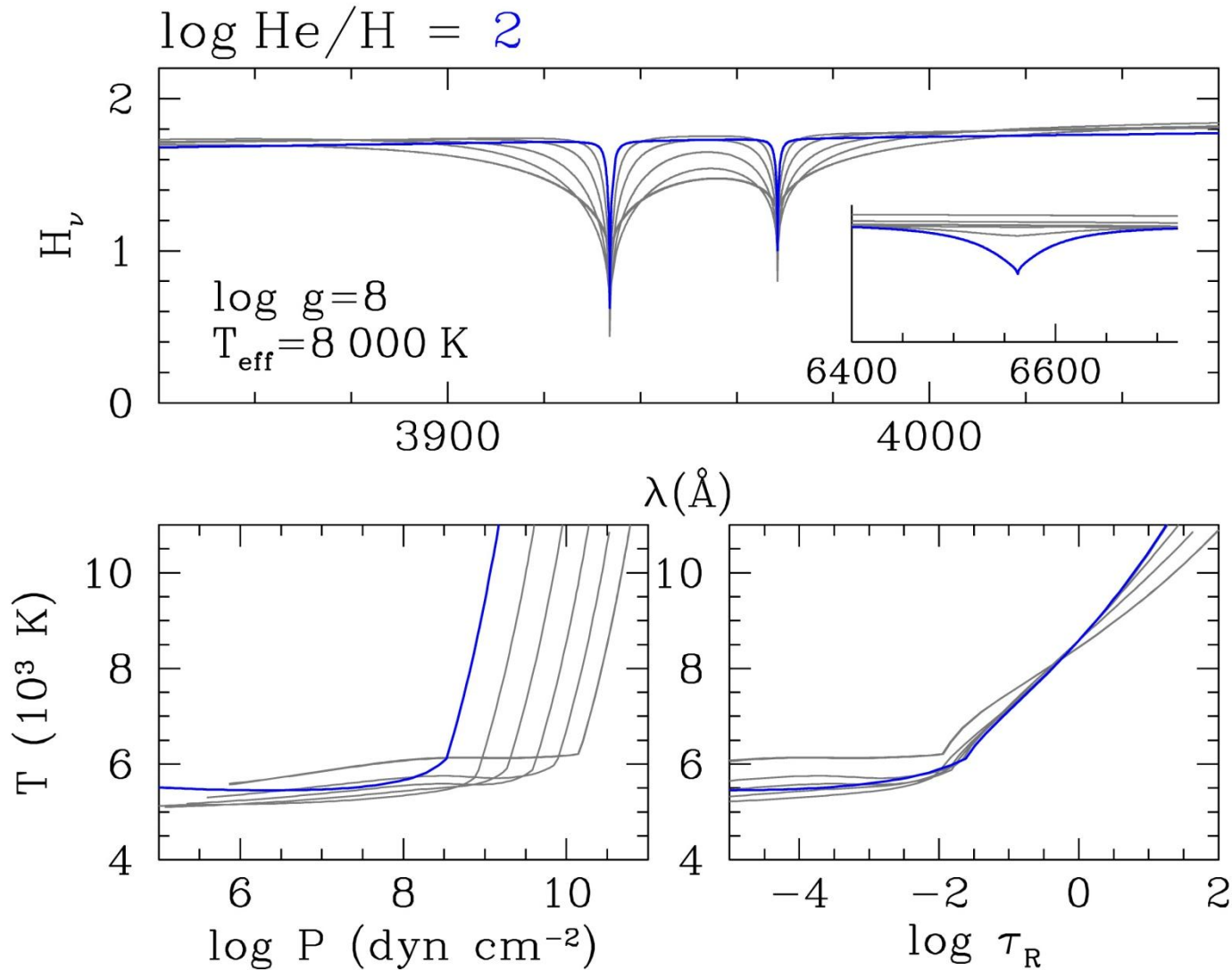
Structure & spectral synthesis



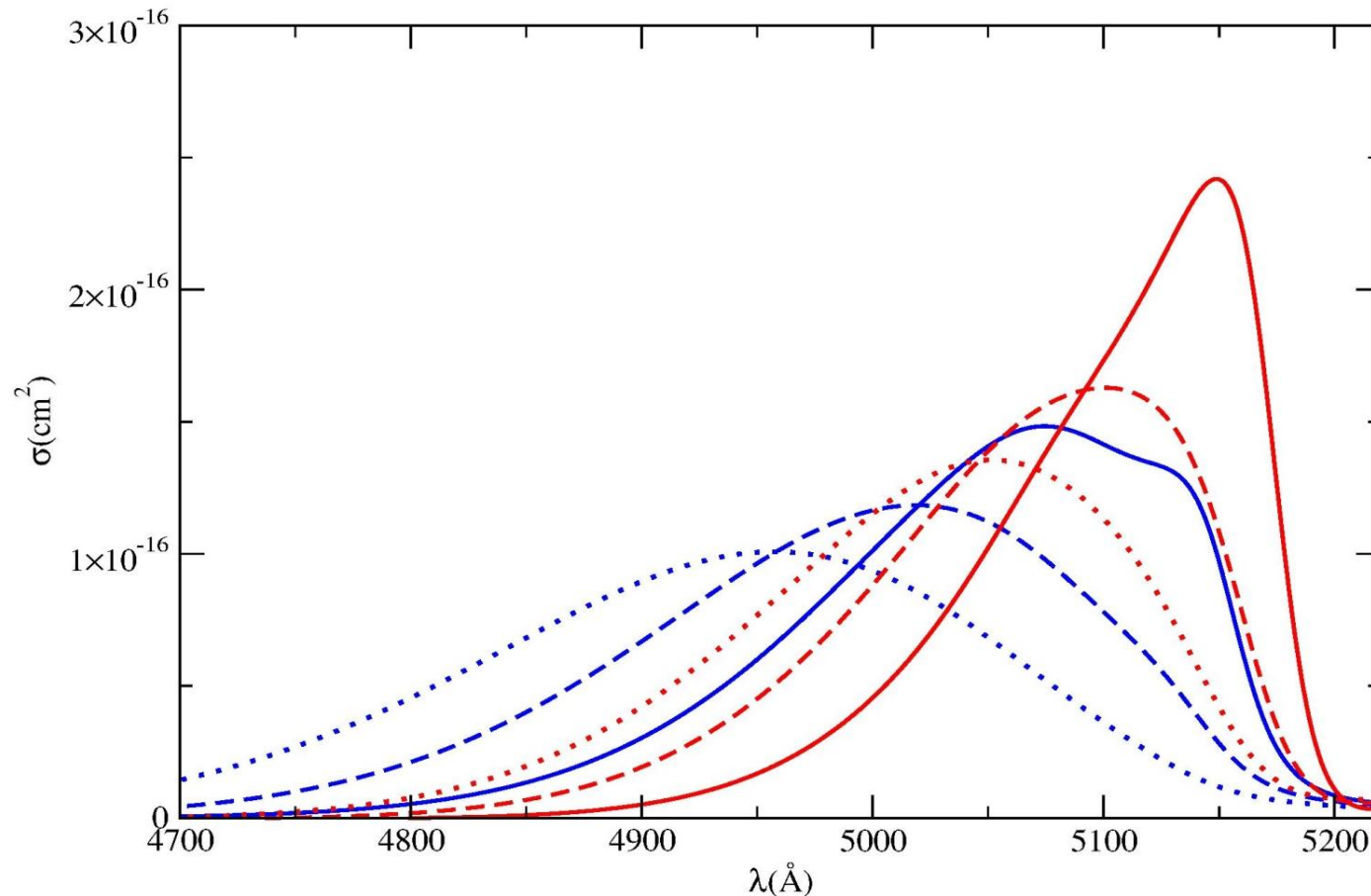
Structure & spectral synthesis



Structure & spectral synthesis

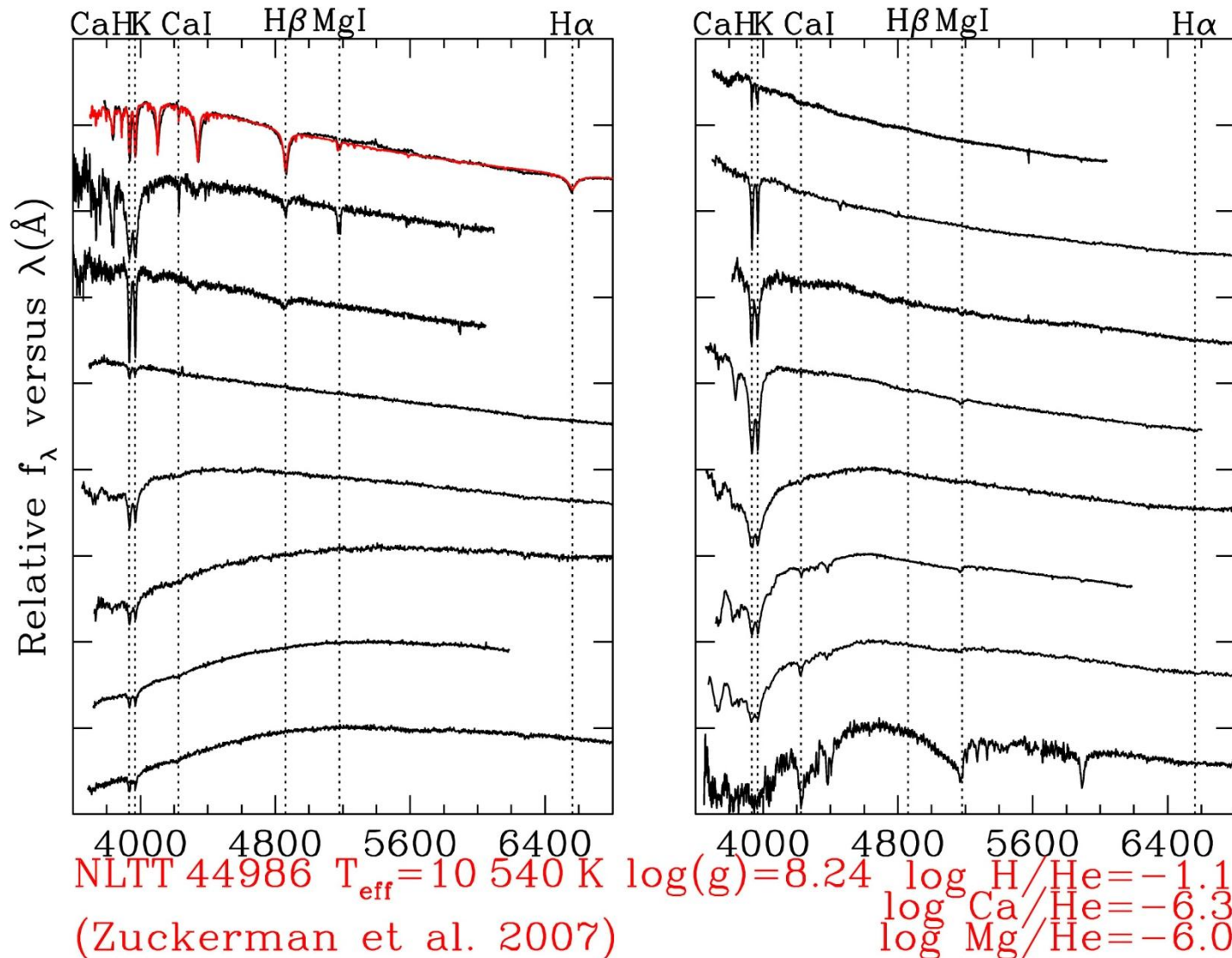


New Mg-He opacity (Allard et al. 2016)

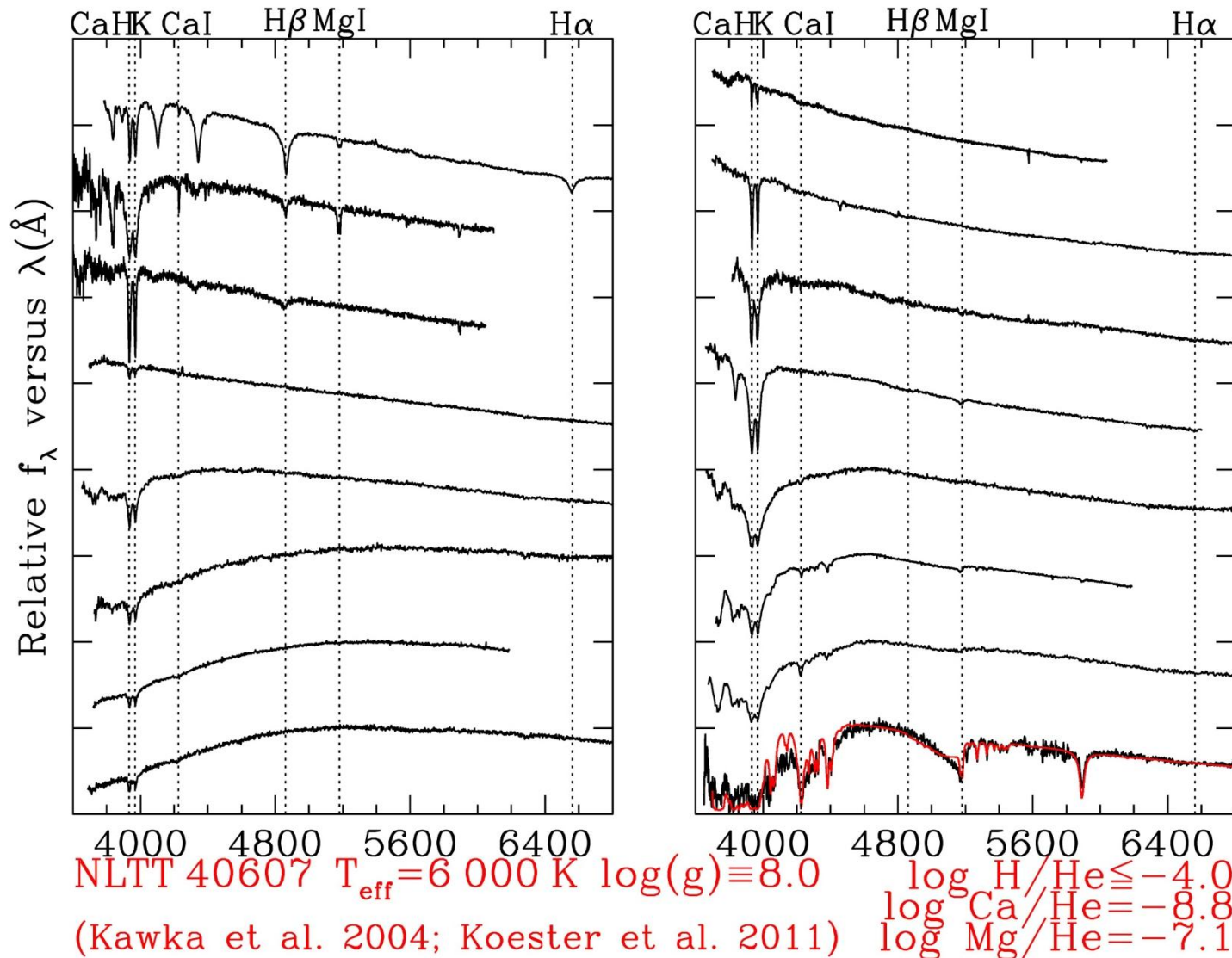


MgI in high-density He atmospheres: $\log n_{\text{He}}/\text{cm}^3 = 21.3, 21.5, 21.6$ (5183.6 in red, 5167.3 in blue). Non-lorentzian profiles! Lorentzian below $\log n_{\text{He}}/\text{cm}^3 = 20$. Currently developing new tables with N.F. Allard.

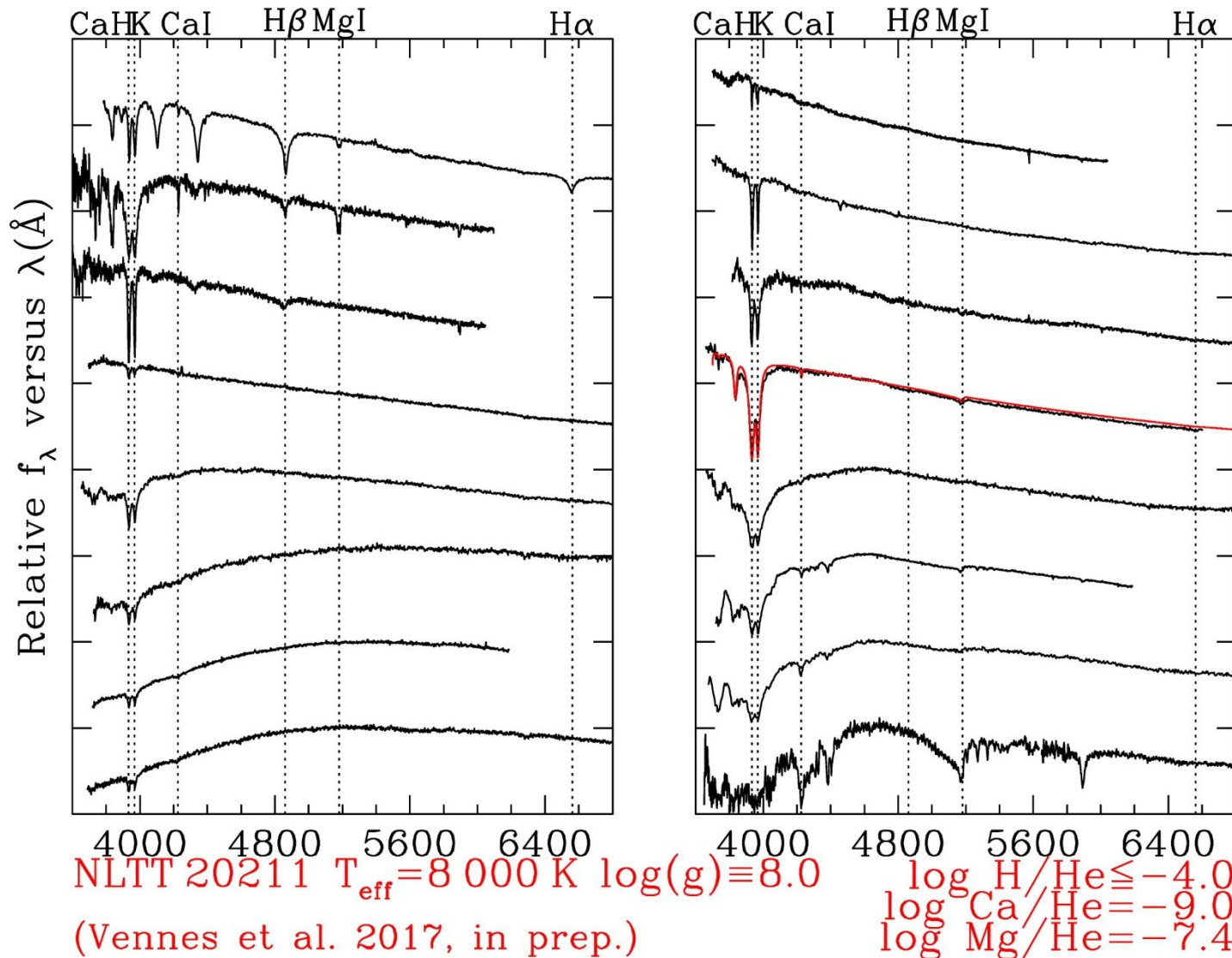
Observations & spectral synthesis



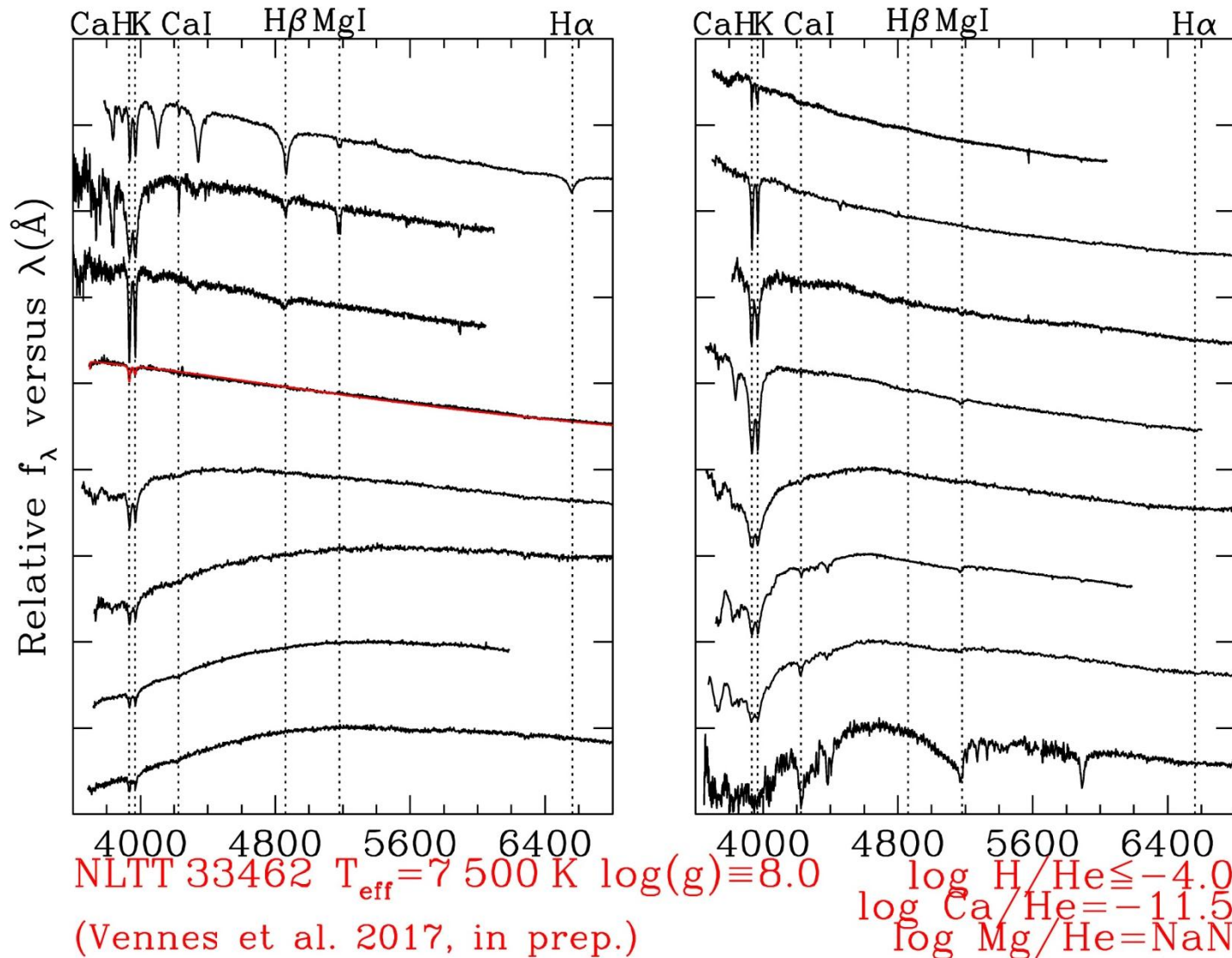
Observations & spectral synthesis



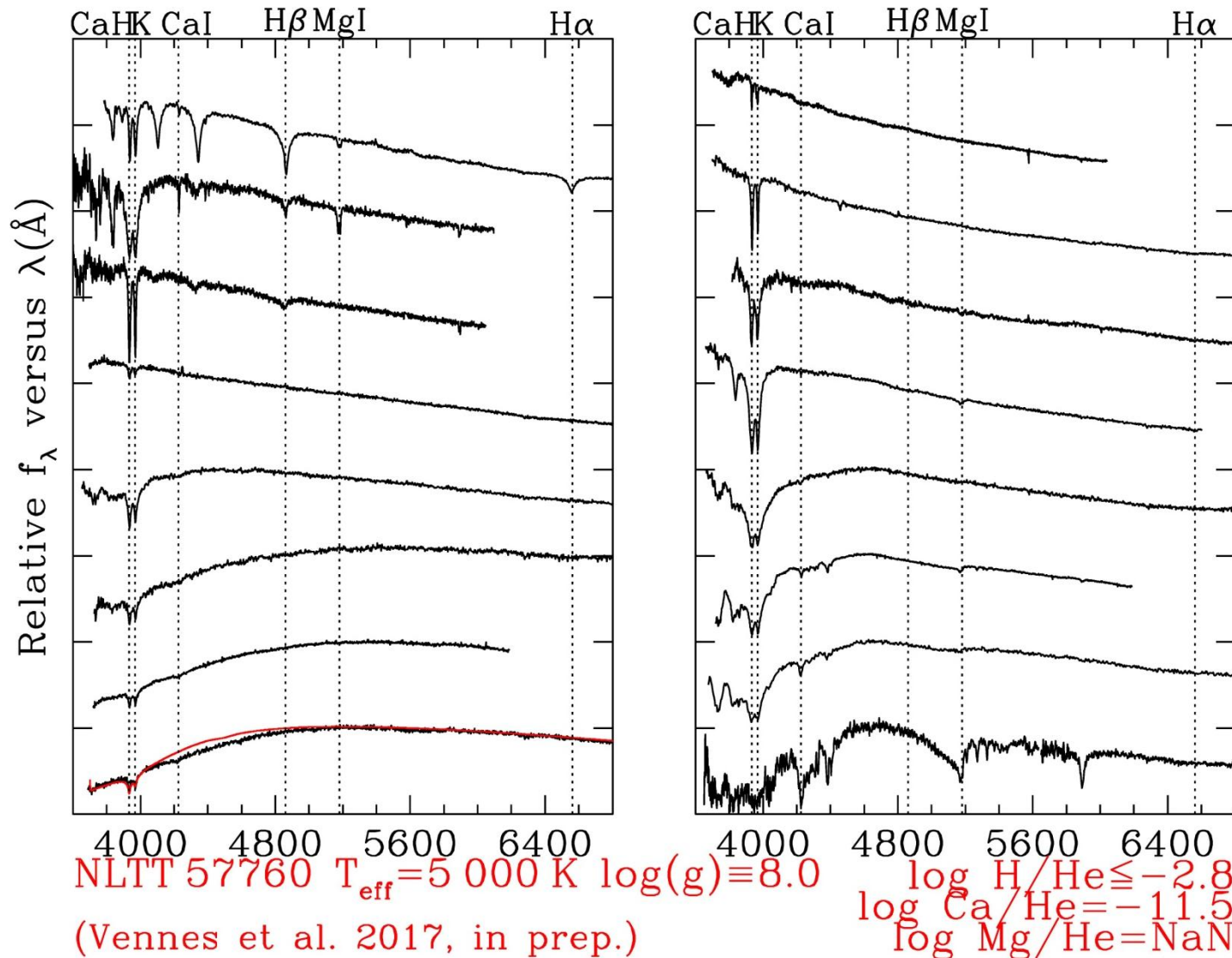
Observations & spectral synthesis



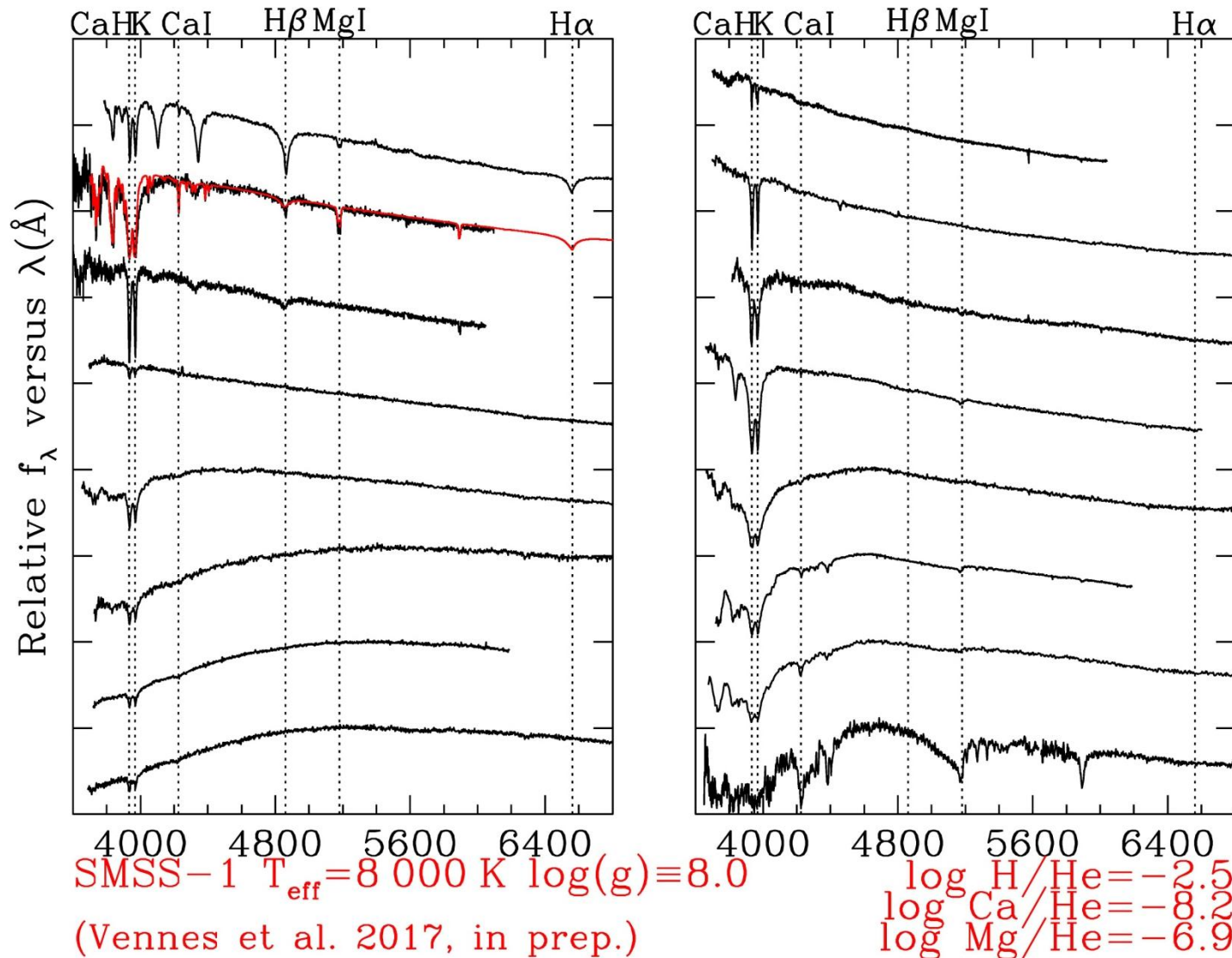
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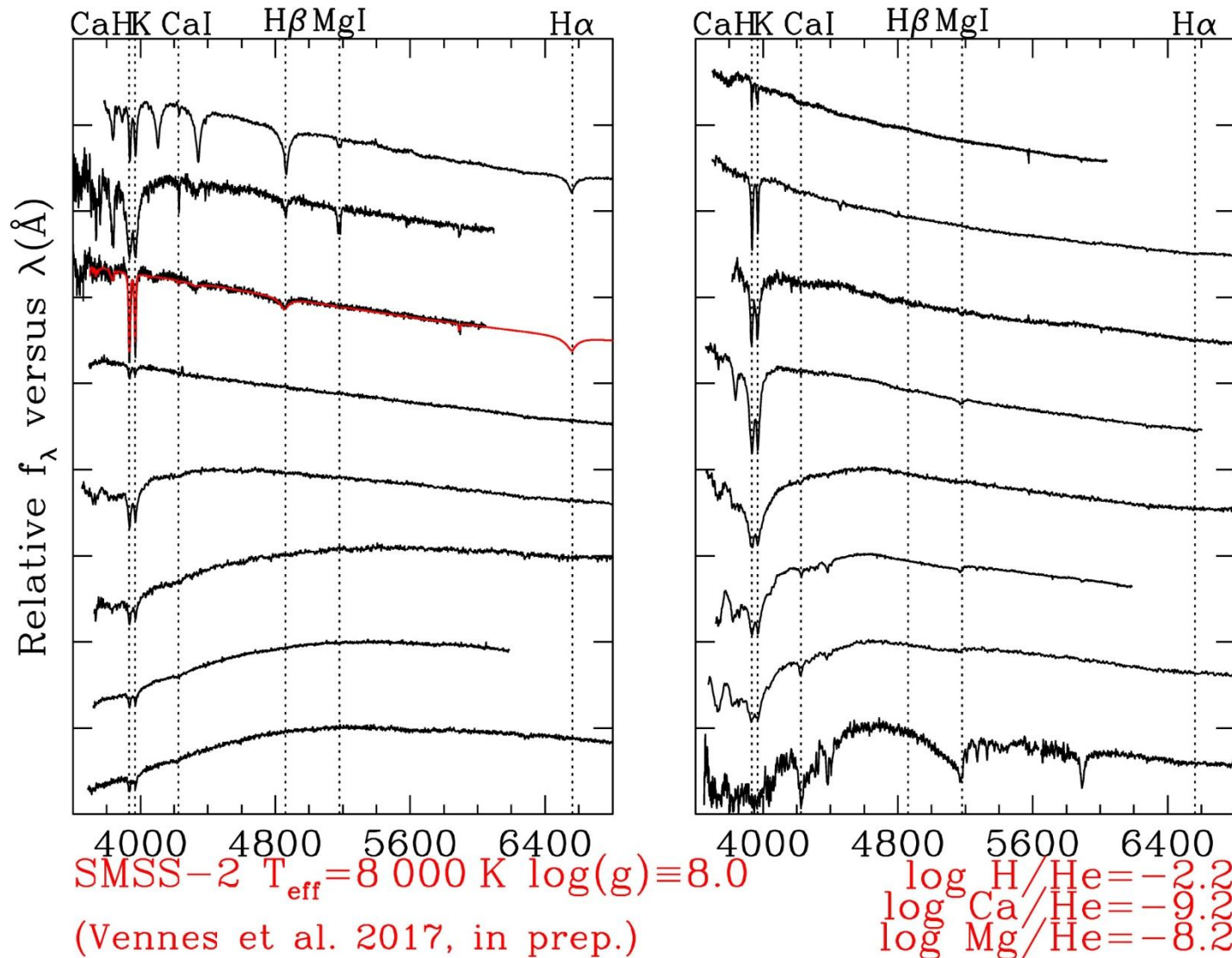
Observations & spectral synthesis



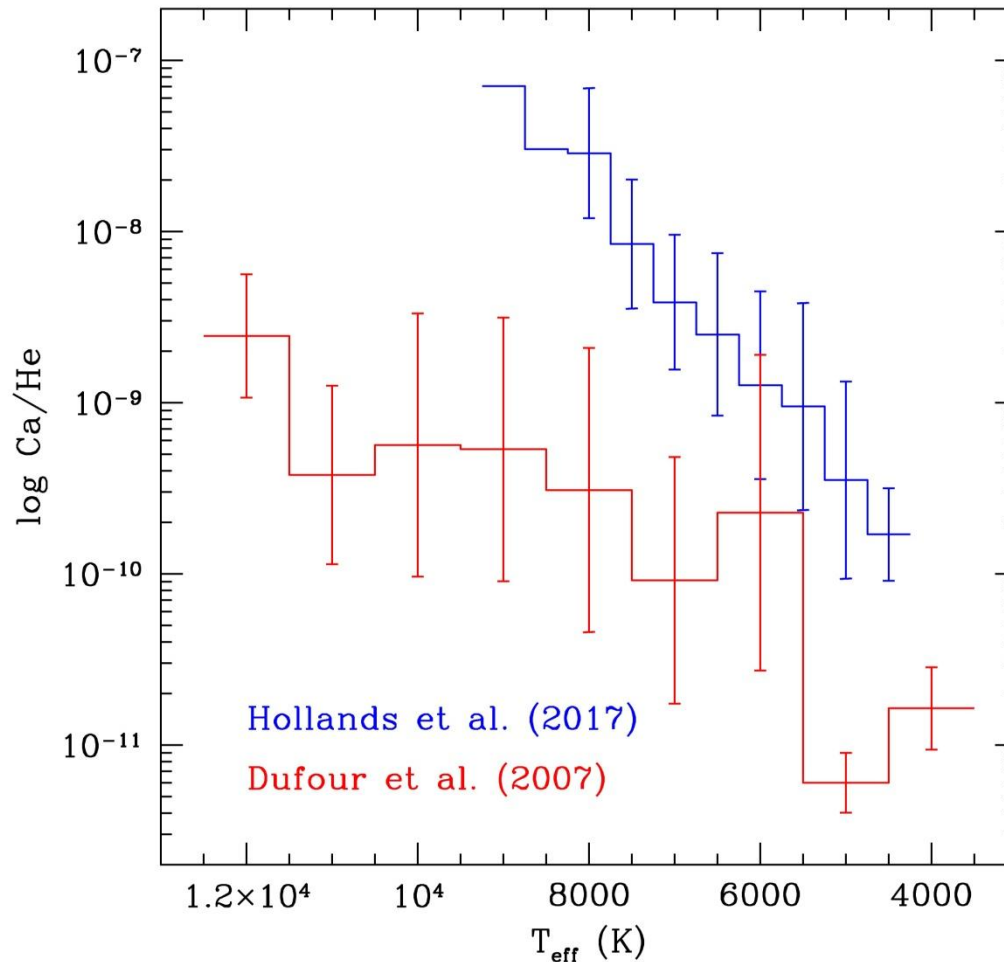
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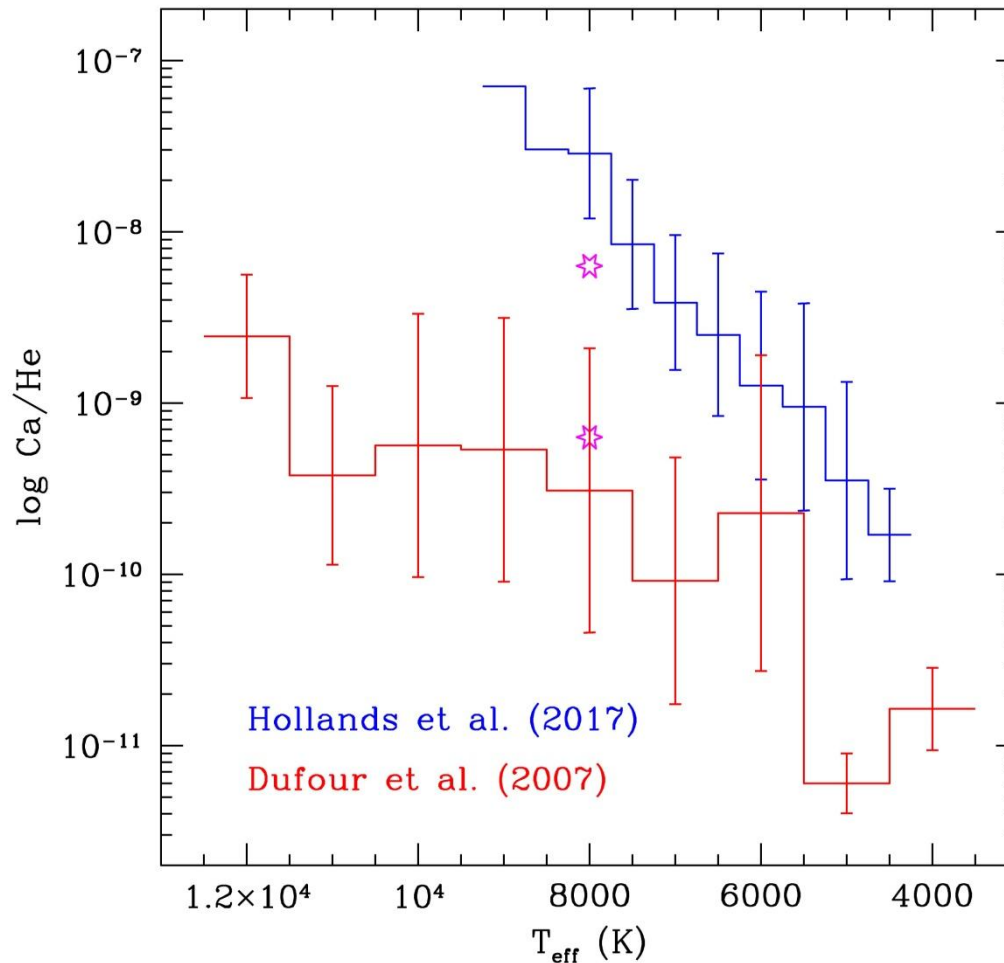
DZ white dwarfs: the Ca problem



SDSS (Dufour et al.; Hollands et al.) and historical surveys (Bergeron, Ruiz, Leggett):

- Hollands et al.: non-UV selection $u-g > 1.5 \dots 3.5$ prefers UV-suppressed high-Z stars.
- Dufour et al.: the UV selection $u-g \sim < 1$ based on Eisenstein et al's WD catalogue prefers low-Z.
- After converting to $dM(\text{Ca})/dt$, M.Hollands (Monday) suggests supply exhaustion with time ... (colour selection still ok?)

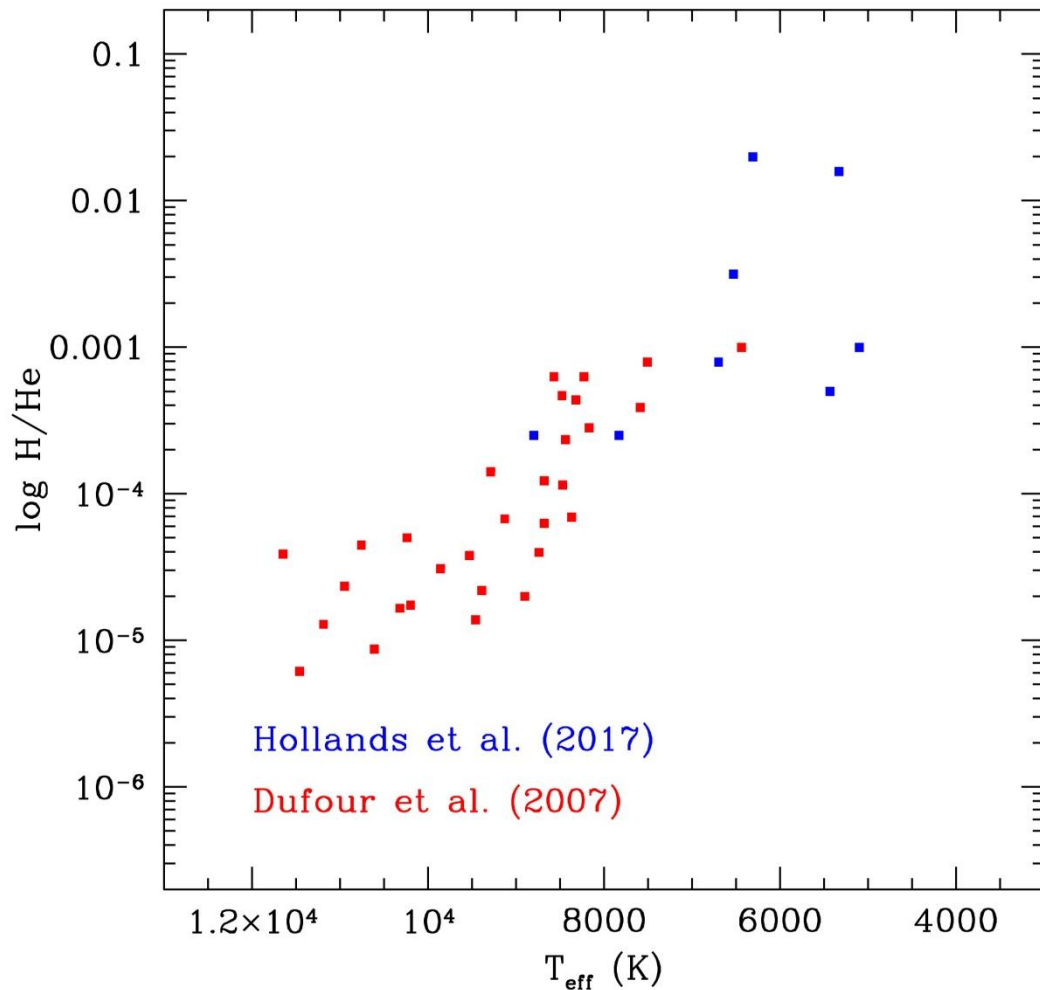
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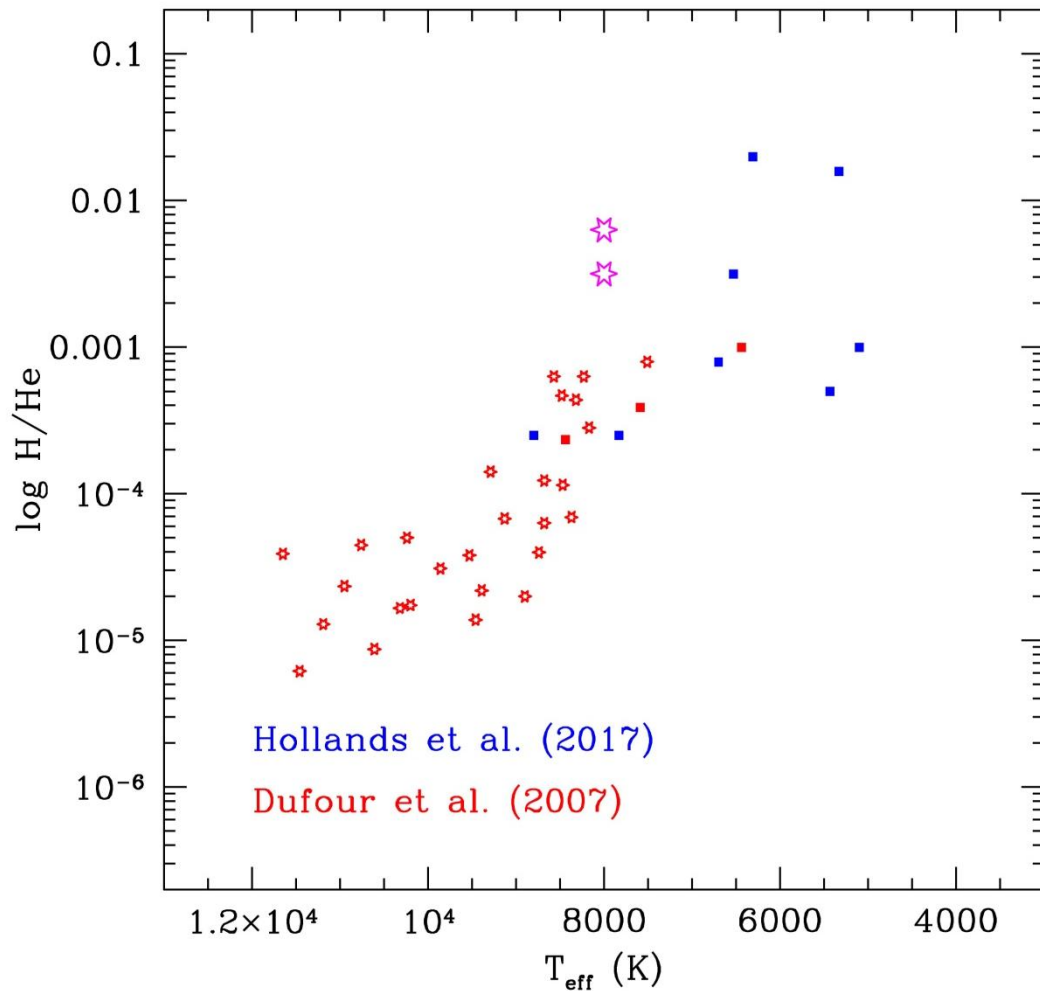
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DZ white dwarfs: the H problem



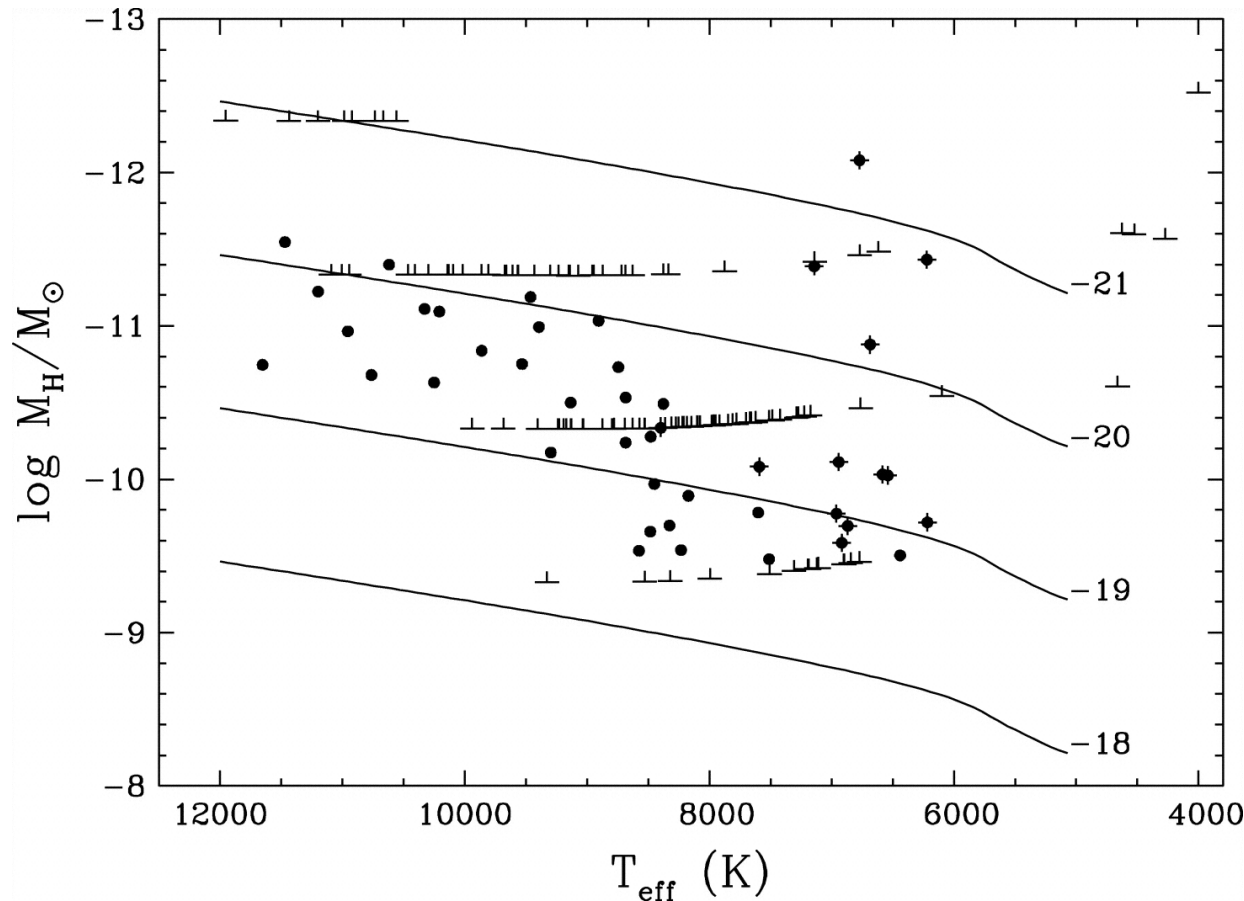
- Warm ($T > \sim 8000\text{K}$) versus cool ($T < \sim 8000\text{ K}$) sample of Dufour et al. versus Hollands et al.
- Only positive Balmer line detections shown
- Trend opposite to Ca: Ca trickles down at bottom of convection zone (He dominated), while H floats up.
- Dufour et al. propose accumulation with age.
- Is apparent correlation only a selection effect?

DZ white dwarfs: the H problem



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Discussion: H increased supply?



- Figure from Dufour et al (2007):
- Calculate total H mass in convection zone M_H versus T_{eff} (as proxy for age).
- Detected H (dots), upper limits (T-bars), Ca-profile analysis (dot-+s). Possible supply increase with time!
- Opposite trend to Ca (beware of the y-axis pointing down).

Summary

- Exploited the canonical Luyten surveys supplemented with Lepine et al.'s
- Initiated a colour-proper motion selection of white dwarf stars in the SkyMapper survey
- Presented preliminary analysis of DZ/DZA white dwarfs
- New DAZs weaken somewhat the increasing trend of the H supply with age, but just (no weakening as seen for Ca)
- Upcoming X-shooter follow-up spectra will clarify the present analysis
- A. Kawka will present our DAZs

Comment added after presentation

- D. Veras: a suitable scenario for a late H supply in DZAs is the accretion of Oort-cloud-type comets onto the white dwarf (Veras, Shannon, Gaensicke 2014, MNRAS 445, 4175).