Presenter: Hodari-Sadiki James
Topic: Stellar Spectral Classification
Course: Astronomy 8000

G & K type Stars

Sequence of Presentation

1) Introduction to G- & K- Type Stars.

2) The Optical & IR Spectral Ranges.

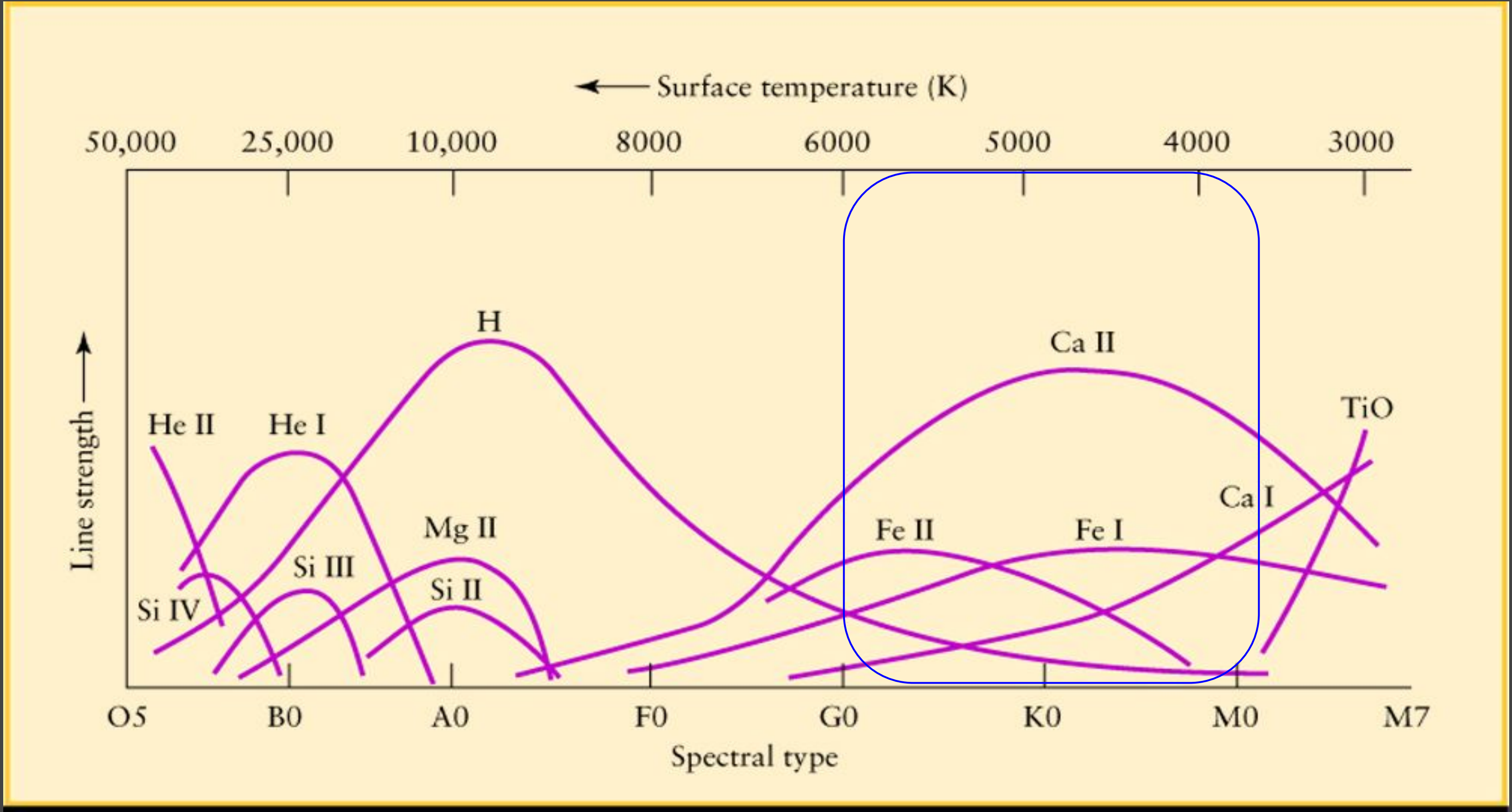
3) Search for a Solar Twin.

4) T Tauri Stars.

Introduction to G- & K- Stars

+ More Spectral Features in the Optical and IR than Hotter stars
+ No strong boundary between G- Types and F Types
+ Dominance of the G band over other spectral features is key
+ G-band, caused by the diatomic CH molecule
+ Increases in strength until about K2, after which it begins to fade

Introduction to G- & K- Stars



Why Are G- & K- Stars Interesting ?

+ Our host-star is a G- Type.
+ Contains ‘Sun-like’ stars which might be hosts to habitable planets.
+ G-K Giants are the dominant source of evolved stars.
+ Peculiar G & K Giant stars show dredge up effect.
+ Supergiants show sudden changes in spectral type.

Sequence of Presentation

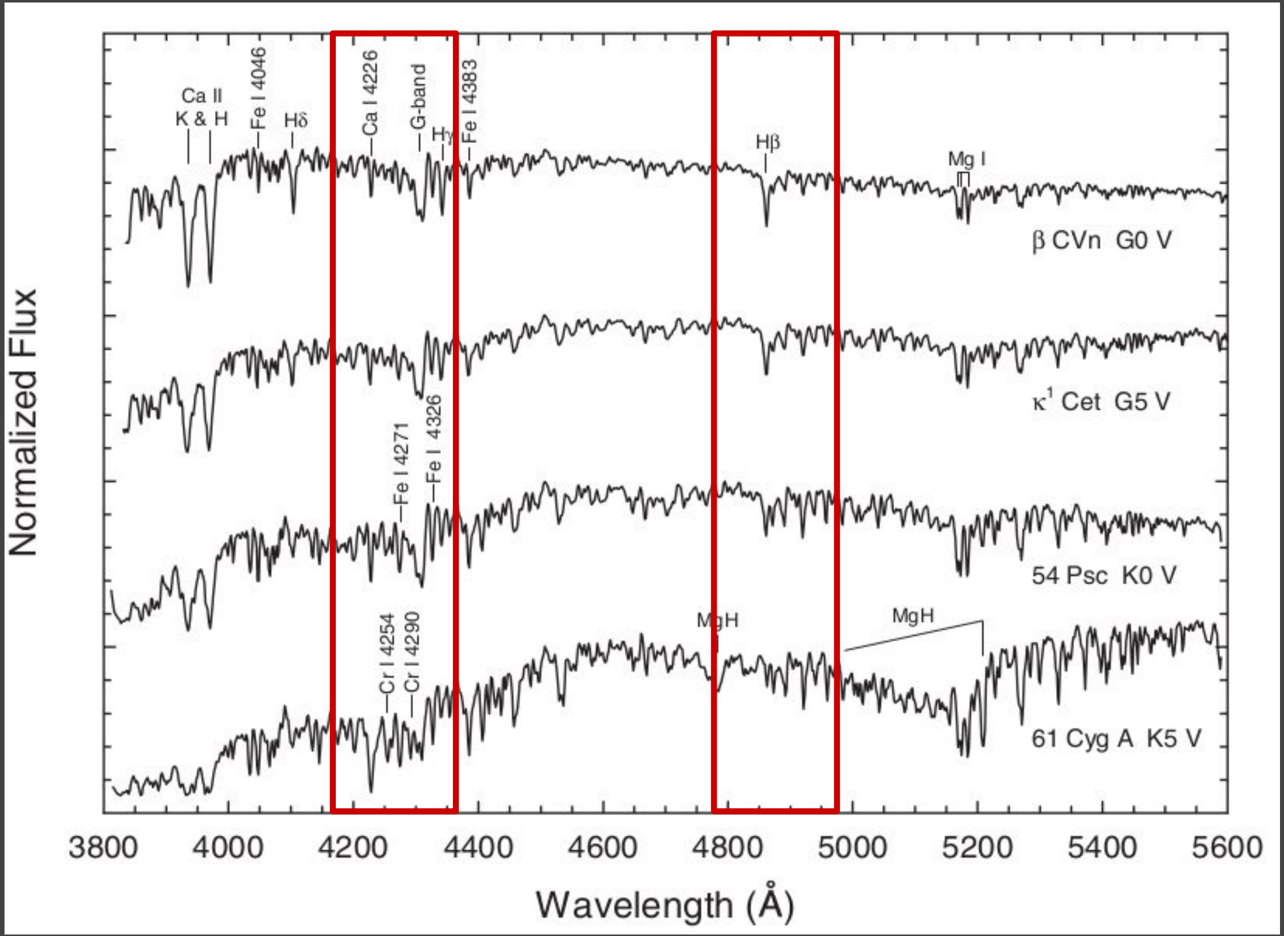
~~1) Introduction to G- & K- Type Stars.~~

2) The Optical & IR Spectral Ranges.

Optical Classification: Temperature

+ Boundary with the F-type stars is not distinct BUT in G-type stars the G-band characteristically dominates.
+ G-band, caused by the diatomic CH molecule.
+ Increases in strength until about K2, after which it begins to fade
+ Hydrogen lines fade steadily. Metallic-line spectrum increases.

Optical Classification: Temperature

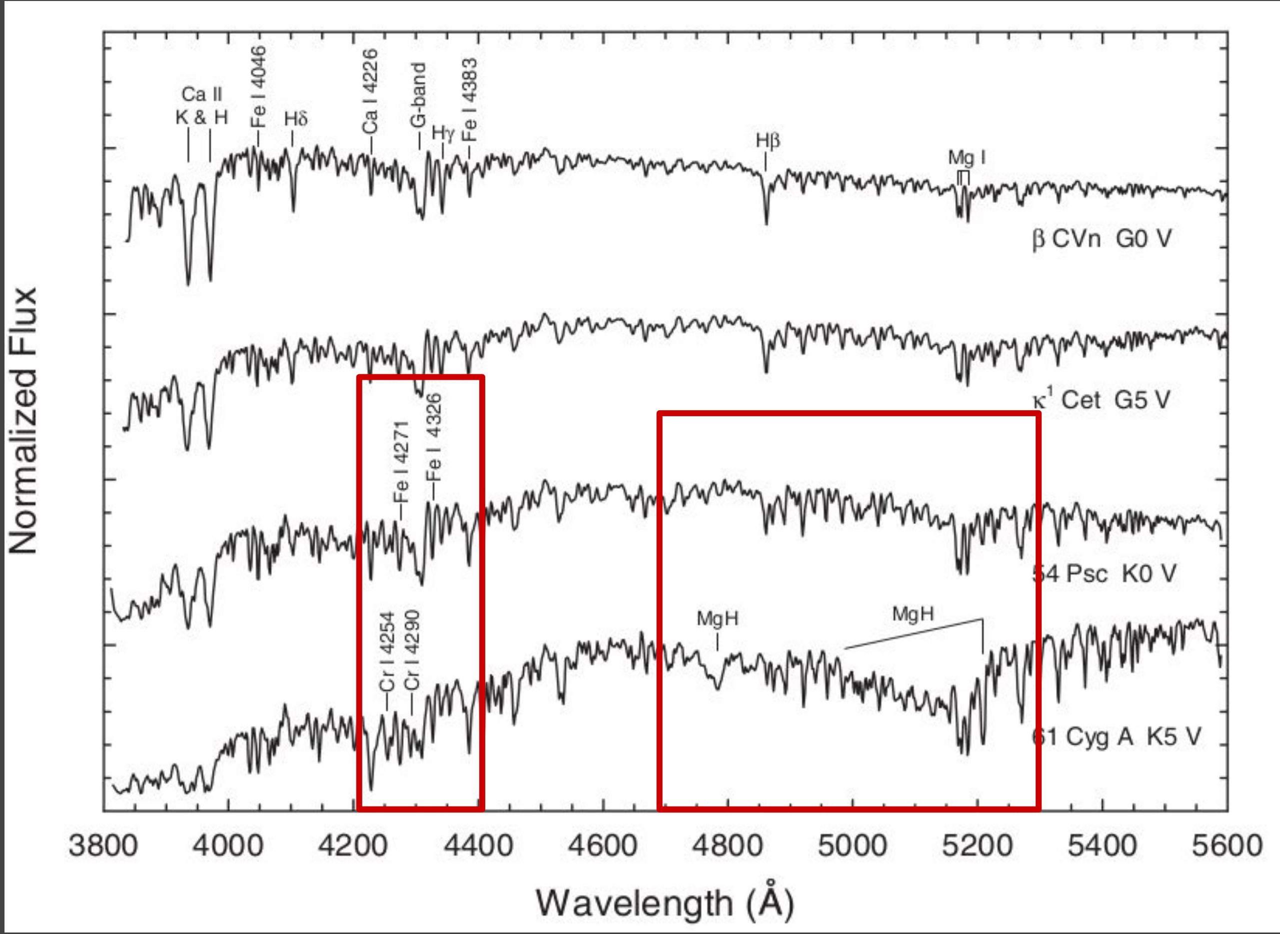


+ Ca I λ4226 resonance line grows gradually in strength until the early K-type stars.

+ Fe I λ4046/Hδ, Fe I λ4144/Hδ, Fe I λ4383/Hγ.

+ Hydrogen ratioed to the metallic lines used as temperature criteria for G- Types.

Optical Classification: Temperature



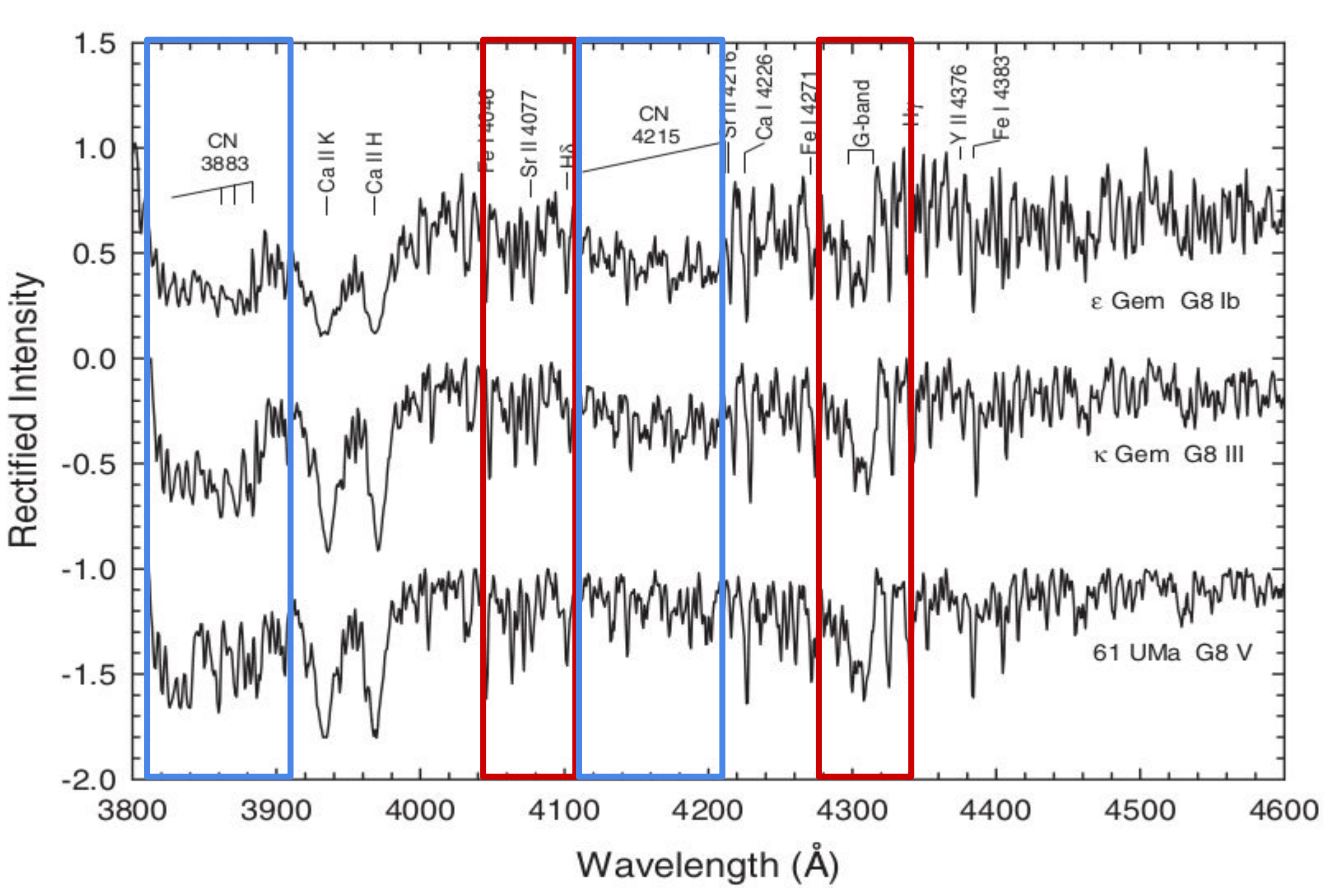
+ Caution when comparing Hydrogen lines to metallic lines for metal weak and metal strong K-Types.

+ Instead make the Cr I triplet (λ4254, λ4275, λ4290; resonance transitions) with nearby Fe I.

+ Mg I triplet, λλ5167, 72, 83, increases as the temperature lowers.

+ MgH bands become significant criteria around K5.

Optical Classification: Luminosity

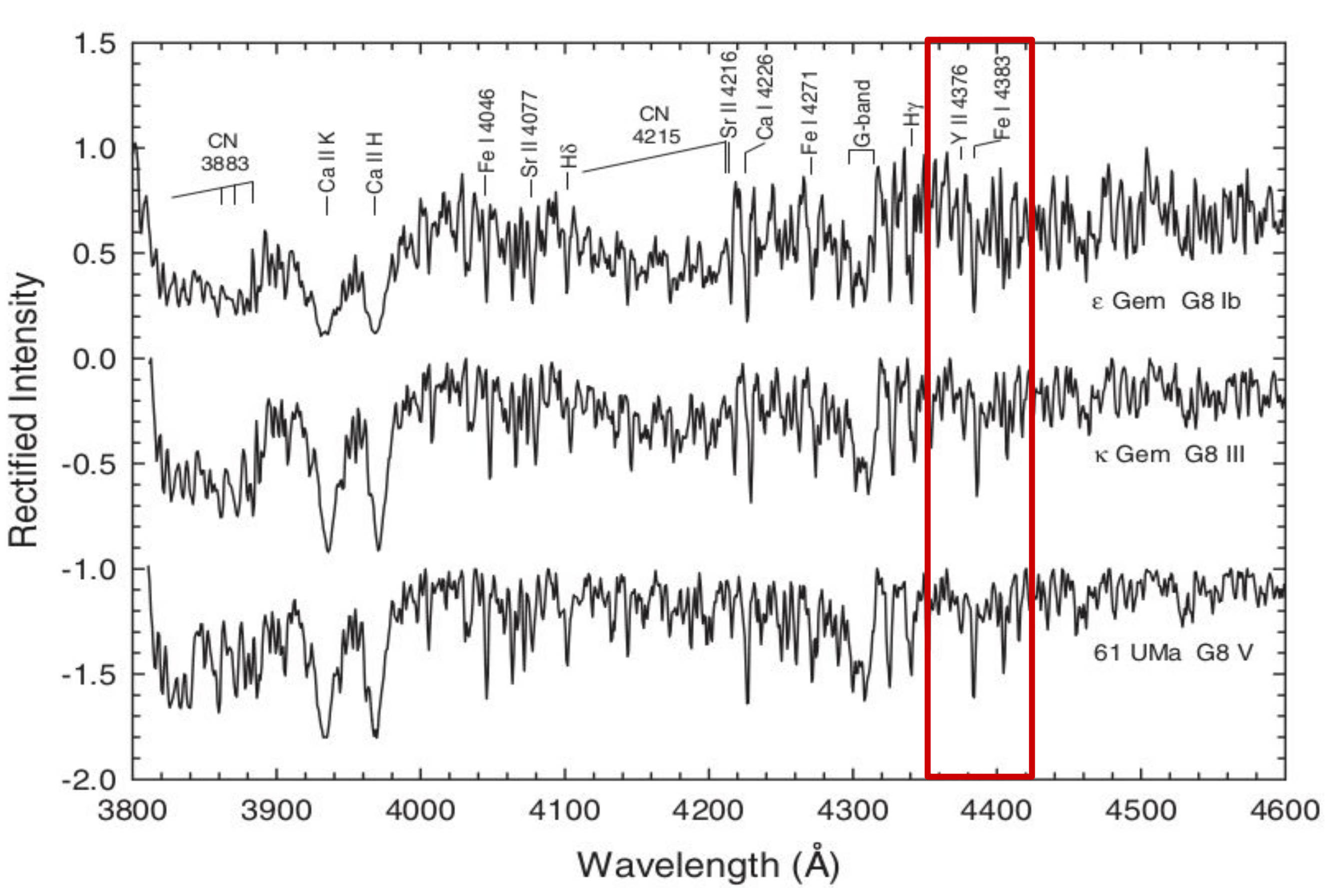


+ The ratio of Sr II λ4077 to nearby iron lines (Fe I λλ4046, 4064, 4072)

+ CN bands, show strong positive luminosity effect. From G5 and into the early-K stars.

+ K5 and later the MgH/TiO blend near λ4770 becomes very sensitive to luminosity (Previous Plot)

Optical Classification: Luminosity



+ rho Cas has a variation in its spectrum from F8 Ia, where it was a MK standard, through early-M, and currently to mid-G type.

+ Best criterion for luminosity classes is the ratio of the Y II λ4376 line to Fe I λ4383.

+ Better than the Sr II lines as they can be significantly enhanced in chemically peculiar G- and K-type stars.

Optical Classification: Luminosity

- Why do the CN bands show a positive luminosity effect while the hydride molecules (CH and especially MgH and CaH) show a negative luminosity effect?
- Answer involves both molecular dissociation with declining pressure, and the behavior of the continuous opacity (G- and K-type stars is due to H- bound-free and free-free absorption).

$$\mathrm{MgH} \rightleftarrows \mathrm{Mg} + \mathrm{H}$$

$$\mathrm{CN} \rightleftarrows \mathrm{C} + \mathrm{N}$$

$$\mathrm{H}^- \rightleftarrows \mathrm{H} + e^-$$

MgH has a lower dissociation energy (1.34 eV) than the CN molecule (7.66 eV).
ALSO decline in H- as we move to giants and supergiants.

Optical Classification: Luminosity

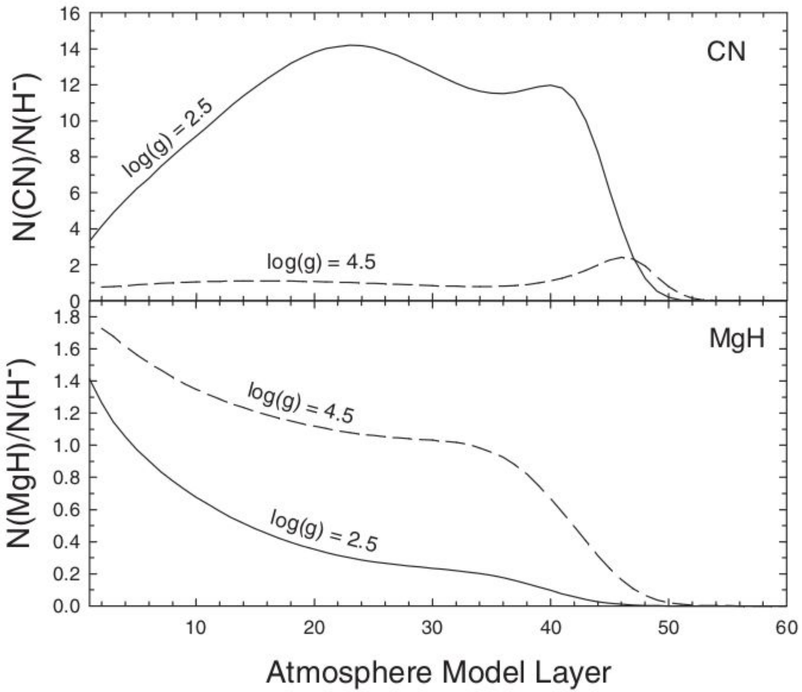


Figure 7.4 The run of the ratios CN/H^- and MgH/H^- in a dwarf ($\log g = 4.5$, dashed lines) and a giant ($\log g = 2.5$, solid lines) atmosphere (both with $T_{\rm eff} = 4500$ K). The "top" of the atmosphere is to the left. Computations made with SPECTRUM and Kurucz (1993) ATLAS9 stellar atmosphere models. See text for explanation.

+ MgH has a lower dissociation energy (1.34 eV) than the CN molecule (7.66 eV).

+ ALSO decline in H- as we move to giants and supergiants.

+ Kurucz (1993) Plot shows this relationship.

Near-IR Classification: Temperature

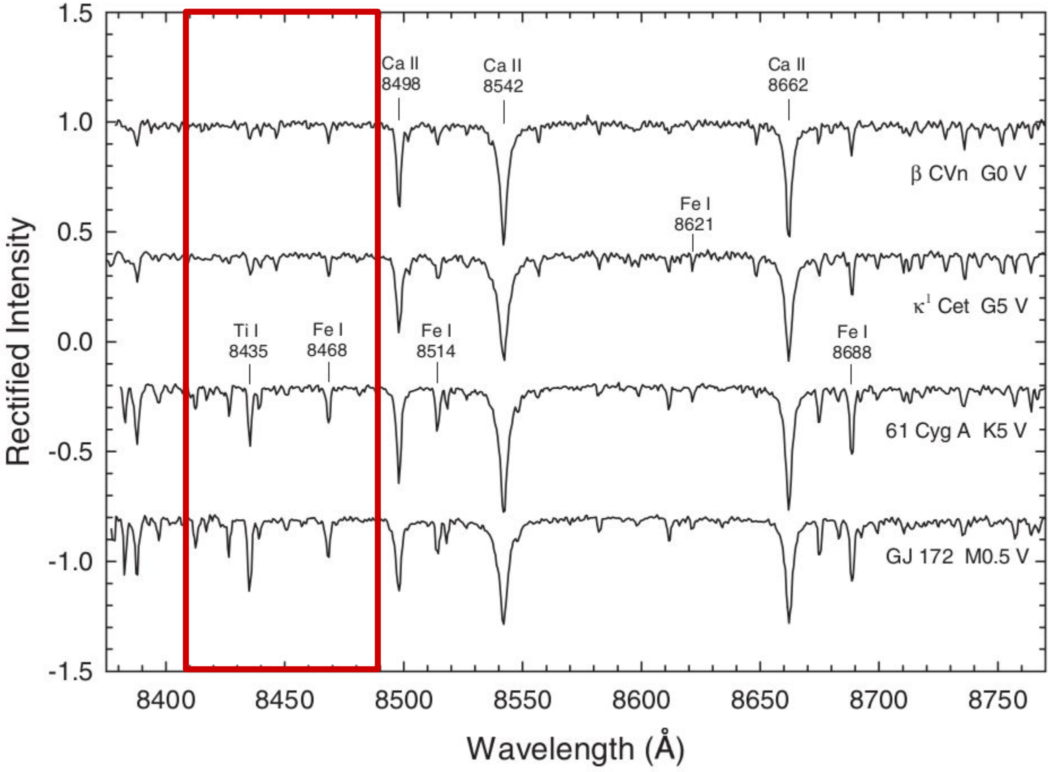


Figure 7.5 A temperature sequence for G–K stars in the near-infrared around the Ca II triplet. The spectra are from Carquillat et al. (1997).

+ Hα to 1.0 μm or 6562 A to 10000 A)

+ Strong telluric (atmospheric) absorption can be avoided by choosing the 8375–8770 Å region.

+ Increase in absolute strength of the Fe I and Ti I lines used to discriminate between early and late G/ K stars.

+ The ratio of the Balmer Hα line with a blend at λ6497 makes a good temperature discriminant. Not Shown.

Near-IR Classification: Luminosity

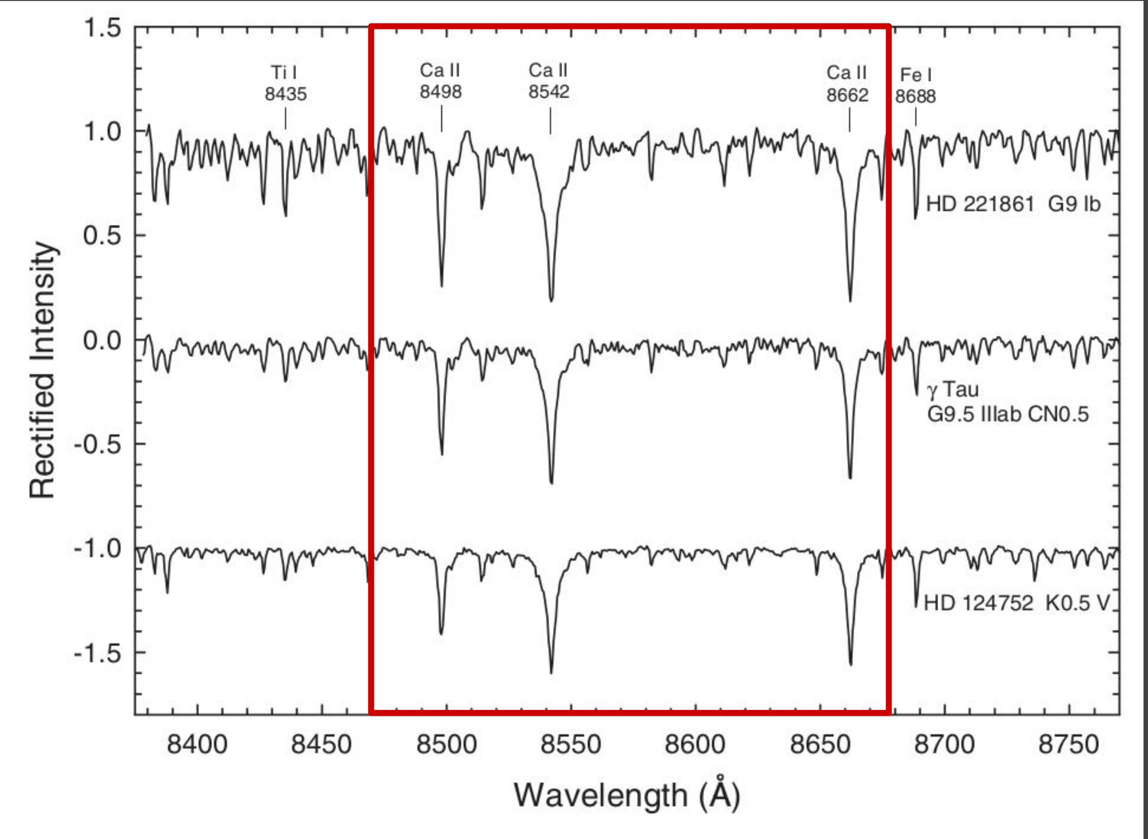
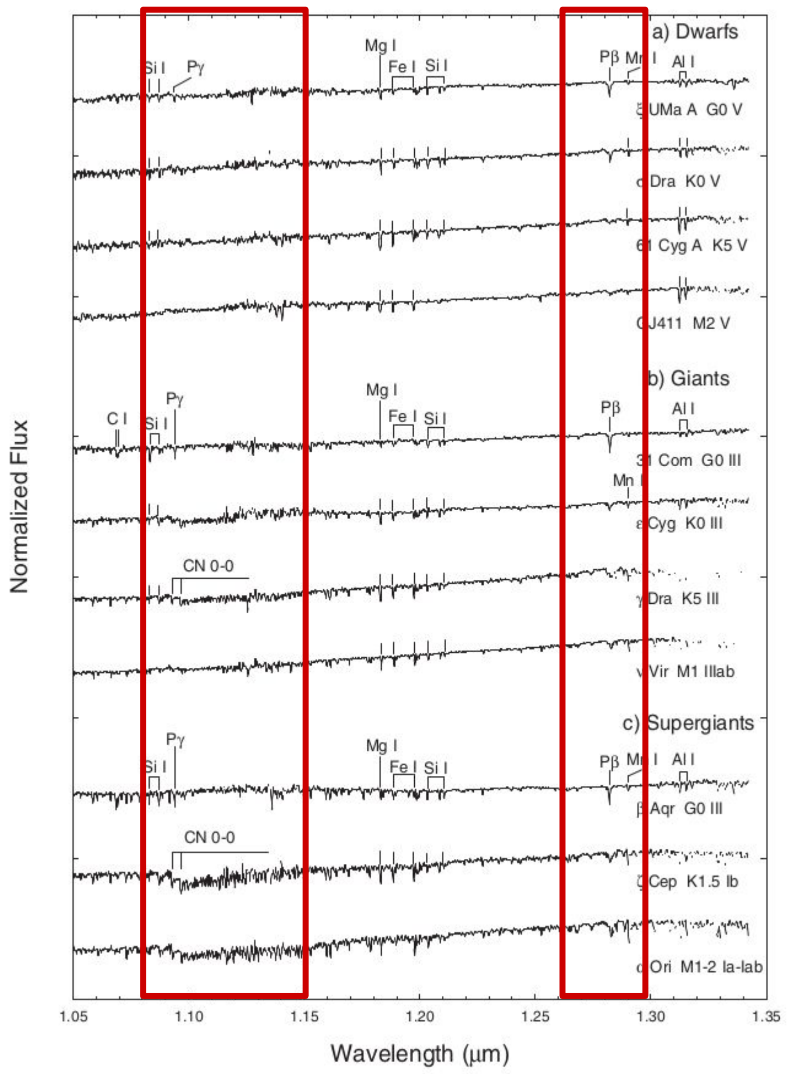


Figure 7.7 Luminosity effects in the near-IR at K0. The spectra are from Carquillat et al. (1997).

+ Luminosity classification the dominant Ca II triplet lines, λλ8498, 8542, and 8662. See Figure 7.7 below.

+ Absolute strength of Ca II Triplet.



IR Classification: J Band

+ Paschen β can be used with the adjacent metallic lines for temperature classification.

+ CN 0-0 band used as a luminosity discriminant.

IR Classification: K Band

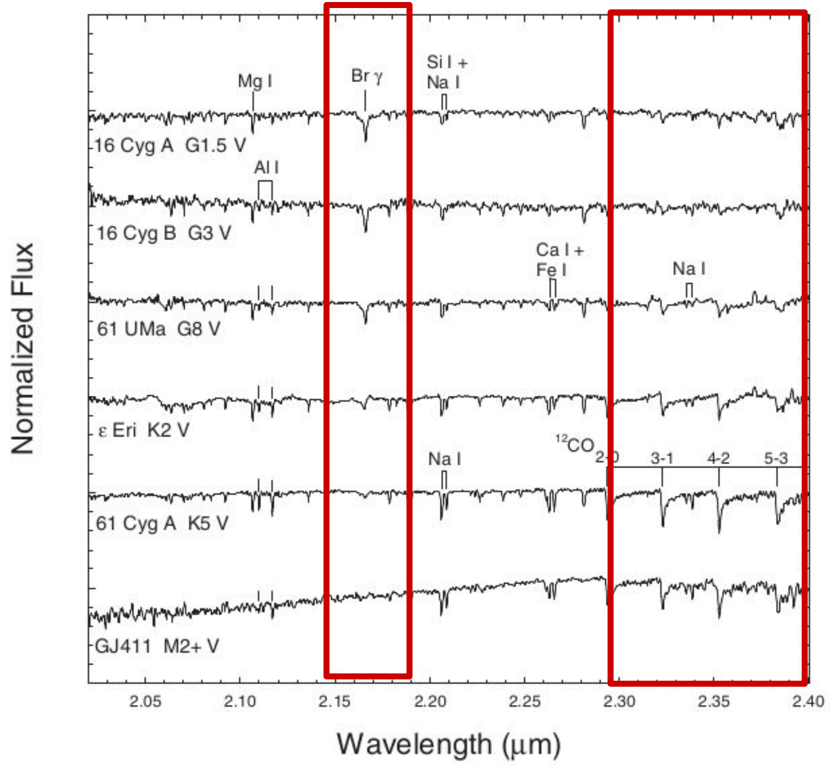


Figure 7.9 A spectral sequence for late-type dwarfs in the K-band. Brackett γ and nearby Na I and Ca I lines are marked. The spectra are from Ivanov et al. (2004) where sequences for giants, with and without metallicity effects, and for supergiants can be found.

+ Brackett γ line at 2.166 μm can be ratioed with nearby Na I and Ca I lines for early-G temperature types.

+ CO bands make good temperature & luminosity criteria for later types. Example CO 1.62 μm band doubling in strength between K5 and M5 types.

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3) Search for a Solar Twin.

Importance of Sun like Stars & Spectral Features

+ Why do we care about finding stars most like the Sun?

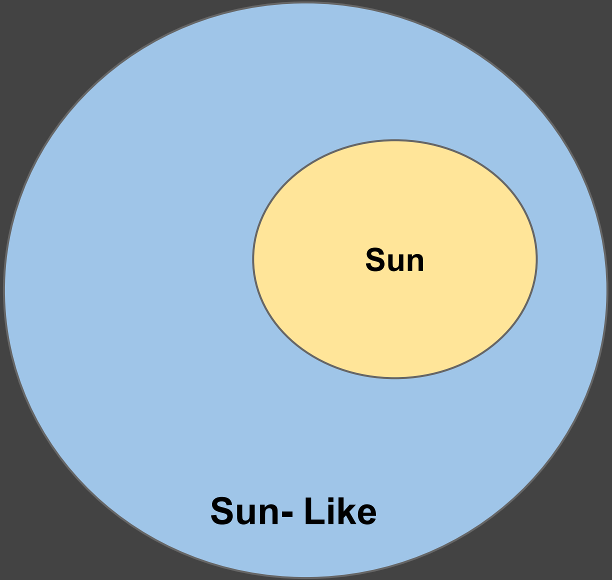
Thomas Ayres during a workshop at Lowell Observatory in 1997 gave these reasons:

+ Solar twins act as a surrogate for nighttime comparisons and calibrations.

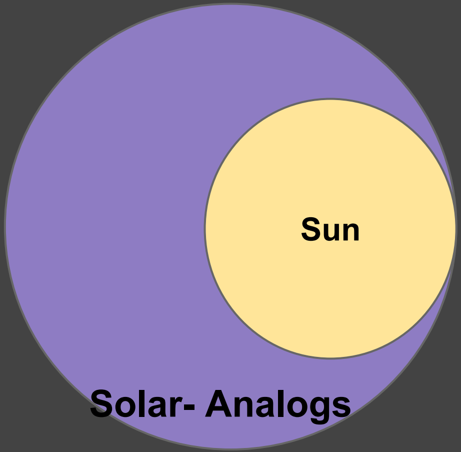
+ Solar twins allow for the study of the envelope of rare variability (Maunder minimum).

+ Solar twins give a broader perspective of the solar atmosphere characteristics, such as activity.

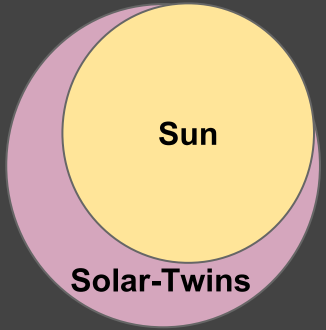
Solar TwinS Classification Groups



Solar-like stars, "a very broad class of stars, in which is found a mixture of late F, early, middle and, sometimes, late G type dwarfs and sub-giants".

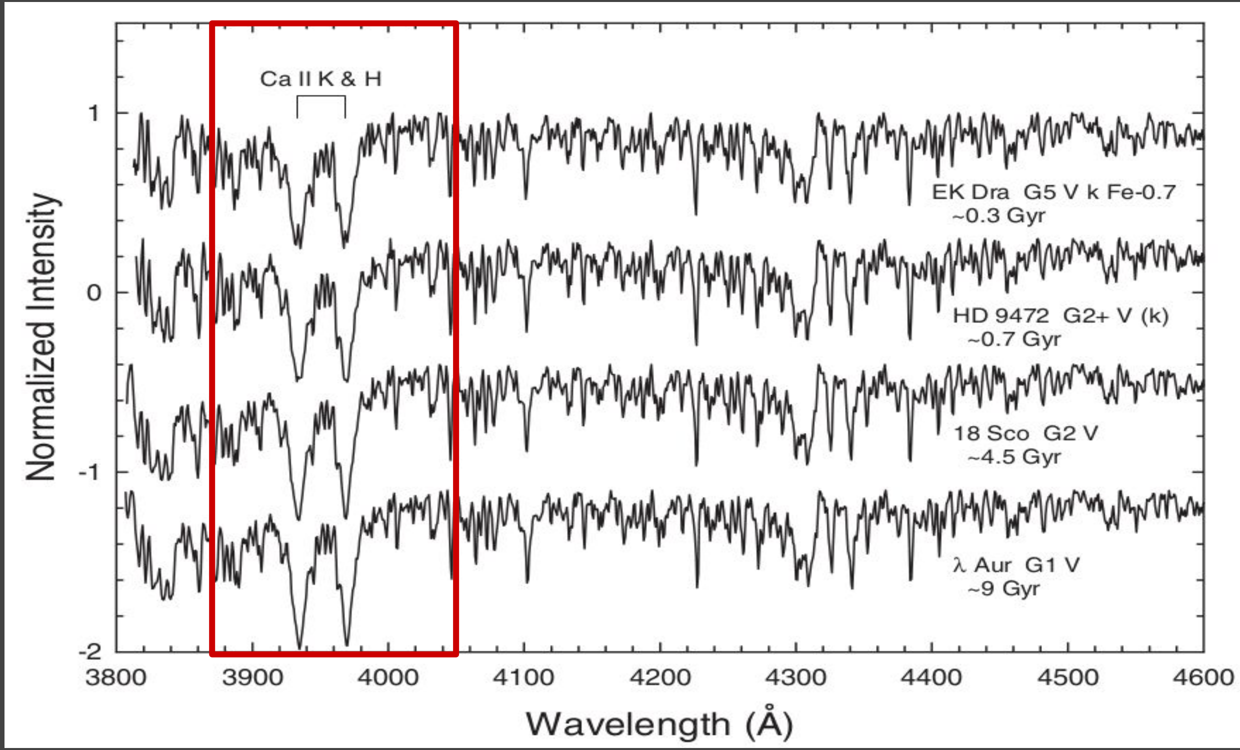


Solar analogs, "those unevolved, or slightly evolved Pop I disk stars with effective temperatures, degree of evolution, metallicities and kinematic properties not very different from those of the Sun".



Solar twins, the "ideal stars possessing fundamental physical parameters (mass, chemical composition, age, effective temperature, luminosity, gravity, velocity fields, magnetic fields, equatorial rotation, etc.) "

Spectrum of Solar Twin: 18 Sco



+ 18 Sco Solar Twin compared to Solar Analogs.

+ Ca II K & H shows line cores shows difference in spectral types.

Chromospheric Activity

+ Stellar Activity can be used as a indicator of age:

  “difference in activity within the chromosphere between two otherwise similar stars indicates a difference in the nonthermal chromospheric heating, brought about by local magnetic fields, which in turn generally indicates a difference in age”

+ NOT always true, example ξ UMa B which is in an old binary system shows high activity due to high rotational speed.

Spectra Showing Stellar Activity:

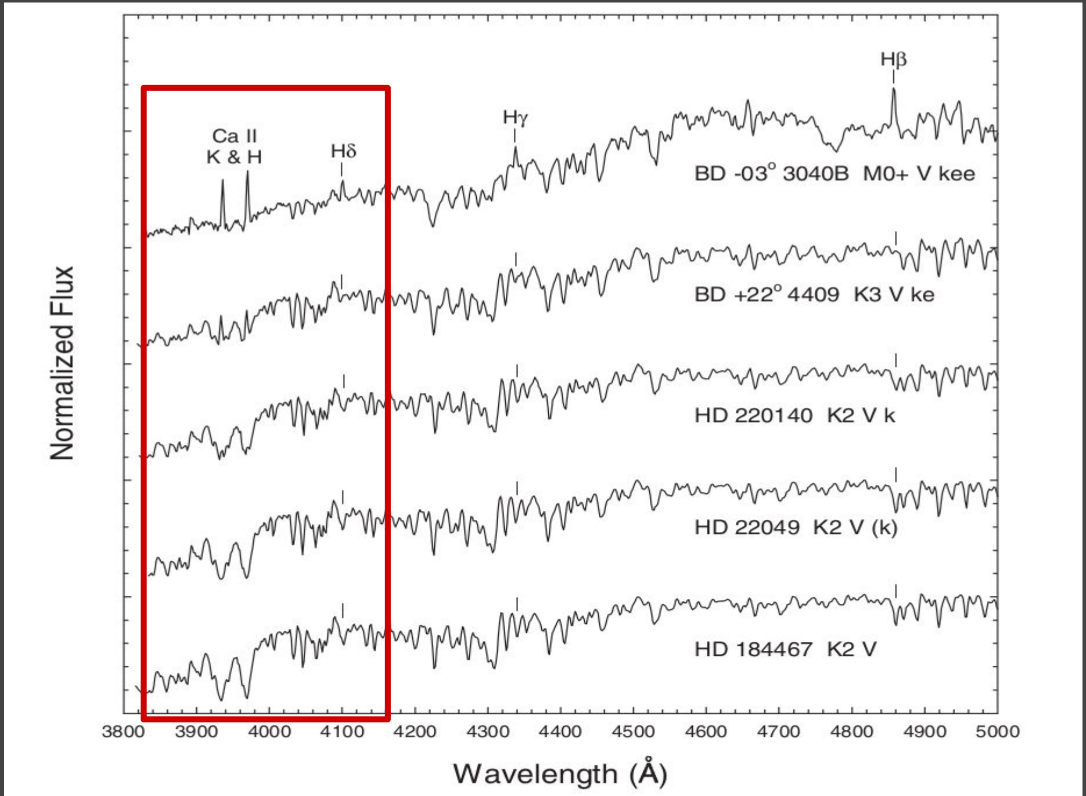


Figure 7.12 Spectra showing increased chromospheric activity, starting at the bottom with the normal, inactive star HD 184467. The Gray et al. (2003) notation for the different levels of activity is given after the spectral type.

Gray et al. (2003)

+ For solar-like stars, Ca II H & K lines, in the core of the Hα line, and in the cores of the **Ca II triplet lines, λλ8498, 8542, and 8662.**

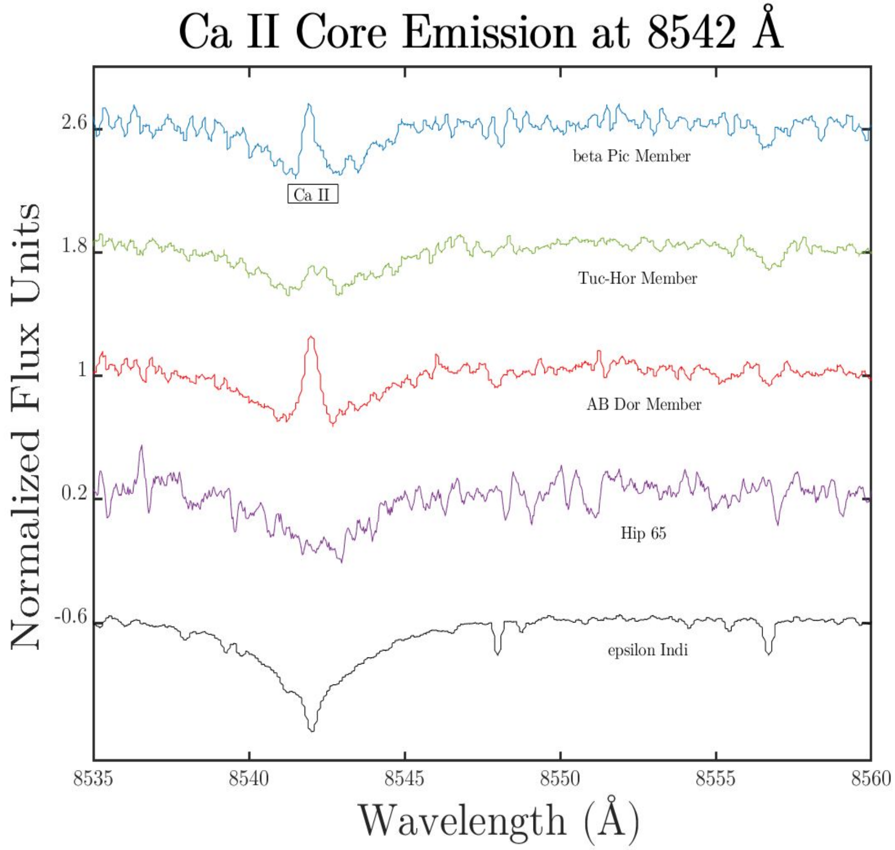
“(k)” indicates that slight emission reversals or infilling of the Ca II K and H lines is visible.

“k” indicates that emission reversals are clearly evident in the Ca II K and H lines but these emission lines do not extend above the surrounding continuum;

“ke” indicates emission in the Ca II K and H lines above the surrounding continuum, usually accompanied with infilling of the Hβ line.

“kee” indicates strong emission in Ca II K and H, Hβ, and perhaps even Hγ and Hδ.

Personal Stuff...



~20 MYR

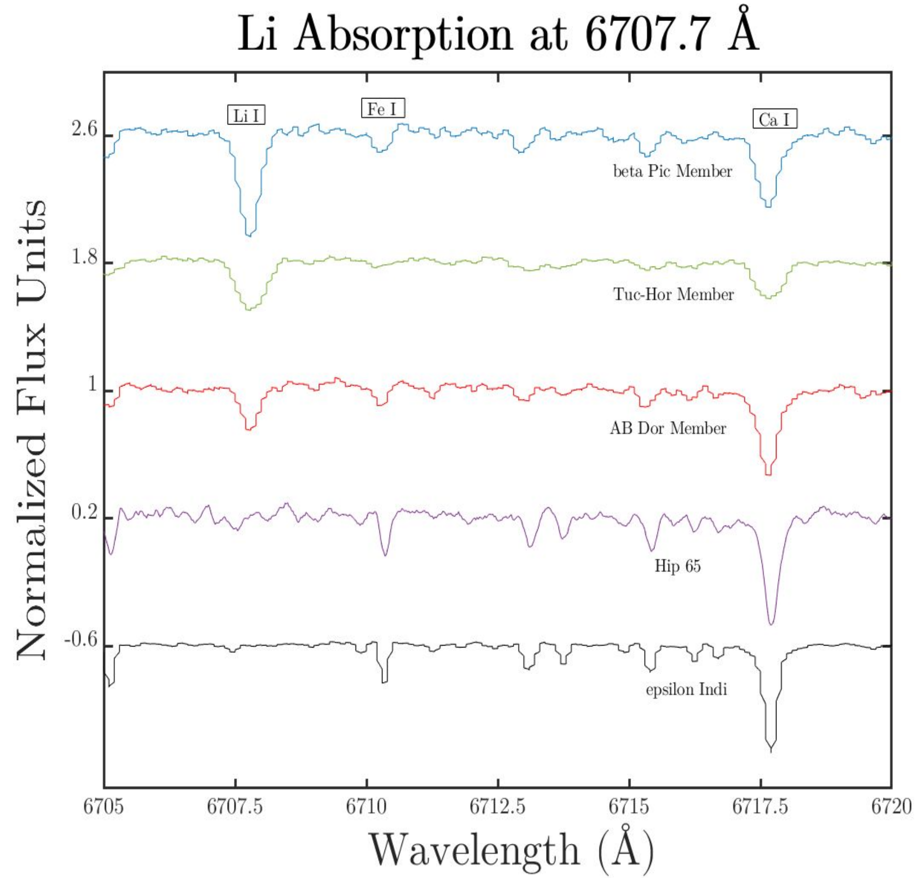
~40 MYR

~40 MYR

> 1 GYR

ALL ~ K5V

Personal Stuff...



~20 MYR

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ALL ~ K5V

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T- Tauri Stars

+ Pre-main sequence (PMS) precursors of solar-type stars (Herbig 1962).
+ Important in the study of star formation.
+ T Tauri stars can be found by spectral classification. Divided into two main categories:
    + “weak-line T Tauri” stars (WTTS) or Naked (NTTS)
    + “classical T Tauri” stars (CTTS)

T- Tauri Stars

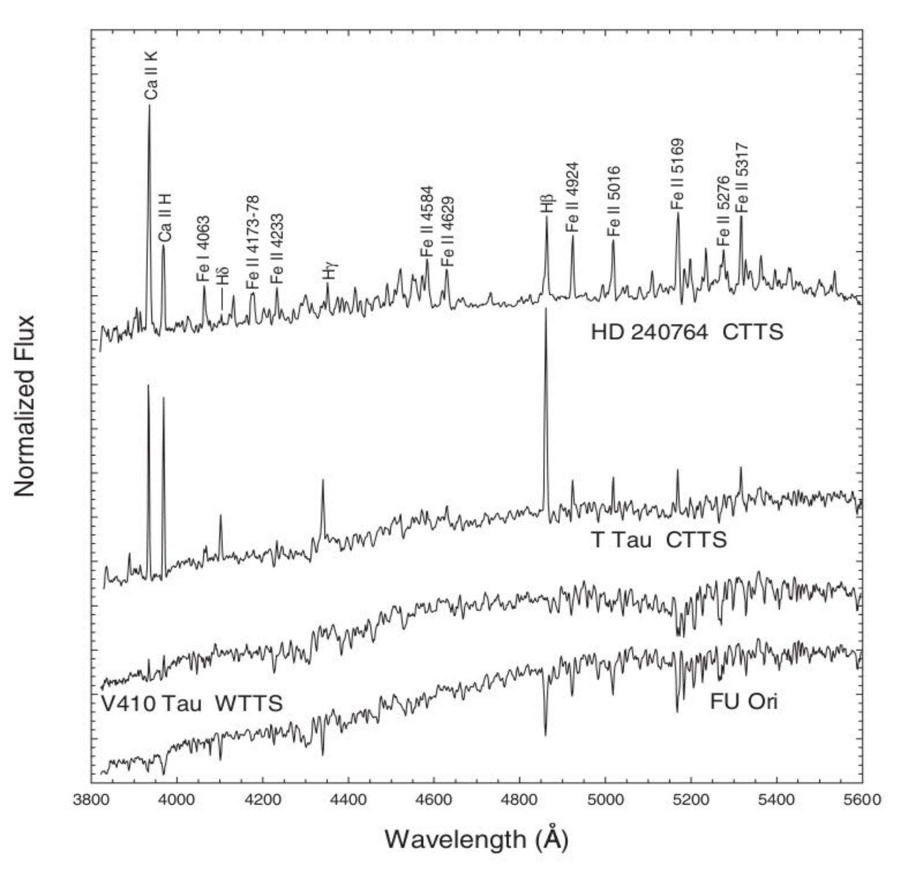

Figure 7.14 A montage of T Tauri stars and the Fuor prototype.

The boundary between the WTTS and the CTTS is somewhat arbitrary

+ Based on Hα equivalent width.

Some use W (Hα) <10 Å for defining the WTTS

Others W (Hα) < 5 Å (Martín 1997)

+ ALSO show emission at Ca II, Fe II, Na I, and fluorescent Fe I (λλ 4063, 4132), and sometimes in [O I] and [S II] lines

Questions ???