Astronomy 404
September 11, 2013

Chapter 8. The Classification of Stellar Spectra

Spectral Types of Stars

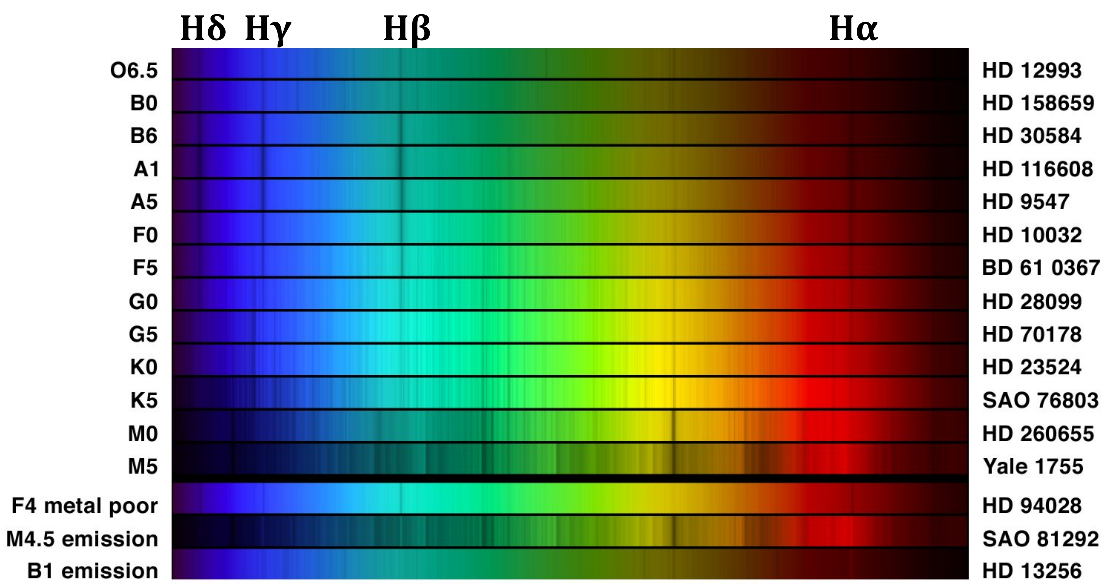
At Harvard, in the 1890's - Pickering and his lab assistants

Edward C. Pickering

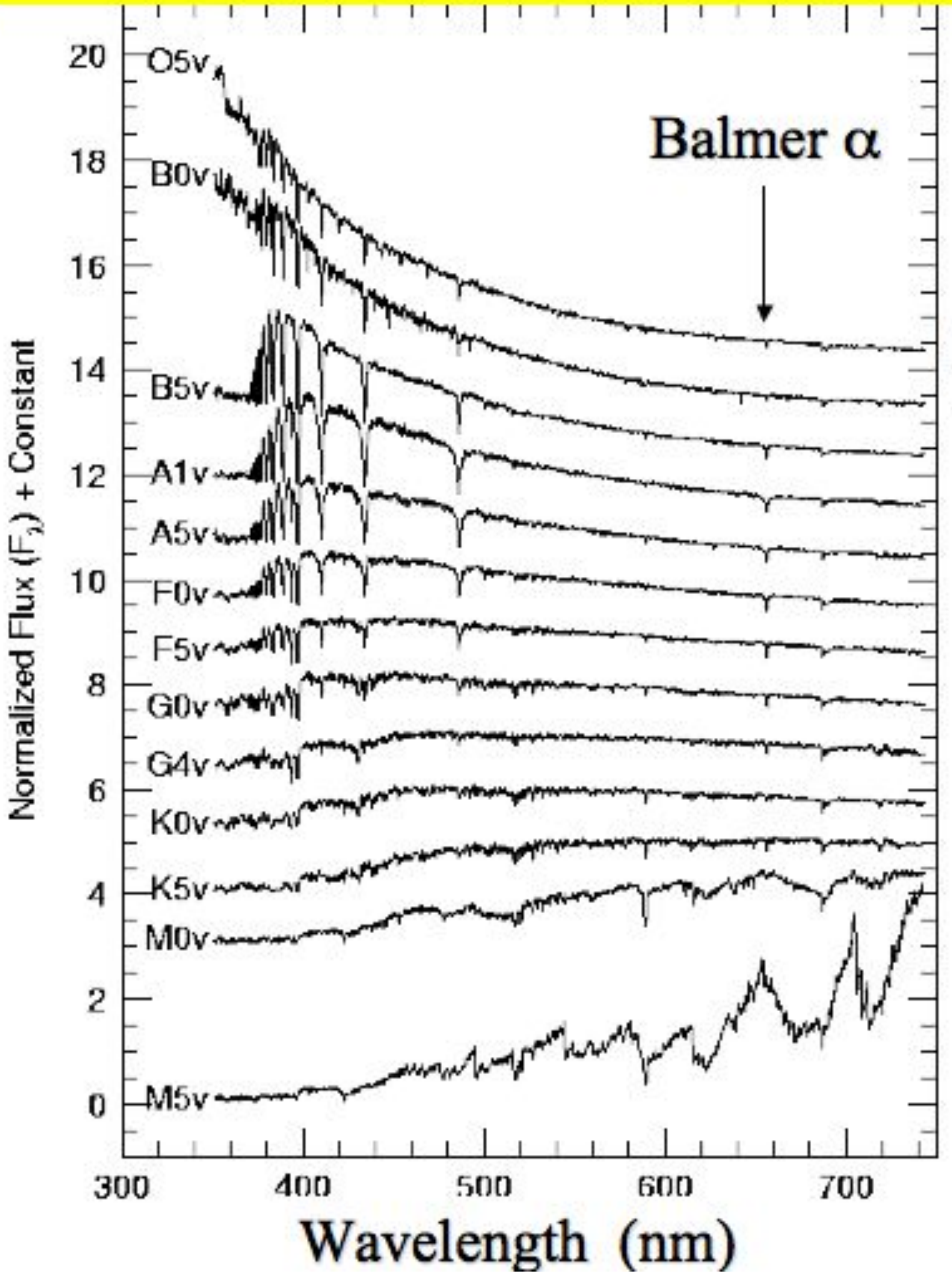
Williamina P. Fleming	**- used hydrogen line strangths**
Antonia Maury	**- used the widths of spectral lines**
Annie Jump Cannon	**- used the H Balmer line strengths**

Cannon - rearranged spectral sequence into OBAFGKM

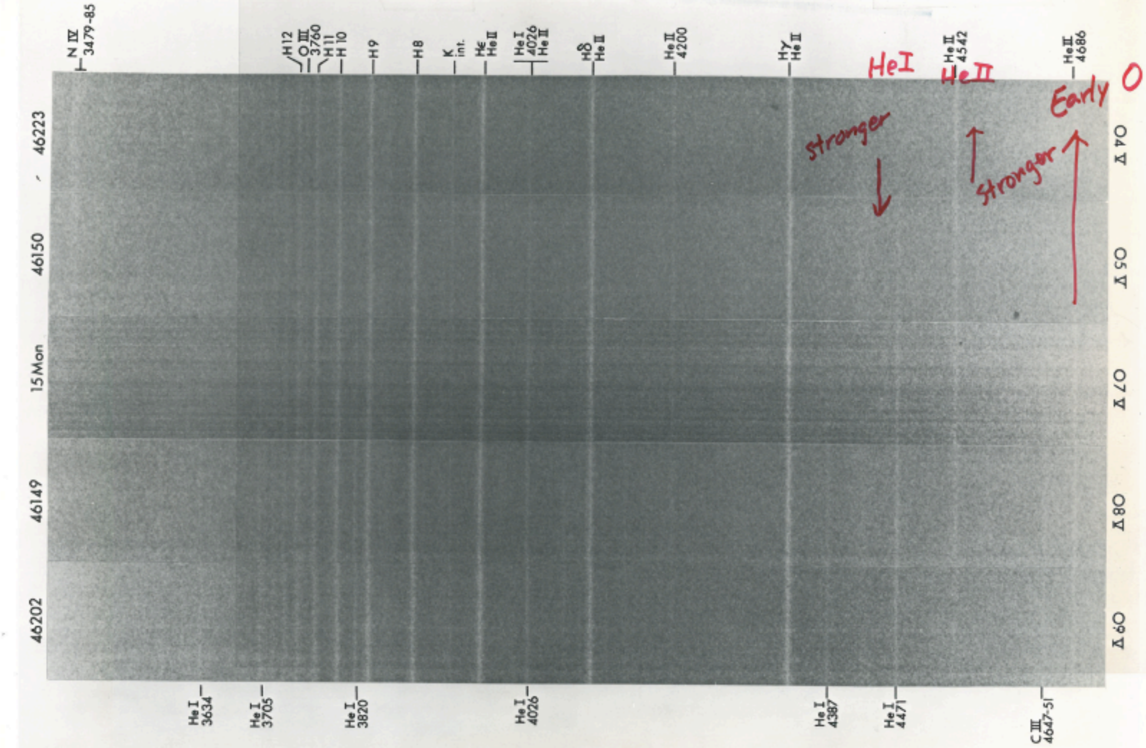
- **added decimal divisions in each class (e.g., A0-A9)**
- **classified 230,000 stars in Henry Draper Catalog (Henry Draper took the first photograph of a stellar spectrum; his estate financed the catalog.)**



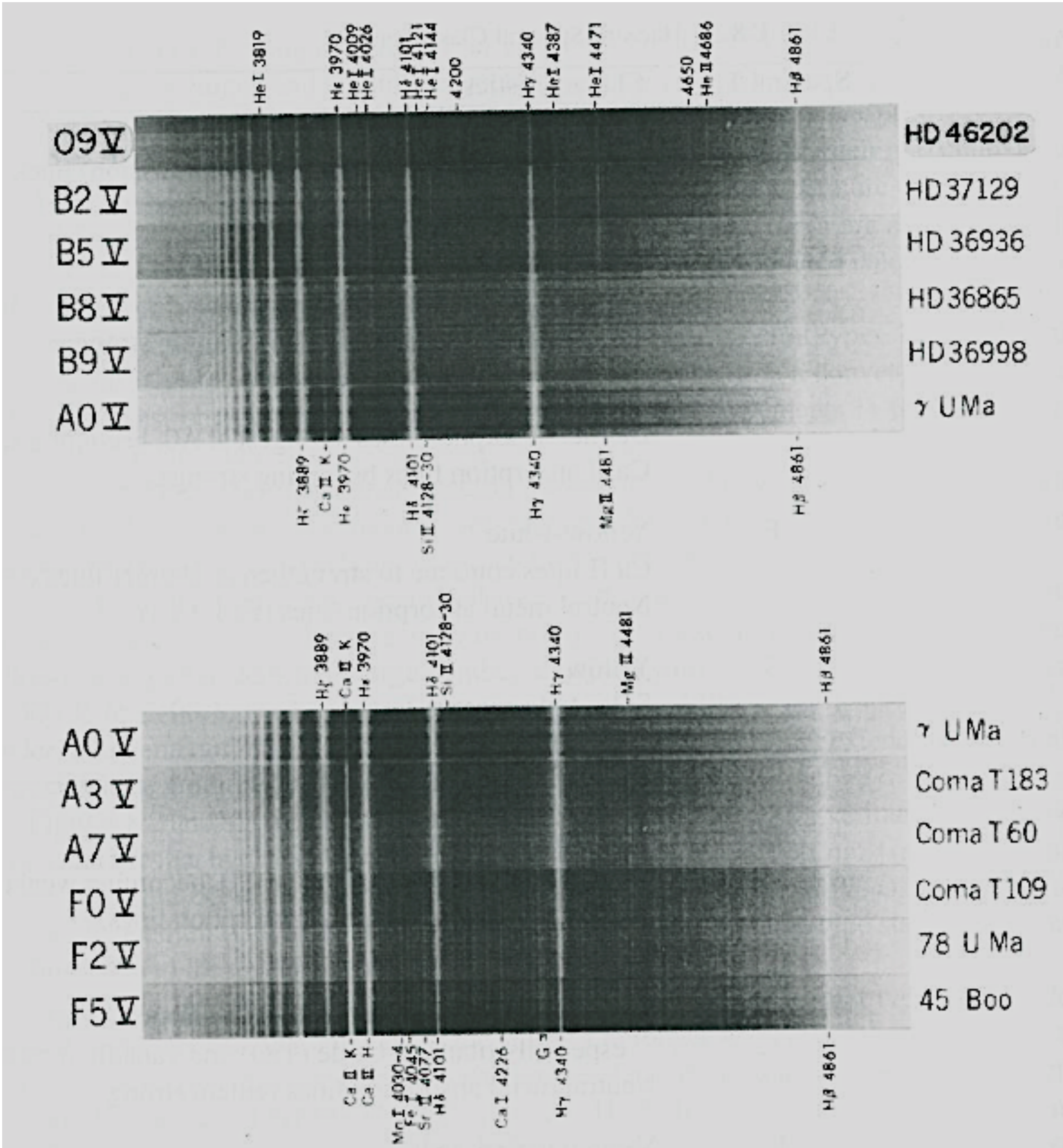
Stellar Spectra: Hottest to Coolest



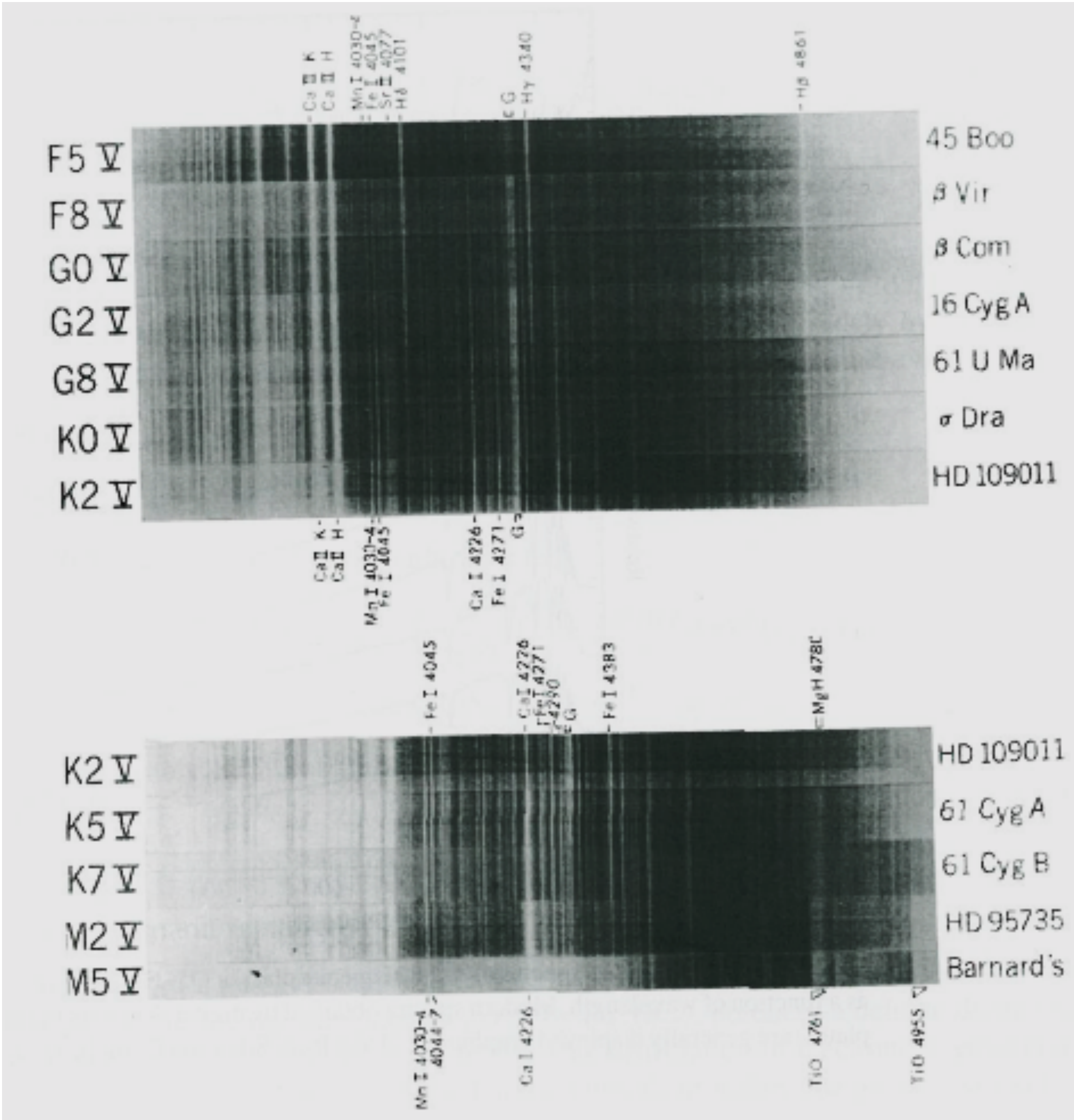
MAIN SEQUENCE O4–O9



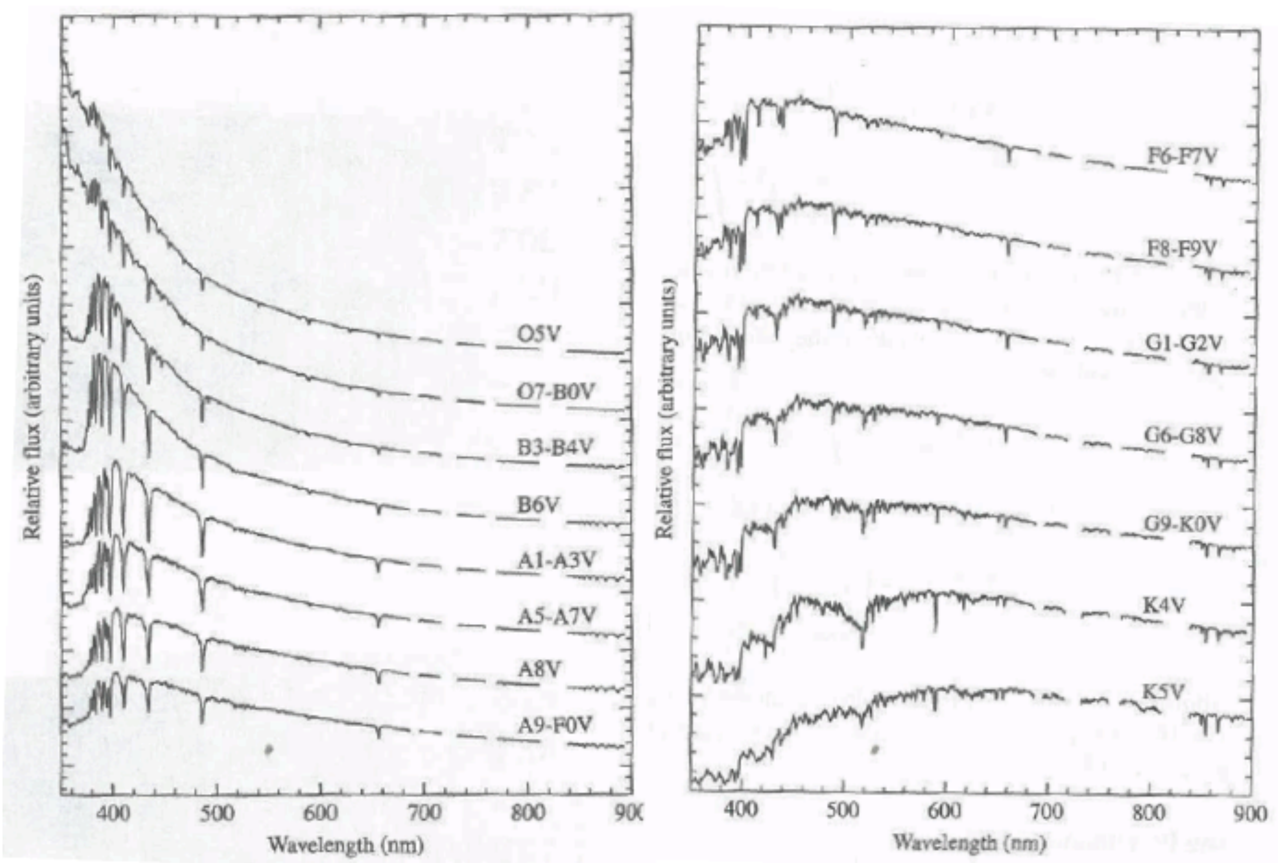
The ratio of the lines He I 4471 to He II 4542 changes smoothly on passing along this spectral sequence. All stars, except for the O7 V standard, are in NGC 2244; 15 Mon is the brightest star in NGC 2264.



O9 V
B2 V
B5 V
B8 V
B9 V
A0 V
HD 46202
HD 37129
HD 36936
HD 36865
HD 36998
γ UMa
He I 3819
Hε 3970
He I 4009
He I 4026
Hδ 4101
He I 4121
He I 4144
4200
Hγ 4340
He I 4387
He I 4471
4650
He II 4686
Hβ 4861
Hζ 3889
Ca II K
Hε 3970
Hδ 4101
Si II 4128-30
Hγ 4340
Mg II 4481
Hβ 4861
A0 V
A3 V
A7 V
F0 V
F2 V
F5 V
γ UMa
Coma T183
Coma T60
Coma T109
78 U Ma
45 Boo
Hζ 3889
Ca II K
Hε 3970
Hδ 4101
Si II 4128-30
Hγ 4340
Mg II 4481
Hβ 4861
Ca II K
Ca II H
Mn I 4030-4
Fe I 4045
Sr II 4077
Hδ 4101
Ca I 4226
G
Hγ 4340
Hβ 4861



Ca II K
Ca II H
Mn I 4030-4
Fe I 4045
Sr II 4077
Hδ 4101
G
Hγ 4340
Hβ 4861
F5 V
F8 V
G0 V
G2 V
G8 V
K0 V
K2 V
45 Boo
β Vir
β Com
16 Cyg A
61 U Ma
σ Dra
HD 109011
Ca II K
Ca II H
Mn I 4030-4
Fe I 4045
Ca I 4226
Fe I 4271
G
Fe I 4045
Ca I 4226
Fe I 4271
4290
G
Fe I 4383
MgH 4780
K2 V
K5 V
K7 V
M2 V
M5 V
HD 109011
61 Cyg A
61 Cyg B
HD 95735
Barnard's
Mn I 4030-4
4044-7
Ca I 4226
TiO 4761
TiO 4955



Relative flux (arbitrary units)
O5V
O7-B0V
B3-B4V
B6V
A1-A3V
A5-A7V
A8V
A9-F0V
400
500
600
700
800
900
Wavelength (nm)
Relative flux (arbitrary units)
F6-F7V
F8-F9V
G1-G2V
G6-G8V
G9-K0V
K4V
K5V
400
500
600
700
800
900
Wavelength (nm)

O Hottest blue-white stars with few lines
Strong He II absorption
He I absorption lines becoming stronger

B Hot blue-white
He I absorption lines strongest at B2
H I (Balmer) absorption lines becoming stronger

A White
Balmer absorption strongest at A0, then weaker
Ca II absorption lines becoming stronger

F Yellow-white
Ca II lines stronger, Balmer lines weakening
Neutral metal absorption lines (Fe I, Cr I)

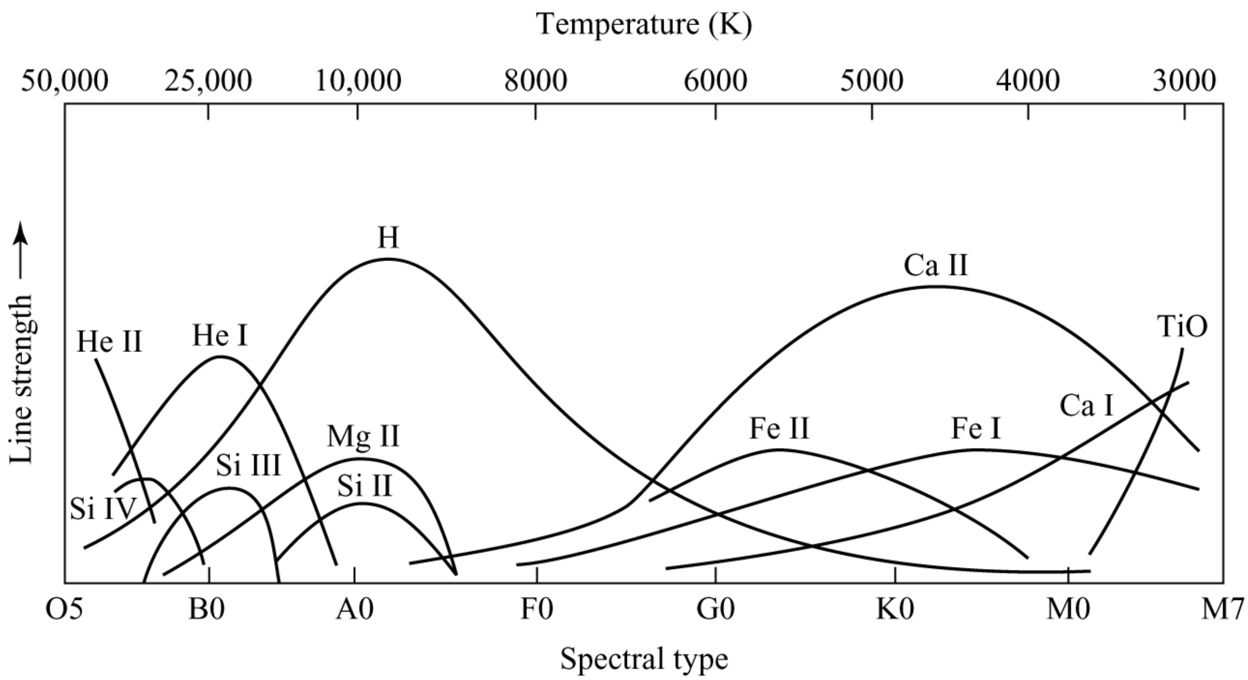
G Yellow (Solar-type spectra)
Ca II lines still stronger
Fe I, other neutral metal lines becoming stronger

K Cool orange
Ca II H and K lines strongest at K0, weaker later
Spectra dominated by metal absorption lines

M Cool red
Spectra dominated by molecular absorption bands (TiO)
Neutral metal absorption lines remain strong

L Very cool, dark red [brown dwarf]
Bright in IR than visible
Strong molecular lines (CrH, FeH, H_2O, CO…)

T Coolest, IR [brown dwarf]
Strong CH_4 bands, but weakening CO bands



The Hertzsprung-Russell Diagram

SCIENTIFIC GENEALOGY OF GEORGE B. FIELD

C. A. YOUNG
↓
H. N. RUSSELL
↓
L. SPITZER, JR
↓
GEORGE B. FIELD
↓

PRINCETON

C. Heiles
P. Frisch
T. Troland
Y.-H. Chu
M. Fich
S. Kulkarni
R. Rand
H. Johnson
J. Navarro
B.-C. Koo
W. Reach
P. McCullogh

In 1905, Ejnar Hertzsprung, a Danish engineer and amateur astronomer, found stars of the same spectral type G, but a range of absolute magnitudes. He called the brighter stars *giants*. This makes sense, as $L = 4\pi r^2\sigma T^4$.

In 1913, Henry Norris Russell published a diagram and called the luminous stars *giants* and the main sequence stars *dwrafs*.

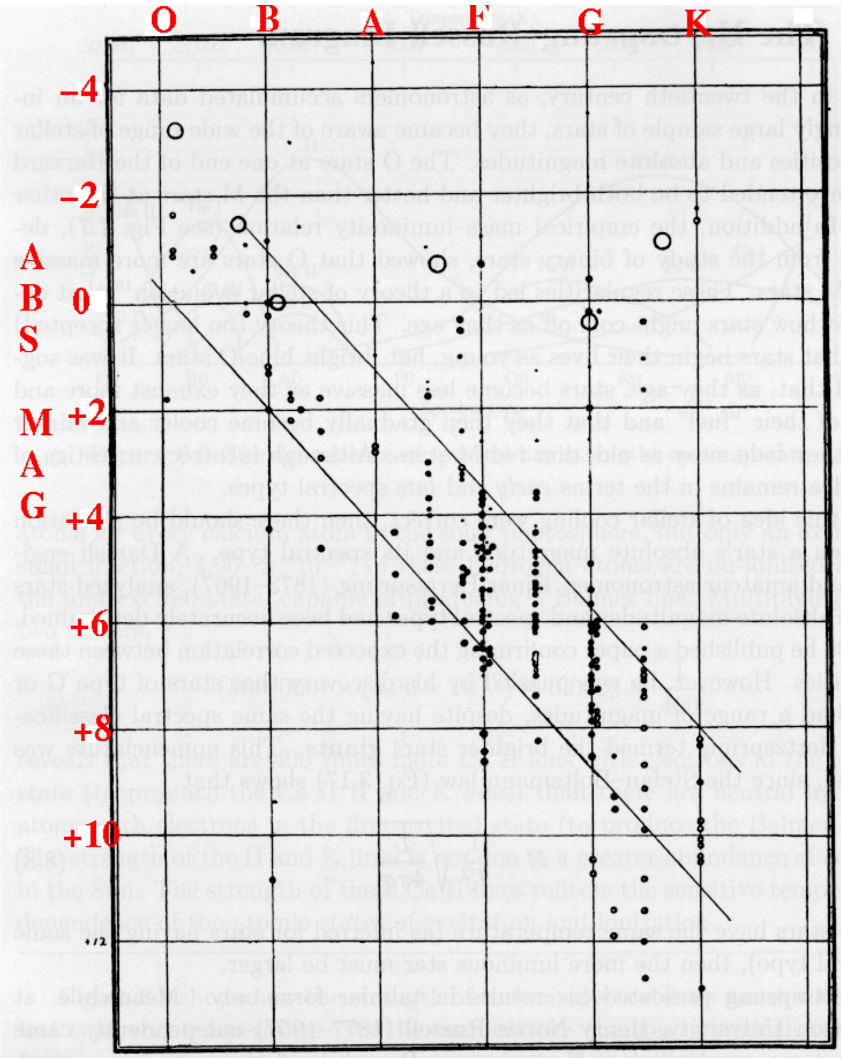
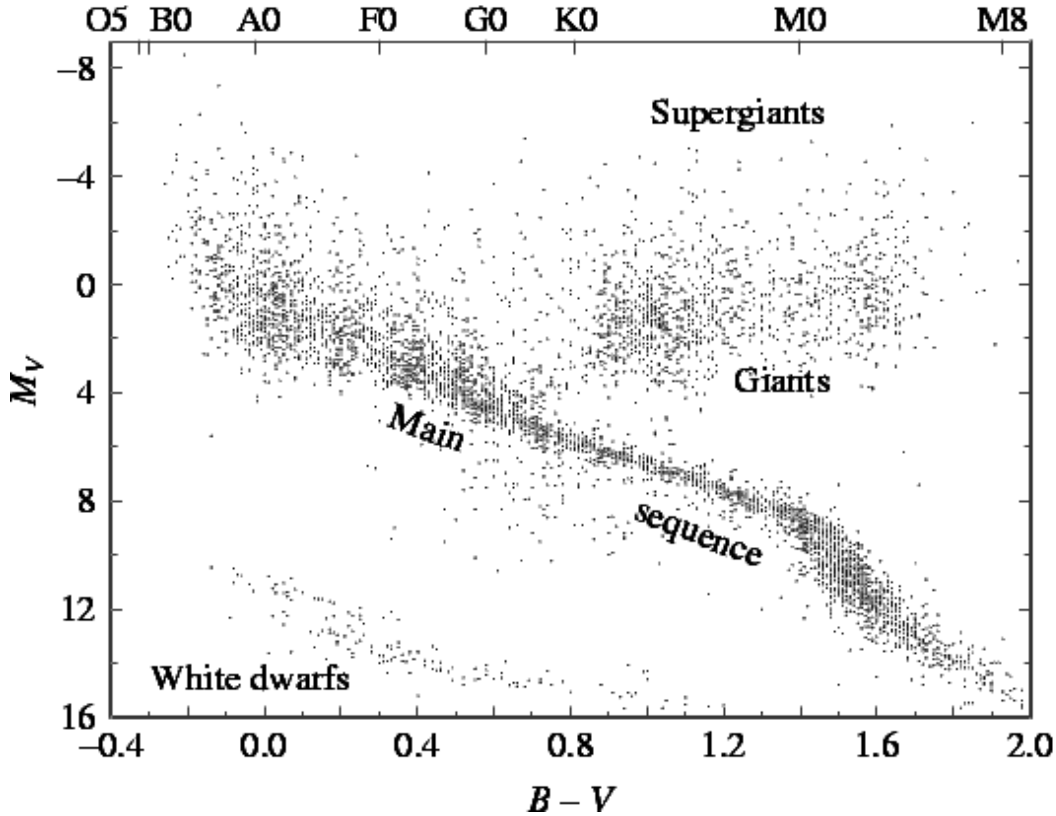
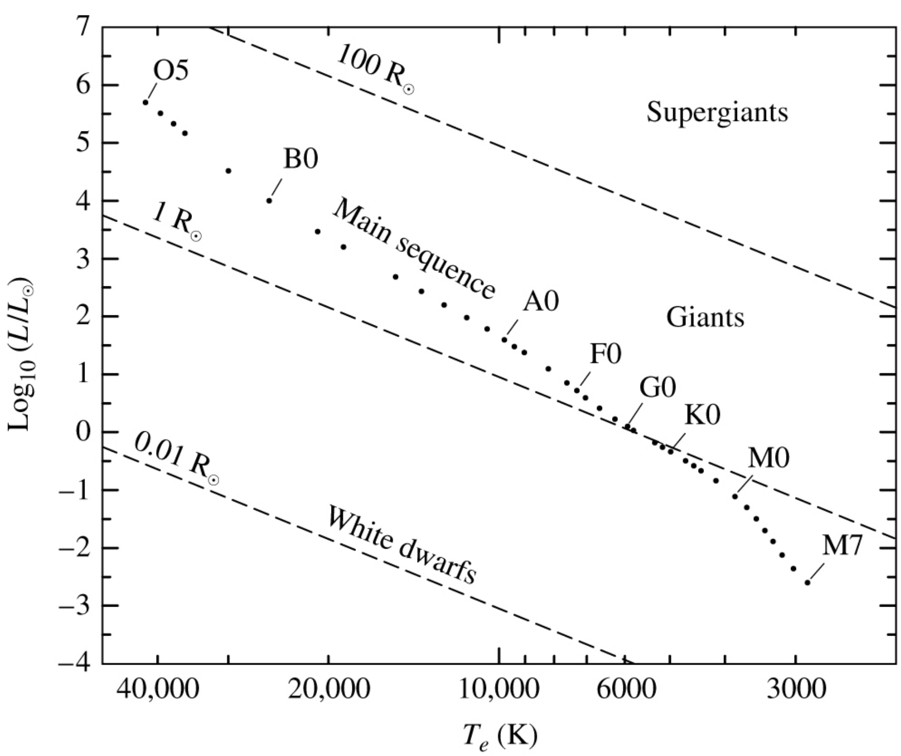


Figure 8.10 Henry Norris Russell's first diagram, with spectral types listed along the top and absolute magnitudes on the left-hand side. (Figure from Russell, *Nature*, *93*, 252, 1914.)

80-90% stars are on the main sequence. One white dwarf sits in the lower left corner.





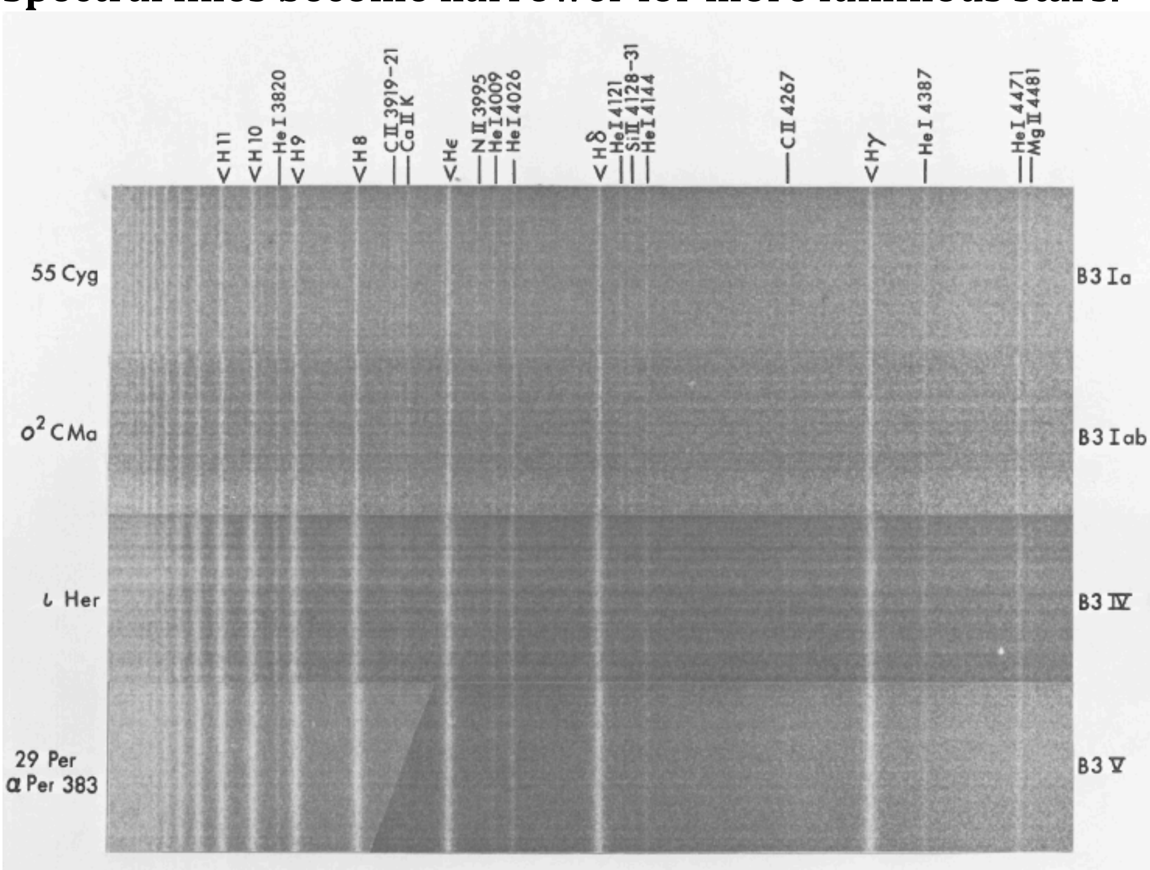
Main sequence: 0.1–20 $R_\odot$; Giants: 10-100 $R_\odot$; Supergiants: up to 1000 $R_\odot$

The main sequence is controlled by *stellar mass* .
O stars have masses approaching 100 $M_\odot$, while M stars have masses as low as 0.08 $M_\odot$.

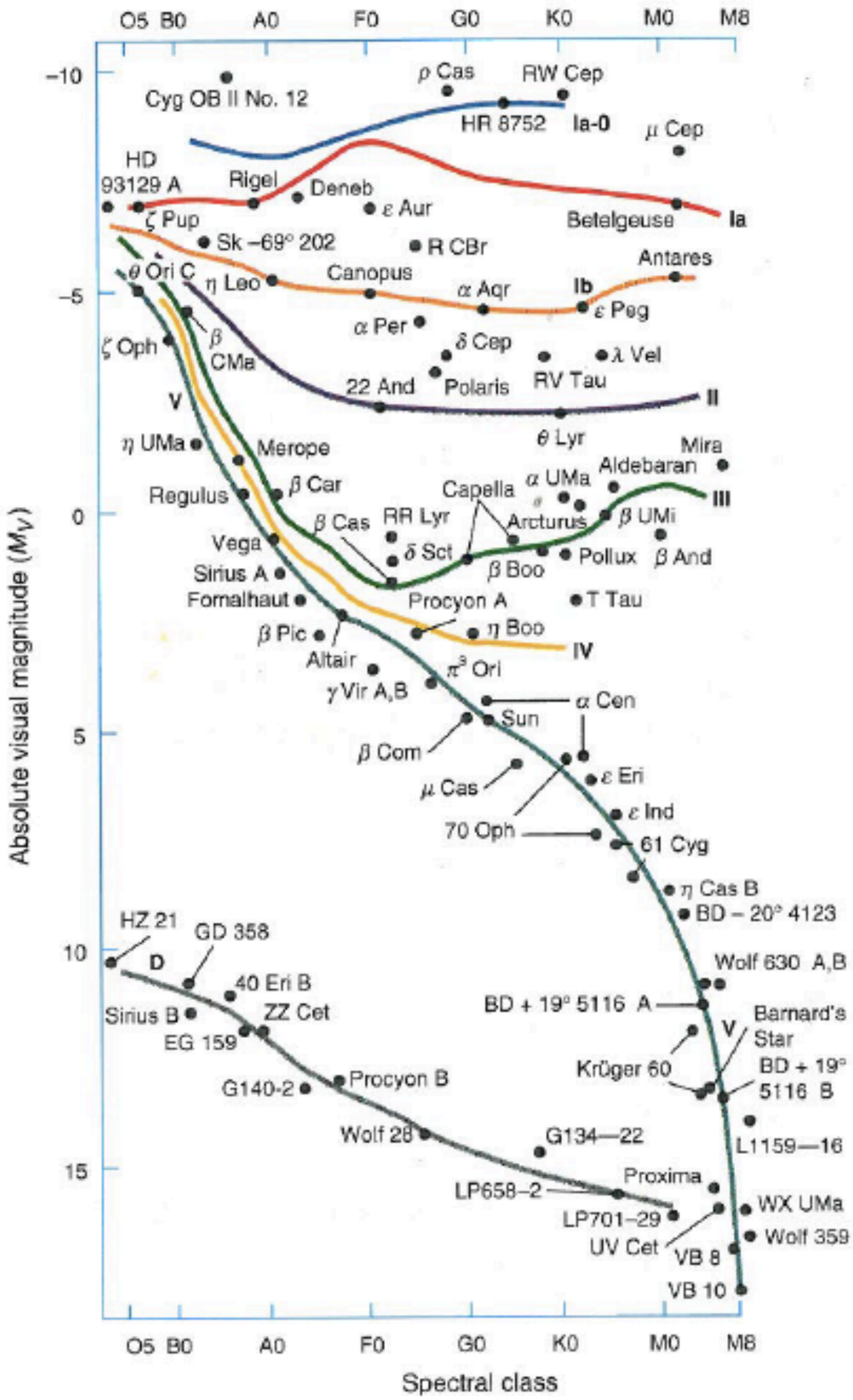
Morgan-Keenan Luminosity Classes

Luminosity class: Ia, Ib supergiants
II-III giants
V dwarfs (main sequence)

Spectral lines become narrower for more luminous stars.



If spectral type and luminosity class of a star is determined spectroscopically, its absolute magnitude is know for distance determination – "spectroscopic parallax".



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