Helium spectral lines at 10830Å: observational trends with stellar parameters

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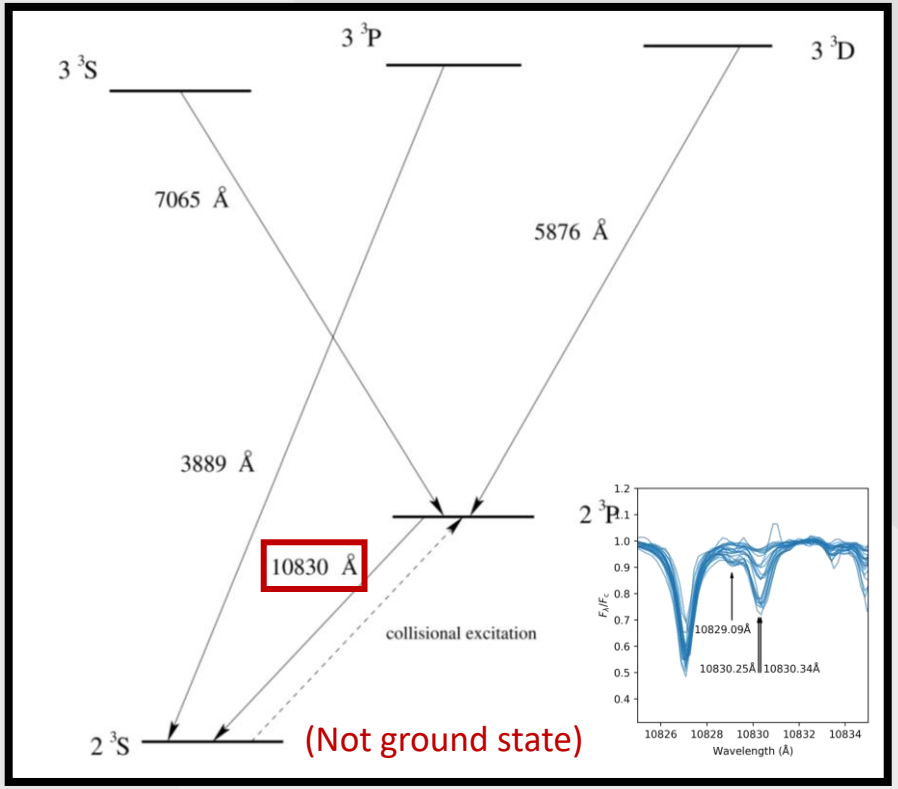
Helium evolution in the Milky Way

- Helium abundance increases as a stellar system evolves.
  - Multiple main-sequence/RGB in globular clusters.
- The detail of helium evolution is unclear:
  - No obvious helium photospheric spectral lines appear in the spectra of cool stars.
- We aim to determine helium abundance of stars in Milky Way
  - Characterize the behavior of helium 10830Å lines and the possibility to be used as helium abundance tracer.

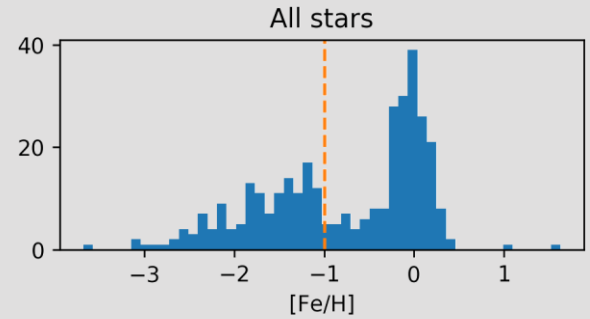
Helium 10830Å lines in late-type stars

- 10830Å: $2s\ ^3S_1$-$2p\ ^3P_{0,1,2}$
- Photoionization Recombination (PR mechanism)
- Collisional Excitation (CE mechanism)
  - $T_e > 20000K$
  - Helium atom / electron diffusion
- The 10830Å lines have chromospheric and coronal origin.

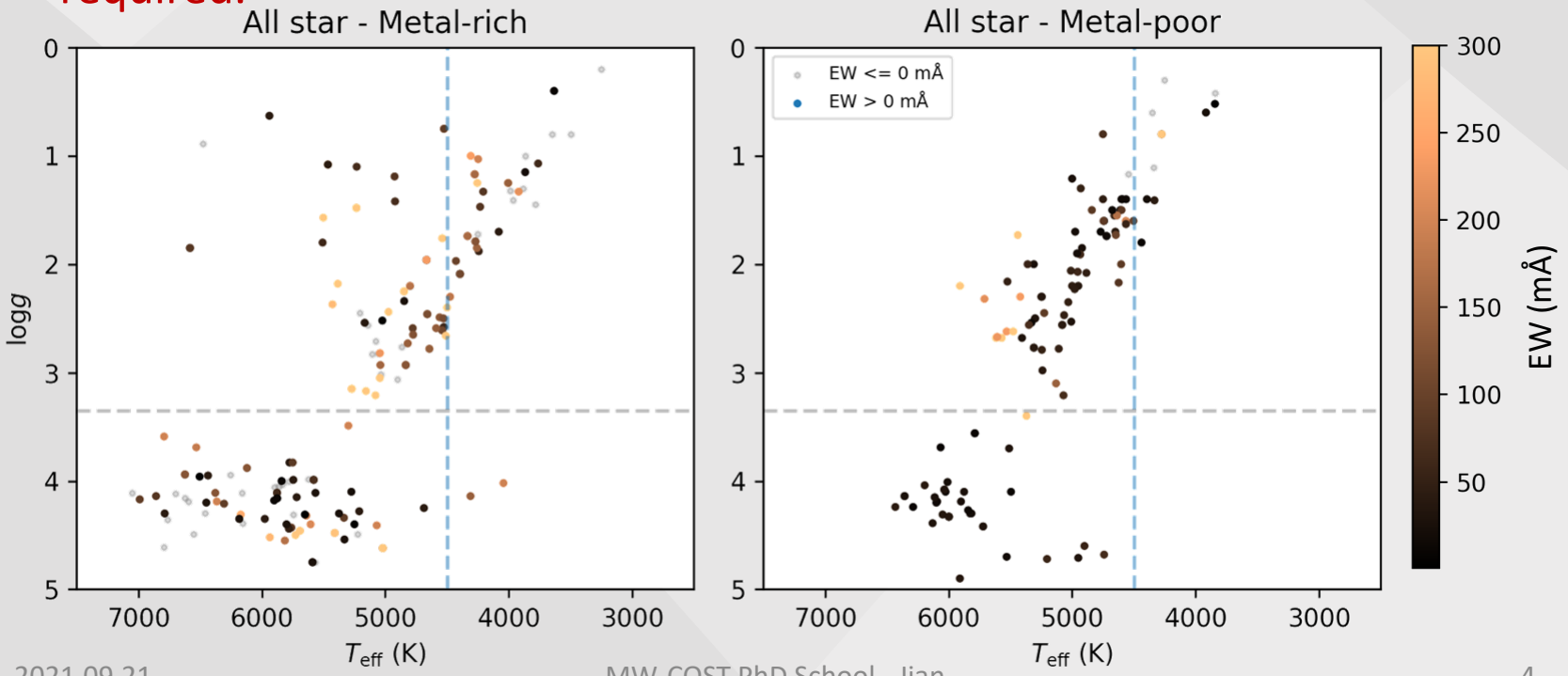


Sanz-Forcada & Dupree 08

Compilation of previous measurements

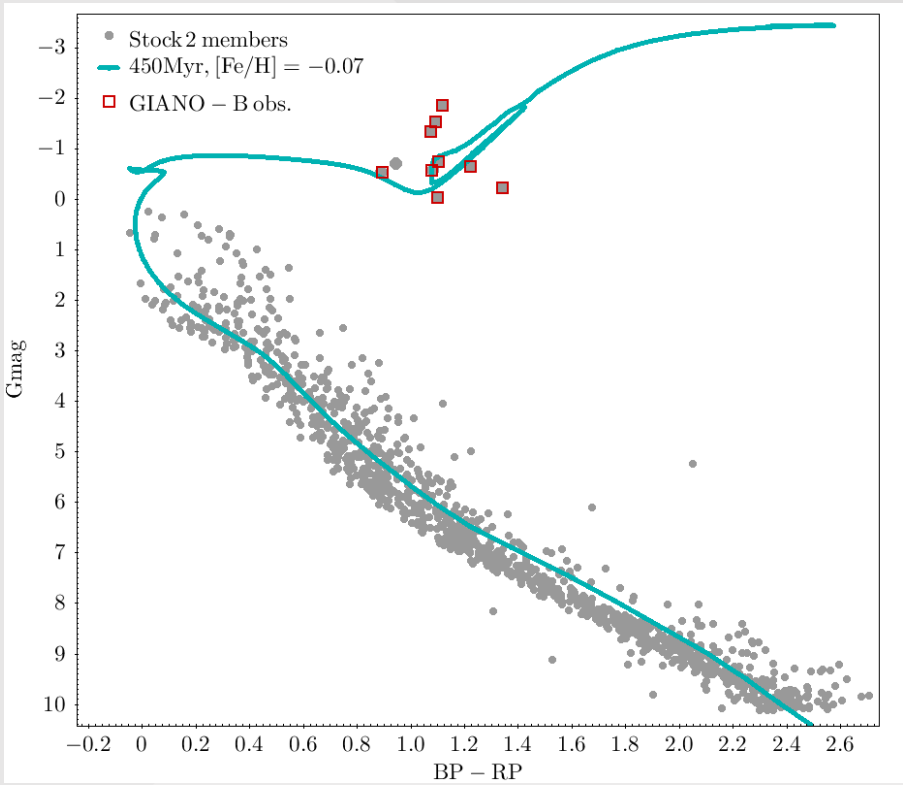


- The result of 13 studies with equivalent width (EW) measurements between 1986-2015 are collected.
- EWs < 100mA are not accurate.
- New, homogeneous measurements with blending lines excluded are required.

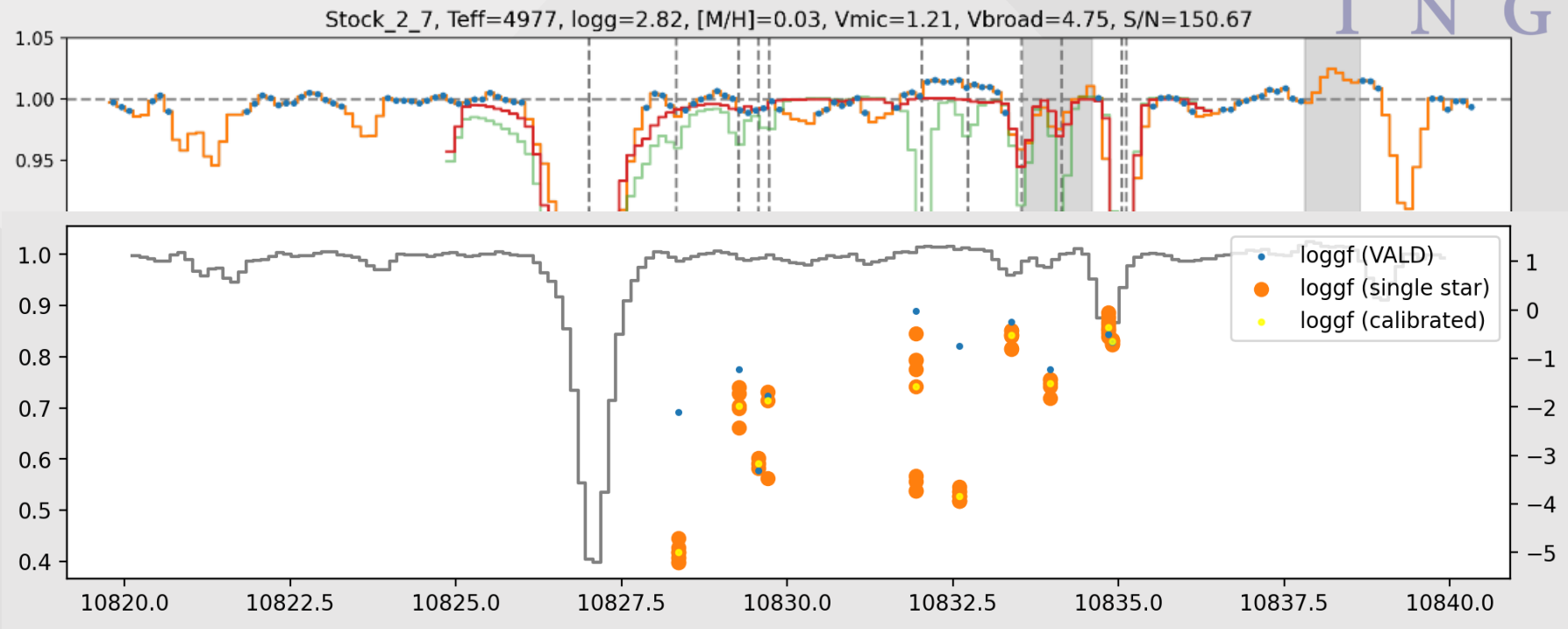


GIANO-B observations

- R~50000, 0.9-2.45μm
- 9 giants in open cluster Stock-2 with stellar parameters determined from HARPS spectra.
- They are used for calibrating $\log gf$ values of the lines around 10830Å.



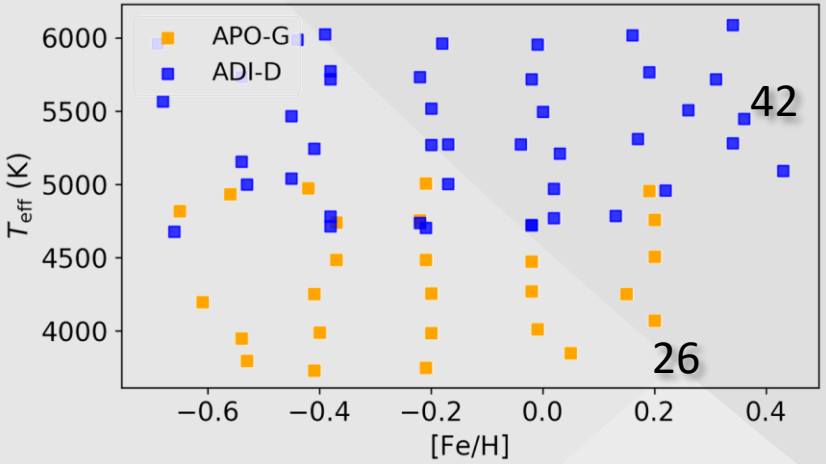
GIANO-B observations



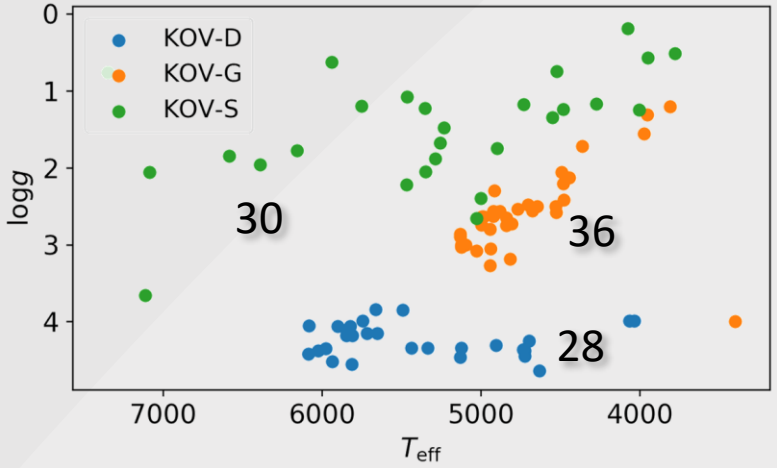
- $\log gf$ values of most blending lines decreased.
- The contamination by atomic lines is at most 15 mÅ for giants and dwarfs in [Fe/H]=0.5.

observations

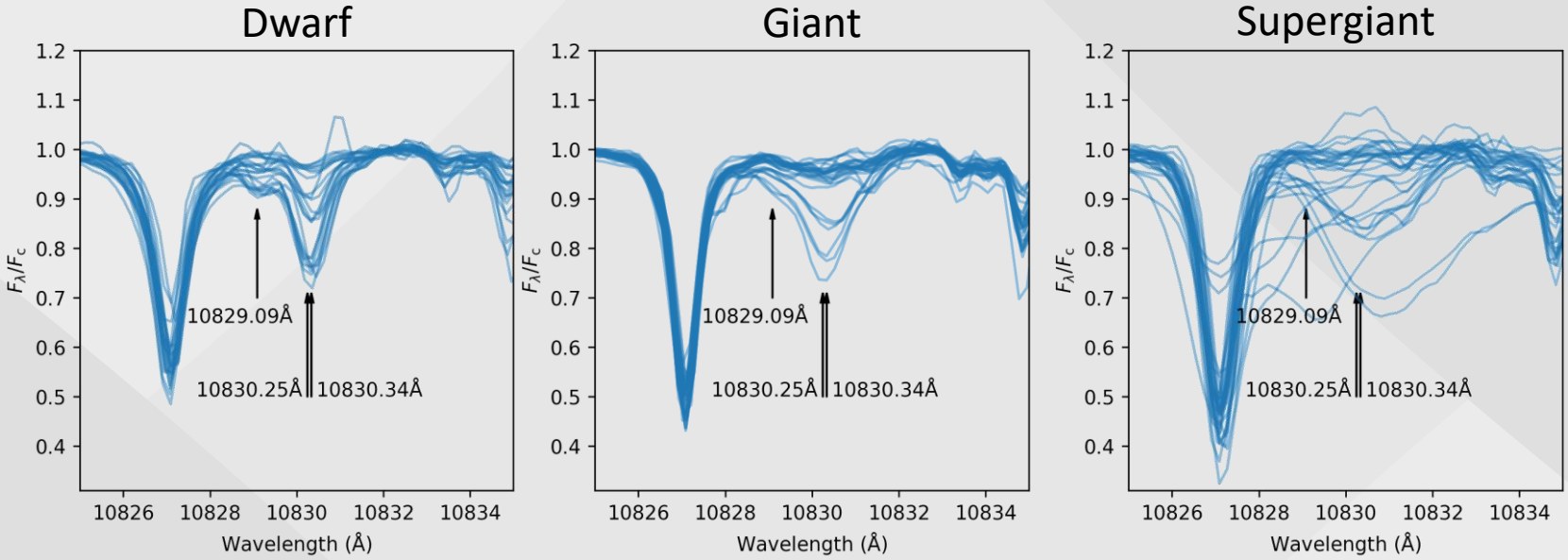
- WINERED sample:
  - R~28000; 0.91-1.35μm
    - Also have R~70000; 0.96-1.11, 1.14-1.35μm
  - Giants: APOGEE survey
  - Dwarfs: Adibekyan+2012



- From line-depth ratio studies (Jian et al. 2020; 2003.10641) on "Kovtyukh" targets

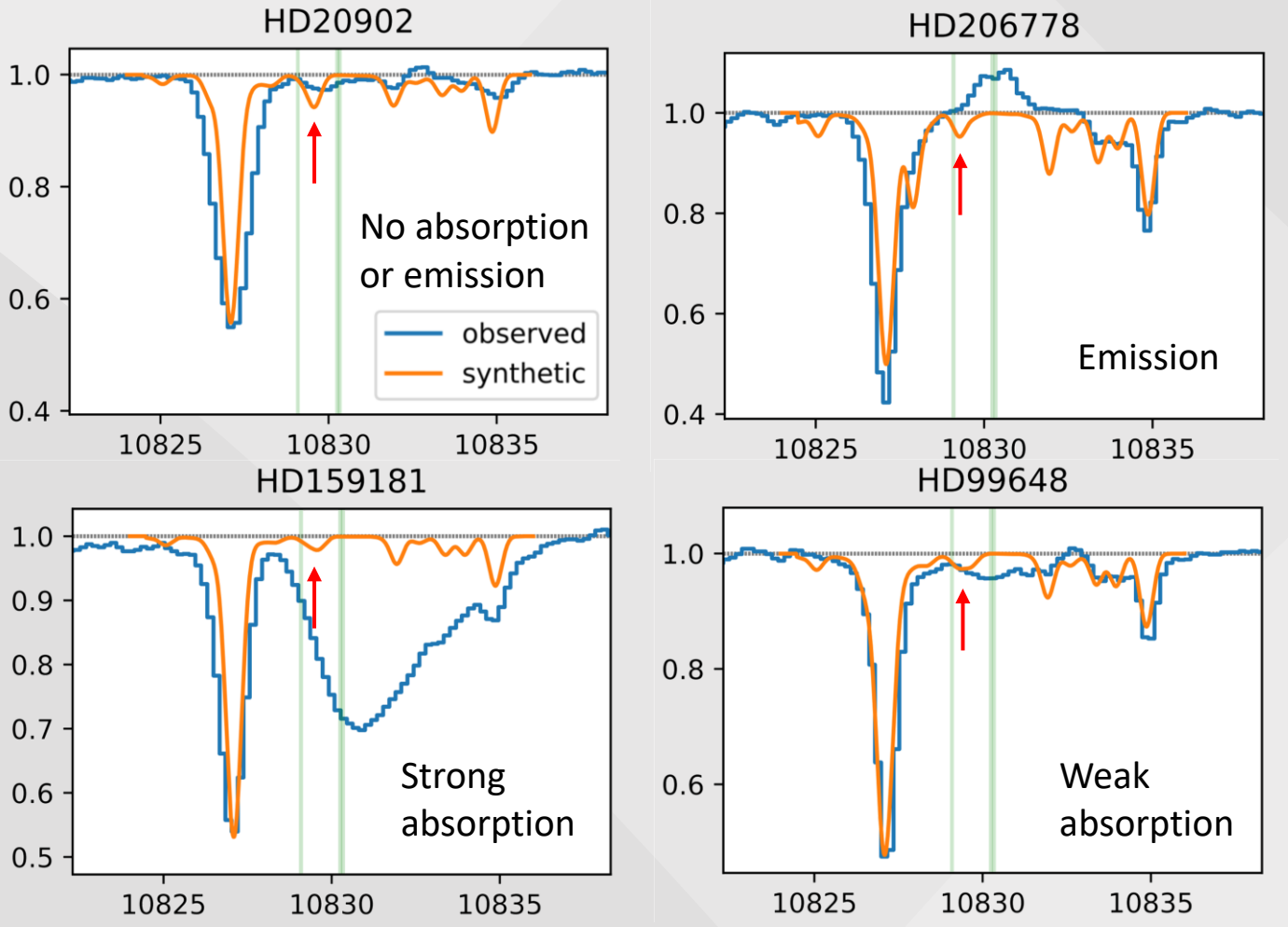


WINERED observations



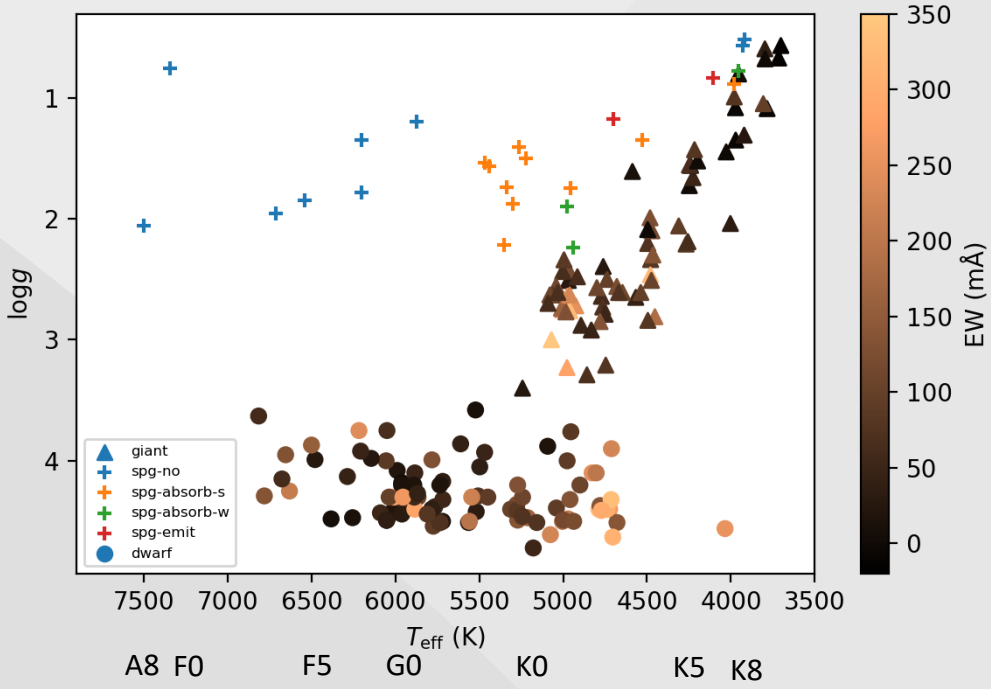
- Line width: supergiant > giant > dwarf
- We fitted the Gaussian to the main 10830 A feature after removing the Si line to estimate the equivalent width (EW).

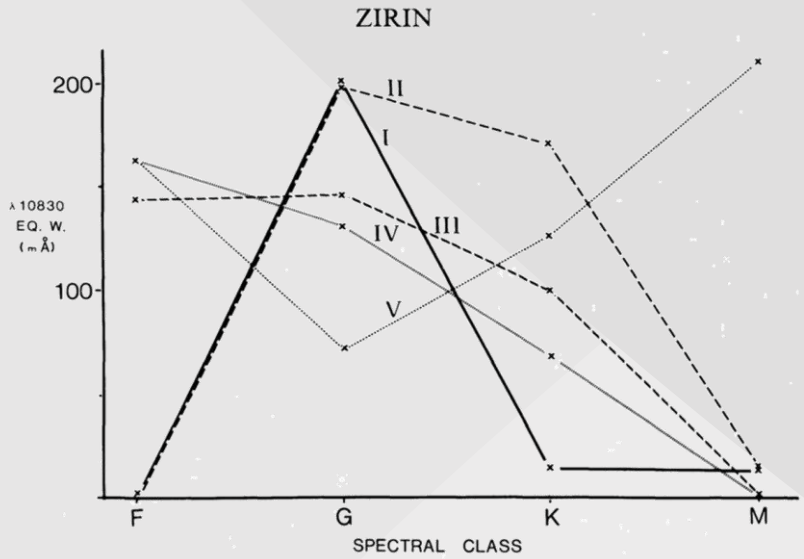
EW classification (supergiants)



- Helium lines are not synthesized;
- A Ca I line (↑) is blended with helium lines.

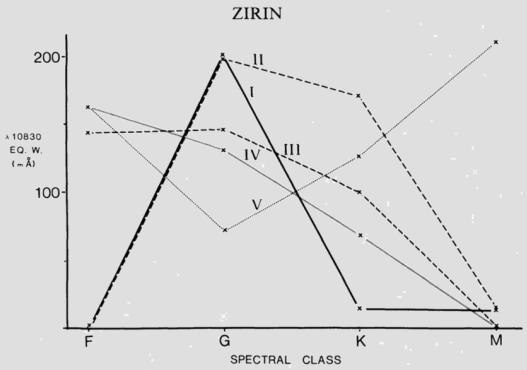
EW – HR diagram



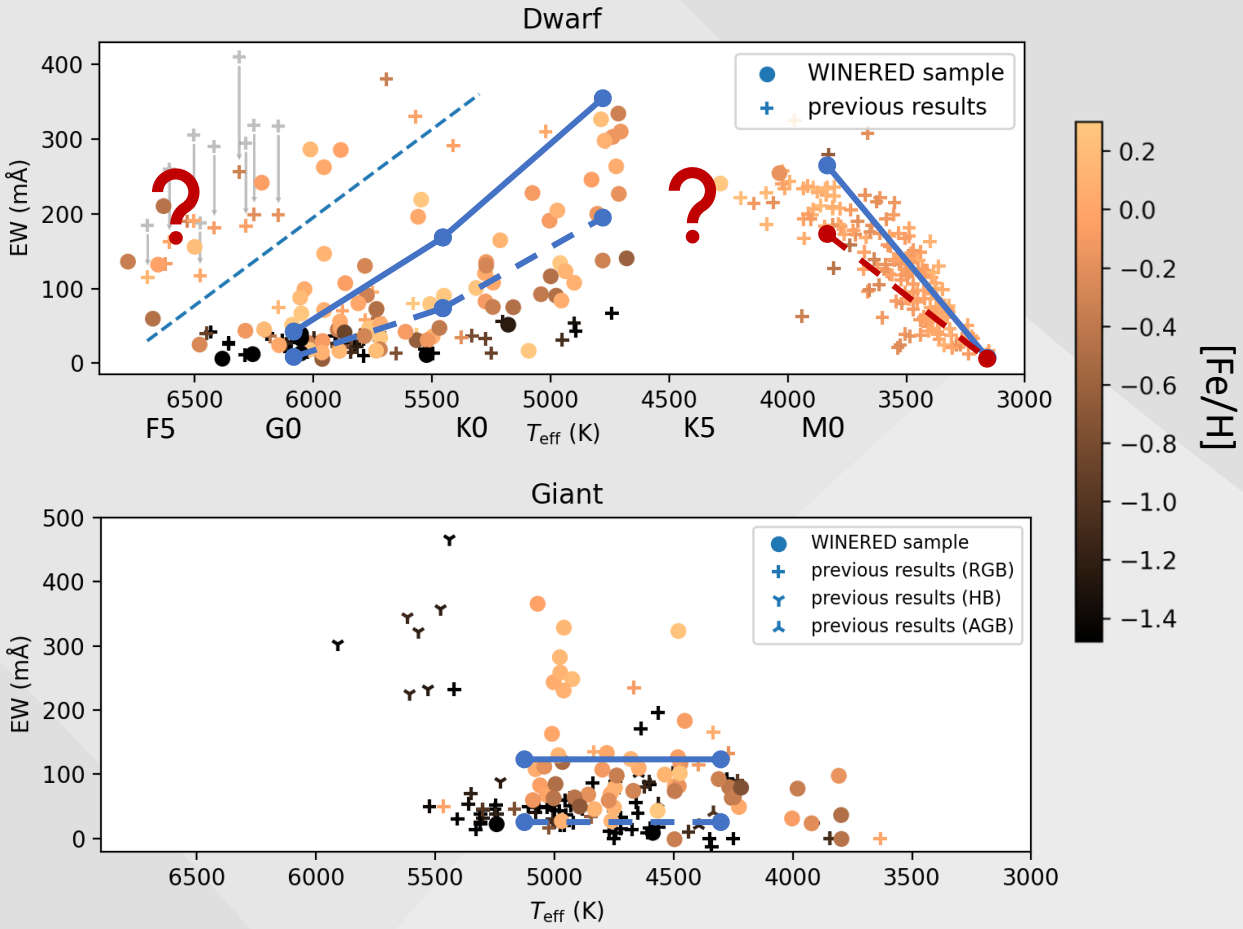


- The trends of EW are similar with those derived in Zirin 1982.

EW – metallicity effect



- EW is sensitive to both $T_{\rm eff}$ and metallicity.
- The absorption of low-metal stars are weaker.



Summary

- The helium 10830 A absorption features in cool stars are spectral lines with chromospheric and coronal origin.
- Its equivalent width varies with stellar parameters, and systematic dependency on T_{eff} and [Fe/H] are seen with the help of the WINERED data.
- By synthesizing the helium along with other chromosphere lines ($\mathrm{H}\alpha$, Ca II HK lines), there is a possibility to trace helium abundance using 10830A line.

WINERED spectrograph