# Aplicaciones astronómicas de la espectroscopía atómica

$$\frac{N_j}{N_k} = \frac{g_j}{g_k} = \frac{e^{-E_j/kT}}{e^{-E_k/kT}} = \frac{g_j}{g_k} e^{-(E_j - E_k)/kT}$$

$$\frac{N_{i+1}}{N_i} = \left(\frac{2\pi mkT}{h^2}\right)^{3/2} \frac{e^{-I_i/kT}}{N_e} 2 \frac{U_{i+1}(T)}{U_i(T)}$$

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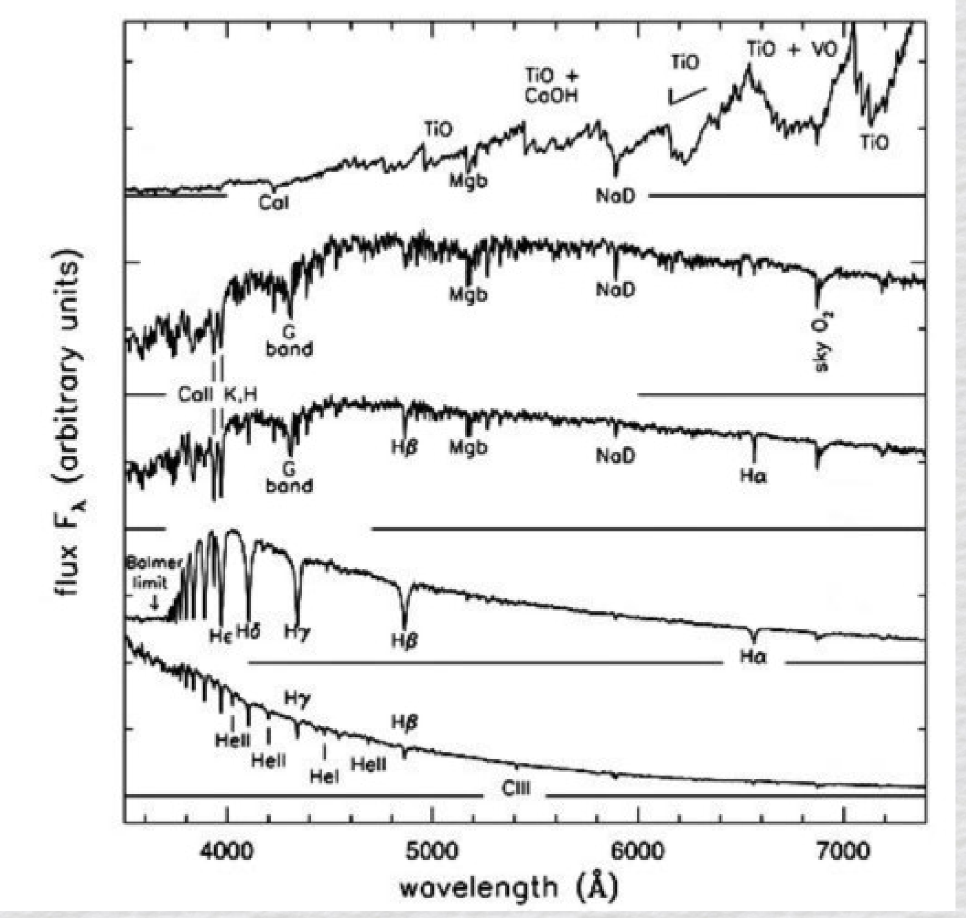

# Así comenzó todo ...

XII. *A Method of examining refractive and dispersive Powers, by prismatic Reflection.* *By* William Hyde Wollaston, *M. D. F. R. S.*

(1802, Philosophical Transactions of the Royal Society, 92: 365–380)

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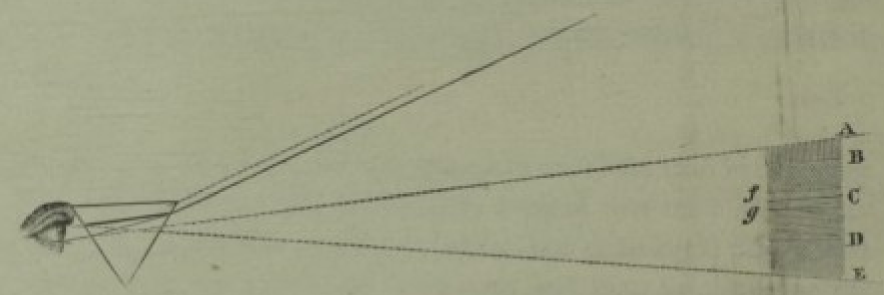

If a beam of day-light be admitted into a dark room by a crevice $\frac{1}{20}$ of an inch broad, and received by the eye at the distance of 10 or 12 feet, through a prism of flint-glass, *free from veins,* held near the eye, the beam is seen to be separated into the four following colours only, red, yellowish green, blue, and violet; in the proportions represented in Fig. 3.

The line A that bounds the red side of the spectrum is somewhat confused, which seems in part owing to want of power in the eye to converge red light. The line B, between red and green, in a certain position of the prism, is perfectly distinct; so also are D and E, the two limits of violet. But C, the limit of green and blue, is not so clearly marked as the rest; and there are also, on each side of this limit, other distinct dark lines, *f* and *g*, either of which, in an imperfect experiment, might be mistaken for the boundary of these colours.

VIII.

# Bestimmung des Brechungs- und Farbenzerstreuungs-Vermögens verschiedener Glasarten, in Bezug auf die Vervollkommnung achromatischer Fernröhre.

Von

Joseph Fraunhofer,

in Benedictbaiern.

Bey Berechnung achromatischer Fernröhre setzt man die genaue Kenntniſs des Brechungs- und Farbenzerstreuungs-Vermögens der Glasarten, die gebraucht werden, voraus. Die Mittel, welche man bisher zur Bestimmung desselben angewendet hat, geben Resultate,

 die

(Determination of the refractive and color-dispersing power of different types of glass, in relation to the improvement of achromatic telescopes)
Denkschriften der Königlichen Akademie der Wissenschaften zu München (Memoirs of the Royal Academy of Sciences in Munich) (**1814-1815**)

Kirchhoff, on the left, and Bunsen

A major advance was made in **1859** by Gustav Kirchhoff and Robert Bunsen. Bunsen's development of a powerful gas burner was essential for the research they did in Heidelberg, Germany. In 1859, Bunsen reported to a colleague that Kirchhoff had made "**a totally unexpected discovery**". He had identified the cause of the dark lines seen in the solar spectra by Fraunhofer and others. When certain chemicals were heated in Bunsen's burner, characteristic bright lines appeared. In some cases these were at exactly the same points in the spectrum as Fraunhofer's dark lines. The bright lines were light coming from a hot gas, whereas the dark lines showed absorption of light in the cooler gas above the Sun's surface.

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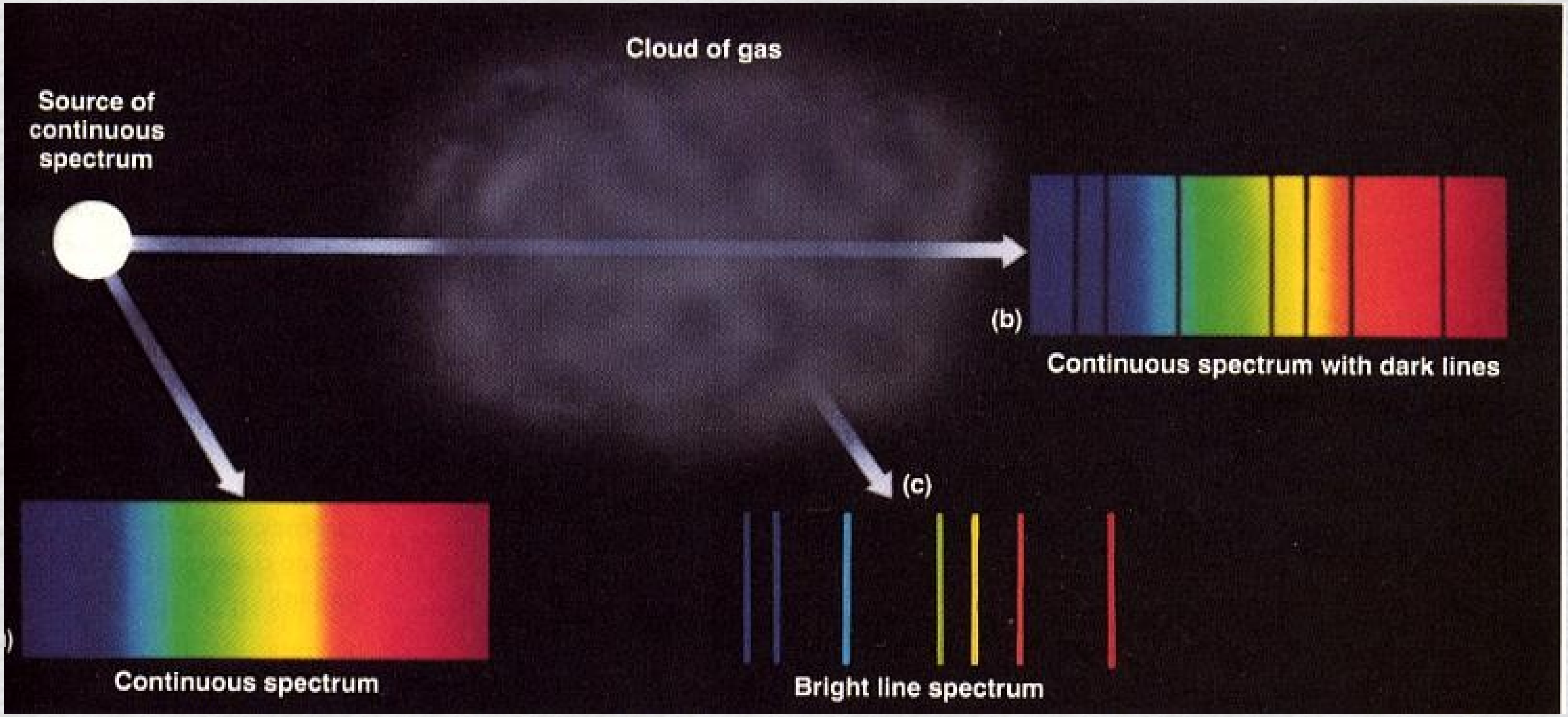
The two scientists found that **every chemical element produces a unique spectrum**. This provides a sort of "fingerprint" which can confirm the presence of that chemical. Kirchhoff and Bunsen recognized that this could be a powerful tool for "the determination of the chemical composition of the Sun and the fixed stars." Throughout the 1860s, Kirchoff managed to identify some 16 different chemical elements among the hundreds of lines he recorded in the sun's spectrum. From those data, Kirchoff speculated on the sun's chemical composition as well as its structure.



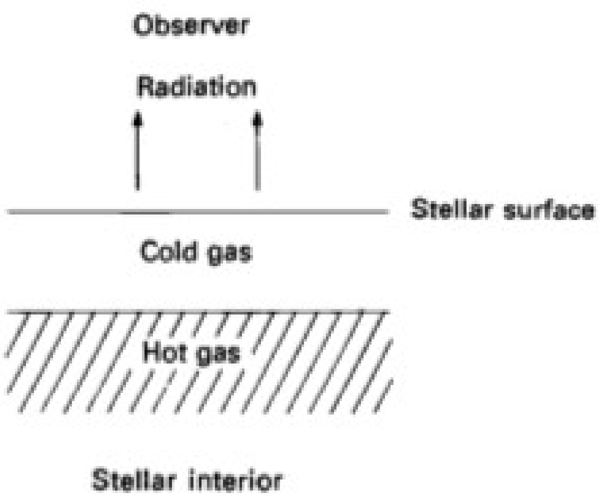




Fig. 10.4. The stellar radiation comes from a hot interior and passes through the cooler surface layers. The spectrum which we observe therefore shows absorption lines.

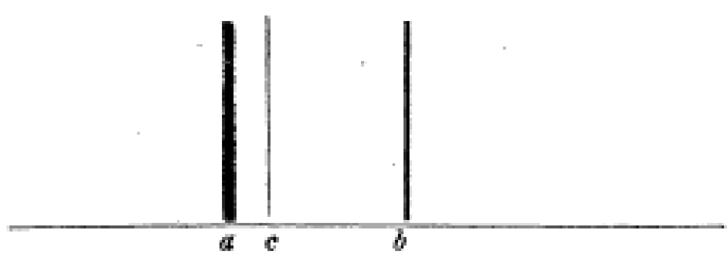
# Clasificación de Secchi (1864)

(Monthly Notices of the Royal Astronomical Society, Vol. 25)

### *On the Spectrum of the Nebula of Orion.*

(*Translation of a Letter from the Rev. Father Secchi to Mr. De La Rue.*)

Some days ago I published in the *Journal of Rome* (20th February) my observations of the light of the Nebula of *Orion*, which is similar to that which Mr. Huggins has found for the planetary nebulæ. I do not know if Mr. Huggins has made the same observation, and yet he can hardly have omitted to study this Nebula with his powerful instrument. I will, however, mention my results; the whole spectrum of this Nebula reduces itself to three lines; one (*a*) tolerably strong, and




which is seen wherever there is nebulosity; the second (*b*) fainter; and the third (*c*) still more faint, and very near to (*a*).

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XIII. *On the Spectra of some of the Nebulæ. By* WILLIAM HUGGINS, *F.R.A.S. A Supplement to the Paper "On the Spectra of some of the Fixed Stars. By* WILLIAM HUGGINS, *F.R.A.S., and* W. A. MILLER, *M.D., LL.D., Treas. and V.P.R.S." Communicated by Professor* W. A. MILLER, *M.D., LL.D.*

Received September 8, 1864, and printed in continuation of the paper preceding.

Philosophical transactions of the Royal Society, v.154 **(1864)**

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Philosophical transactions of the Royal Society, v.154 **(1864)**

of Huggins' classic works. We must be content here to summarize that work in relation to that of Fr. Secchi in the words of Russell, Dugan, and Stewart, who have commented fittingly:

> Huggins studied a few stars carefully and identified lines of sodium, magnesium, calcium, iron, hydrogen, etc.; Secchi examined a great number of stars, nearly 4000 in less detail and with a view to their classification.[8]

# Clasificación de Secchi (1864)

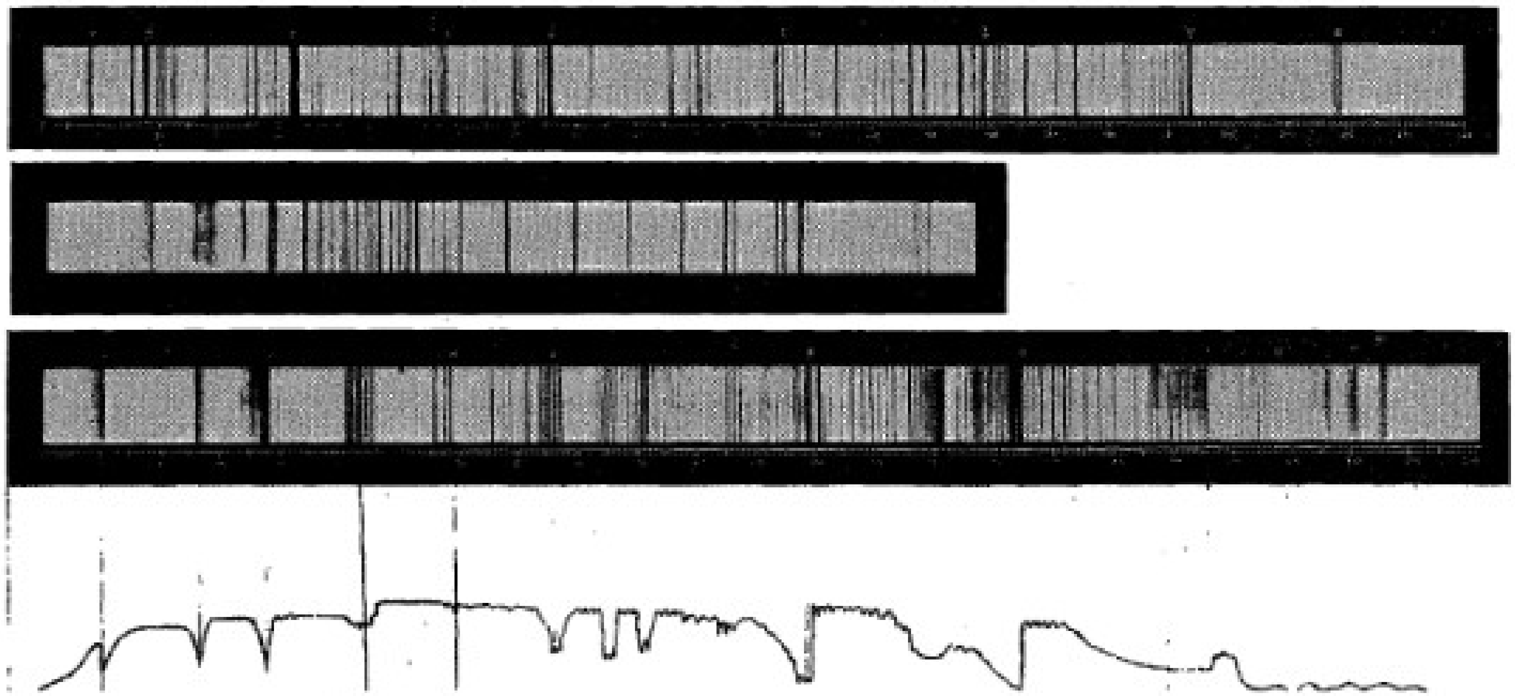
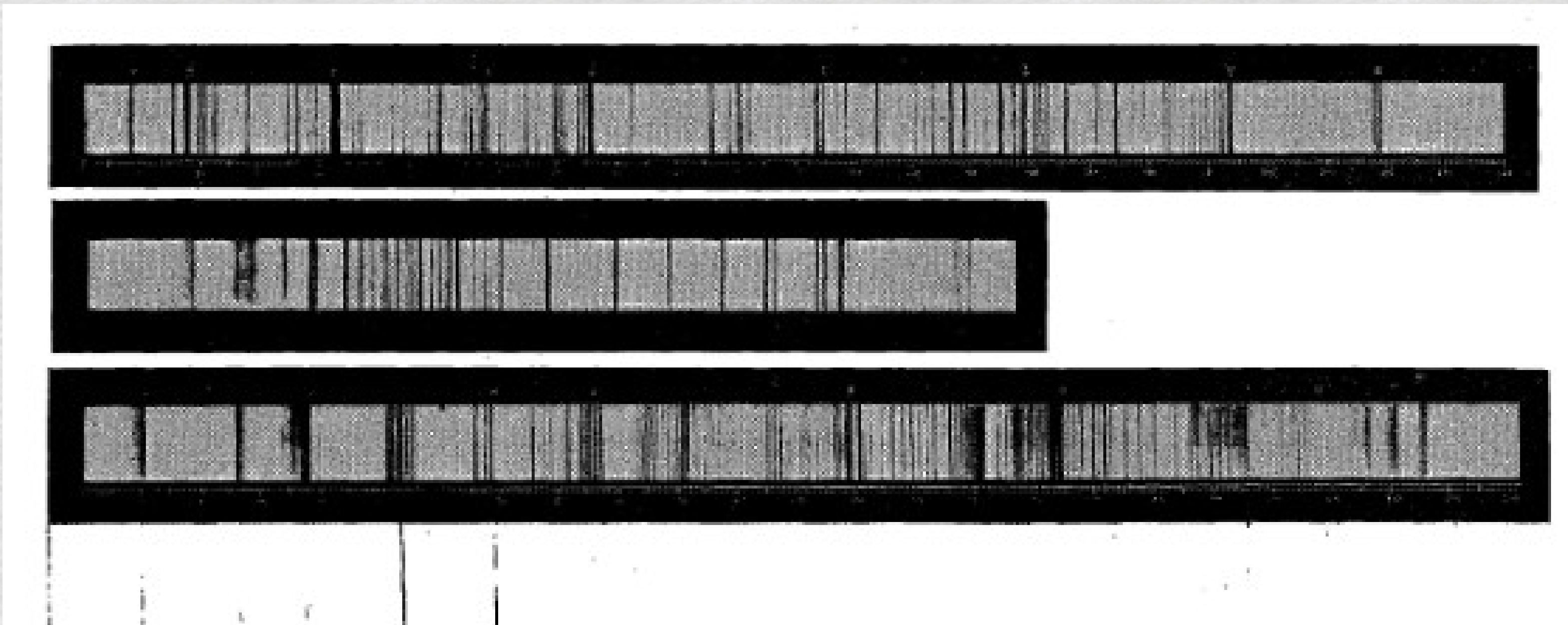


FIGURE 3

Spectrum of $\alpha$ Orionis (Top); $\alpha$ Tauri (Middle); $\alpha$ Scorpii (Bottom). Graph at bottom is Secchi's curve for the variation of light intensity in the spectrum of $\alpha$ Scorpii.

# Clasificación de Secchi (1864)



Grupo I: estrellas blancas. Solamente presenta líneas del H
Grupo II: estrellas amarillas. Espectros similares al solar.
Grupo III: estrellas rojas. Espectros ~ al solar, + bandas moleculares en el rojo.
Grupo IV: estrellas muy rojas. Intensas bandas moleculares en la región azul.

## TABLE I

### Summary of Spectral Classifications

| Fraunhofer | Donati | Rutherfurd | Carpenter | Secchi 1863 | Secchi 1866 | Secchi 1868 | Adopted | Cannon |
|---|---|---|---|---|---|---|---|---|
| | | Group Three (Spica, Rigel) | | | | | $V_{Pickering}$ I 0 | P-O B0-B7 |
| Stars with Blue Bands | White Stars | Group Two (Sirius) | Group Two (White Stars) | Class Two (White Stars) | | | I 0-I | B8-B9 |
| | | | | | | | $V_{Secchi}$ | Oe5p-B9p |
| | | | | | Type One (Vega) | Type One (Vega) | I | A0-F2 |
| Solar-type Stars | Yellow Stars | | Group Three (Solar Stars) | | Type Three (Sun) | Type Two ($\alpha$ Bootis) | I-II | F5 |
| | | | | | | | II | F8-K2 |
| | Orange Stars | Group One (Stars with Lines and Bands) | Group One (Red Stars) | Class One (Stars with Bands) | | | II-III | K5 |
| Red Stars | Red Stars | | | | Type Two ($\alpha$ Ori) | Type Three ($\alpha$ Her) | III | M |
| | | | | | | Type Four (152 Schjellerup) | IV | R-N |

E. Pickering (1877 - 1919)

Observatorio de Harvard (~ 1890)

E. Pickering (O. Harvard)

# Tipos espectrales de las estrellas

- W. Flemming: clasificación de acuerdo a la intensidad de las líneas del H en absorción.
- A, B, … , N, O, P (16 clases)

# Tipos espectrales de las estrellas

- A. Maury: clasificación de acuerdo a los anchos de las líneas espectrales.
- Reordenó las clases: B, A, ...

# STARS HAVING SPECTRA OF CLASS B.

IT has been shown in No. I of this Volume, that the distribution of the stars whose spectra are of Class B, the so-called Orion stars, is unlike that of the stars of the other principal classes. Also, that the number of these stars so far known is comparatively small, in fact less than that of Class M, the third type stars. The total number of stars, whose spectra have been classified and catalogued, is about thirty thousand. Arranging the classes of spectra according to the total number of stars contained in them, we have A, K, F, G, M, and B. The order is the same in the Milky Way except that there B precedes M. The proportion will vary according as we examine visual or photographic spectra, since, for stars brighter than a given magnitude, the former will include more of the red, the latter more of the blue, stars.

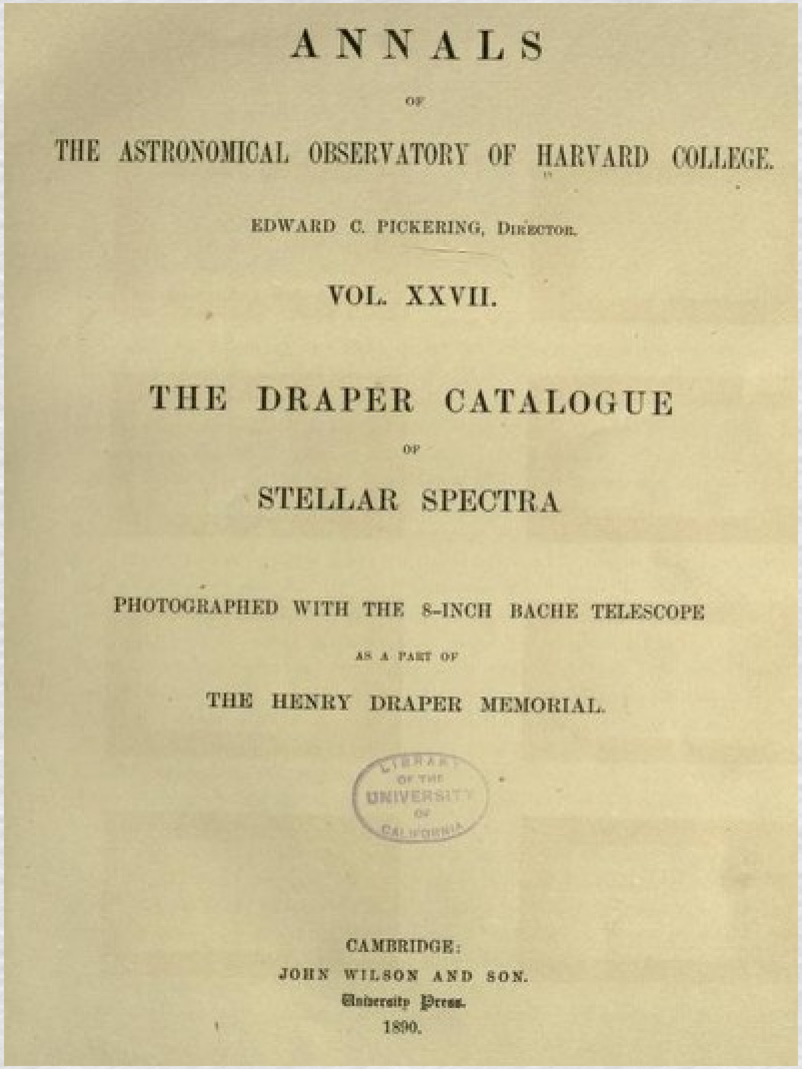
# Tipos espectrales de las estrellas

- A. J. Cannon: subdividió las clases (A0 … A9)
- Reordenó y definió definitivamente las clases: **O, B, A, F, G, K, M**.

←

TEMPERATURA

# Clasificación espectral de Harvard
# - **secuencia uniparamétrica** -



ANNALS

OF

THE ASTRONOMICAL OBSERVATORY OF HARVARD COLLEGE.

EDWARD C. PICKERING, DIRECTOR.

VOL. XXVII.

THE DRAPER CATALOGUE

OF

STELLAR SPECTRA

PHOTOGRAPHED WITH THE 8-INCH BACHE TELESCOPE

AS A PART OF

THE HENRY DRAPER MEMORIAL.



CAMBRIDGE:
JOHN WILSON AND SON.
University Press.
1890.

# Harvard College Observatory.

## CIRCULAR 173.

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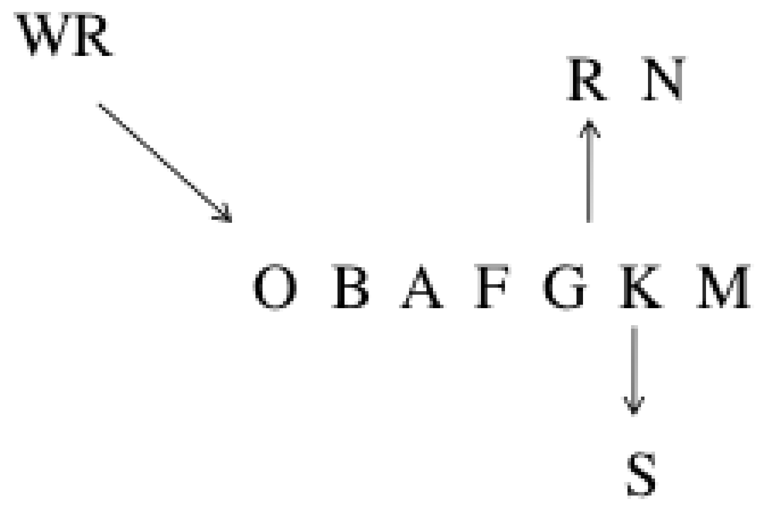
## PERIODS OF 25 VARIABLE STARS IN THE SMALL MAGELLANIC CLOUD.

The following statement regarding the periods of 25 variable stars in the Small Magellanic Cloud has been prepared by Miss Leavitt.

A Catalogue of 1777 variable stars in the two Magellanic Clouds is given

**TABLE 8.1** Harvard Spectral Classification.

| Spectral Type | Characteristics |
|---|---|
| O | Hottest blue-white stars with few lines<br>Strong He II absorption (sometimes emission) lines.<br>He I absorption lines becoming stronger. |
| B | Hot blue-white<br>He I absorption lines strongest at B2.<br>H I (Balmer) absorption lines becoming stronger. |
| A | White<br>Balmer absorption lines strongest at A0, becoming weaker later.<br>Ca II absorption lines becoming stronger. |
| F | Yellow-white<br>Ca II lines continue to strengthen as Balmer lines continue to weaken.<br>Neutral metal absorption lines (Fe I, Cr I). |
| G | Yellow<br>Solar-type spectra.<br>Ca II lines continue becoming stronger.<br>Fe I, other neutral metal lines becoming stronger. |
| K | Cool orange<br>Ca II H and K lines strongest at K0, becoming weaker later.<br>Spectra dominated by metal absorption lines. |
| M | Cool red<br>Spectra dominated by molecular absorption bands,<br>especially titanium oxide (TiO) and vanadium oxide (VO). |




R y N: Bandas con compuesto de C, en lugar del TiO de los tipos K y M
S: Bandas de óxido de zirconio.

WR: Wolf Rayet (T ~60 000 - 100 000 K) : Bandas brillantes del H y del He en emisión. Se subdividen en WC (con bandas de carbono) y WN (con bandas de nitrógeno).

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| M | Cool red<br>Spectra dominated by molecular absorption bands,<br>especially titanium oxide (TiO) and vanadium oxide (VO). |
| L | Very cool, dark red<br>Stronger in infrared than visible.<br>Strong molecular absorption bands of metal hydrides (CrH, FeH), water ($H_2O$), carbon monoxide (CO), and alkali metals (Na, K, Rb, Cs).<br>TiO and VO are weakening. |
| T | Coolest, Infrared<br>Strong methane ($CH_4$) bands but weakening CO bands. |

Enanas marrones

| Class | Effective temperature | Conventional color description | Actual apparent color |
|---|---|---|---|
| O | ≥ 30,000 K | blue | blue |
| B | 10,000–30,000 K | blue white | deep blue white |
| A | 7,500–10,000 K | white | blue white |
| F | 6,000–7,500 K | yellow white | white |
| G | 5,200–6,000 K | yellow | yellowish white |
| K | 3,700–5,200 K | orange | pale yellow orange |
| M | 2,400–3,700 K | red | light orange red |
| L | 1,300–2,400 K | red brown | scarlet |
| T | 500–1,300 K | brown | magenta |
| Y | ≤ 500 K | dark brown | black |

The Astronomical Journal, 152:78 (12pp), 2016 September doi:10.3847/0004-6256/152/3/


# THE SPECTRAL ENERGY DISTRIBUTION OF THE COLDEST KNOWN BROWN DWARF*

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[1] Department of Astronomy and Astrophysics, The Pennsylvania State University, University Park, PA 16802, USA; kluhman@astro.psu.edu
[2] Center for Exoplanets and Habitable Worlds, The Pennsylvania State University, University Park, PA 16802, USA
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## ABSTRACT

WISE J085510.83–071442.5 (hereafter WISE 0855–0714) is the coldest known brown dwarf (~250 K) and the fourth-closest known system to the Sun (2.2 pc). It has been previously detected only in the *J* band and two mid-IR bands. To better measure its spectral energy distribution (SED), we have performed deep imaging of WISE 0855–0714 in six optical and near-IR bands with Gemini Observatory, the Very Large Telescope, and the *Hubble Space Telescope*. Five of the bands show detections, although one detection is marginal (S/N ~ 3). We also have

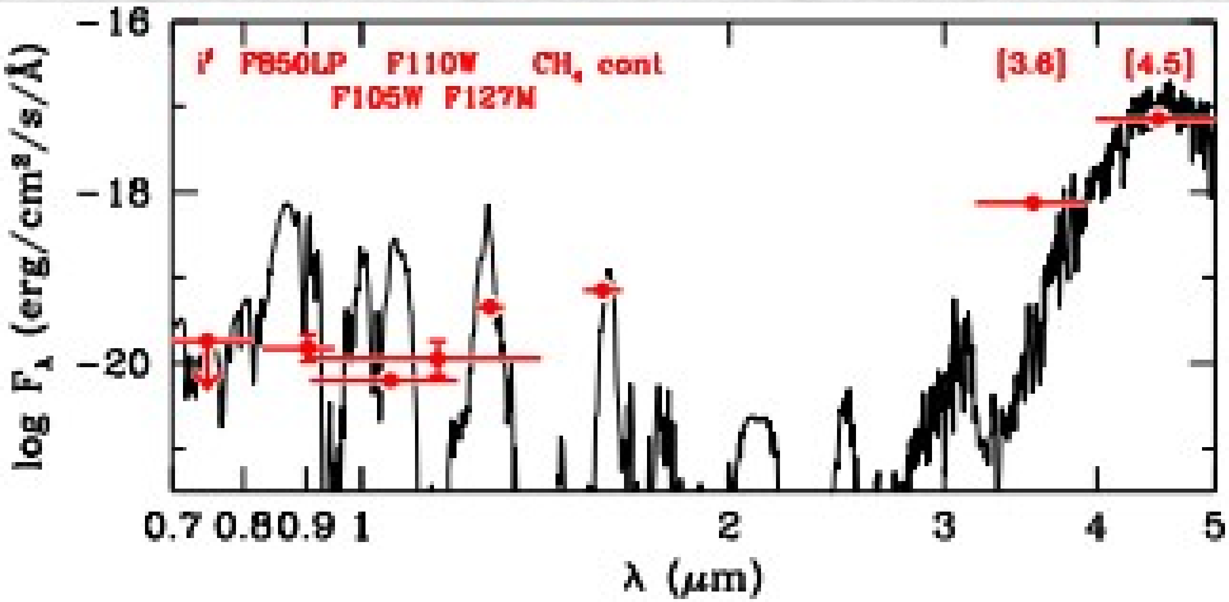
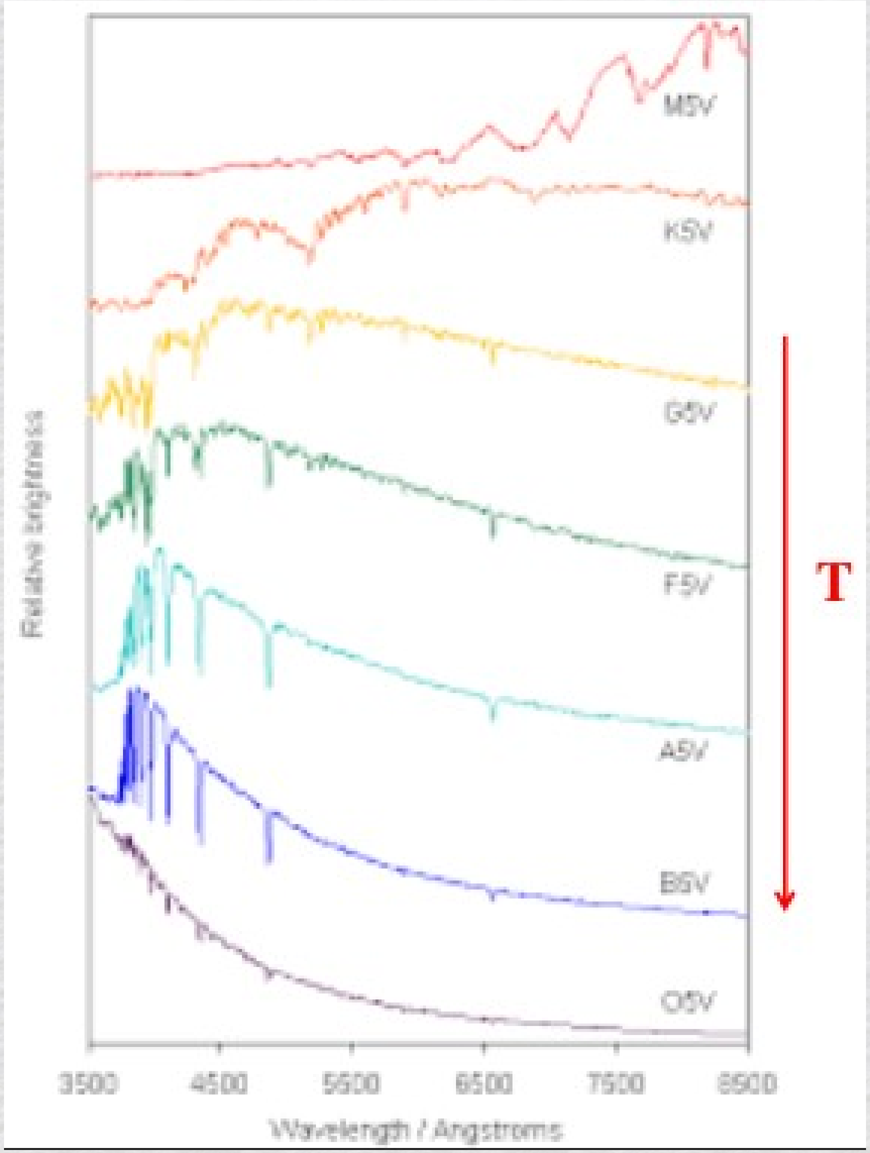



**Figure 7.** Bottom: SED of WISE 0855–0714 (red points) and an example of a theoretical spectrum of a brown dwarf at the distance and $M_{4.5}$ of WISE 0855–0714 (50% cloud coverage, 250 K; Morley et al. 2014b). The




| Tipo Espectral | Temperatura (K) |
|---|---|
| O | 30000 |
| B | 13000-20000 |
| A | 10000 |
| F | 7000-9000 |
| G | 5000-6000 |
| K | 4000 |
| M | 3000 |

# Cecilia Payne-Gaposchkin on Arthur Eddington

We present two similar descriptions of Arthur Eddington by Cecilia Payne-Gaposchkin.

**1.** The following short extract is from Cecilia Payne-Gaposchkin's autobiography "The dyer's hand". It relates to the time when she was an undergraduate student at the University of Cambridge:

There was to be a lecture in the Great Hall of Trinity College. Professor Eddington was to announce the results of the eclipse expedition that he had led to Brazil in 1918 [Note by EFR: Payne-Gaposchkin's memory is incorrect here. Eddington actually led the expedition to Principe Island off West Africa for the eclipse on 29 May 1919. There was a second expedition which set out from England at the same time and went to Sobral in Brazil which has confused Payne-Gaposchkin]. Four tickets for the lecture had been assigned to students at Newnham College and (almost by accident, for one of my friends was unable to go) a ticket fell to me. The Great Hall was crowded. The speaker was a slender, dark young man with a trick of looking away from his audience and a manner of complete detachment. He gave an outline of the Theory of Relativity in popular language, as none could do better than he. He described the Lorenz-Fitzgerald contraction, the Michelson-Morley experiment and its consequences. He led up to the shift of the stellar images near the Sun as predicted by Einstein and described his verification of the prediction. ... I began to attend Eddington's lectures. Those on Relativity revived the interest first stimulated in the Great Hall of Trinity College. The Determination of Orbits and the Reduction of Observations proved to be of more lasting value. Under his eye we computed the orbits of several comets - all, of course, with the use of logarithms. These computational sessions were topped off by the special treat of tea at the Observatory, at the invitation of old Mrs Eddington and her sweet and gentle daughter Winifred. There were only three or four students at these sessions and we were warmly received in the family atmosphere. It came as a slight shock to me to learn that Eddington's favourite composer was Humperdinck, and that the music he liked best included the songs of Harry Lauder, especially *Roamin' in the gloaming*. He was a very quiet man and a conversation with him was punctuated by long silences. He never replied immediately to a question; he pondered it, and after a long (but not uncomfortable) interval would respond with a complete and rounded answer.

Cecilia **Payne**-Gaposchkin:

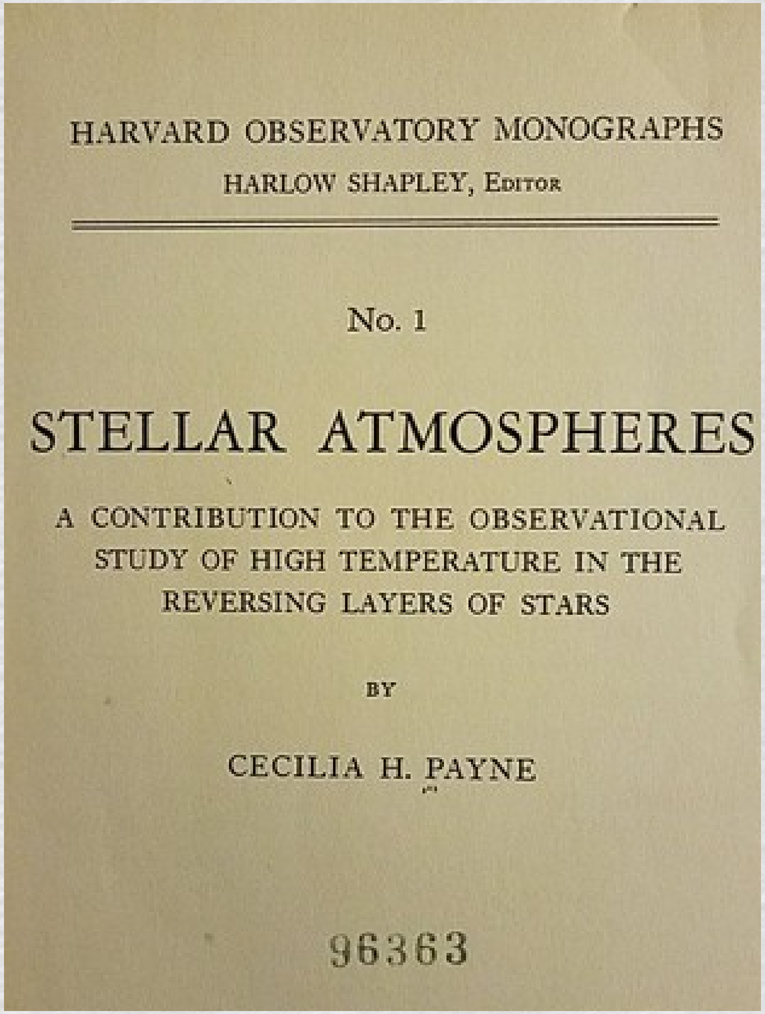
- Dependencia de la clasificación espectral con la temperatura
- Comp. química de la gran mayoría de las estrellas es similar: ~ 75% H, 23% He y 2%.

- Relacionó las clases espectrales de las estrellas con sus temperaturas. Aplicó “*the ionization theory by* ***Saha*****”**.

- Mostró que la gran variación en las líneas de absorción --> a las diferentes cantidades de ionización a diferentes temperaturas, ~~**diferencia en la cantidad de los elementos**~~.

- Relacionó las clases espectrales de las estrellas con sus temperaturas, aplicando “*the ionization theory by* ***Saha*****”**.

- Mostró que la gran variación en las líneas de absorción --> a las diferentes cantidades de ionización a diferentes temperaturas, ~~**diferencia en la cantidad de los elementos**~~.


HARVARD OBSERVATORY MONOGRAPHS
HARLOW SHAPLEY, EDITOR

NO. 1

STELLAR ATMOSPHERES

A CONTRIBUTION TO THE OBSERVATIONAL STUDY OF HIGH TEMPERATURE IN THE REVERSING LAYERS OF STARS

BY

CECILIA H. PAYNE

96363

“***The most brilliant PhD thesis ever written in astronomy***” (O. Struve)

**Harvard Names Woman Professor of Astronomy**

Dr. Cecilia Payne-Gaposchkin

Special to The New York Times.

CAMBRIDGE, Mass., June 20—Harvard University announced today the appointment of Dr. Cecilia Payne-Gaposchkin as Professor of Astronomy.

She is the first woman to attain full professorship at Harvard through regular faculty promotion. Since 1938, she had been Phillips Astronomer in the Harvard College Observatory and lecturer on

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"Do not undertake a scientific career in quest of fame or money. There are easier and better ways to reach them. Undertake it only if nothing else will satisfy you; for nothing else is probably what you will receive. Your reward will be the widening of the horizon as you climb. And if you achieve that reward you will ask no other."

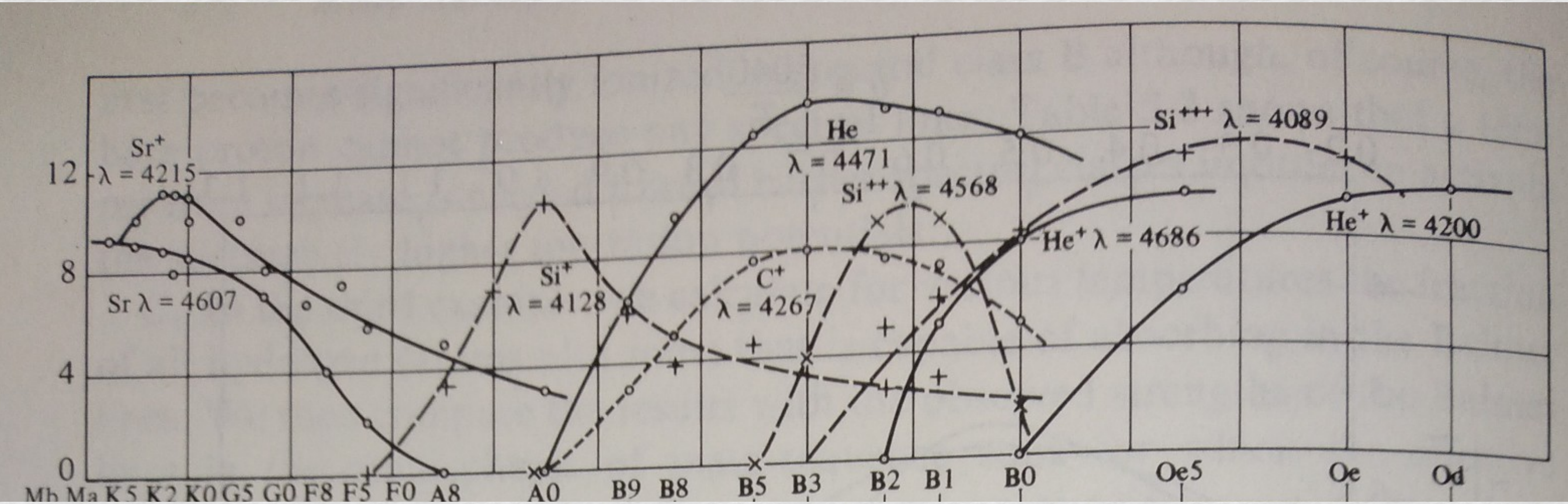
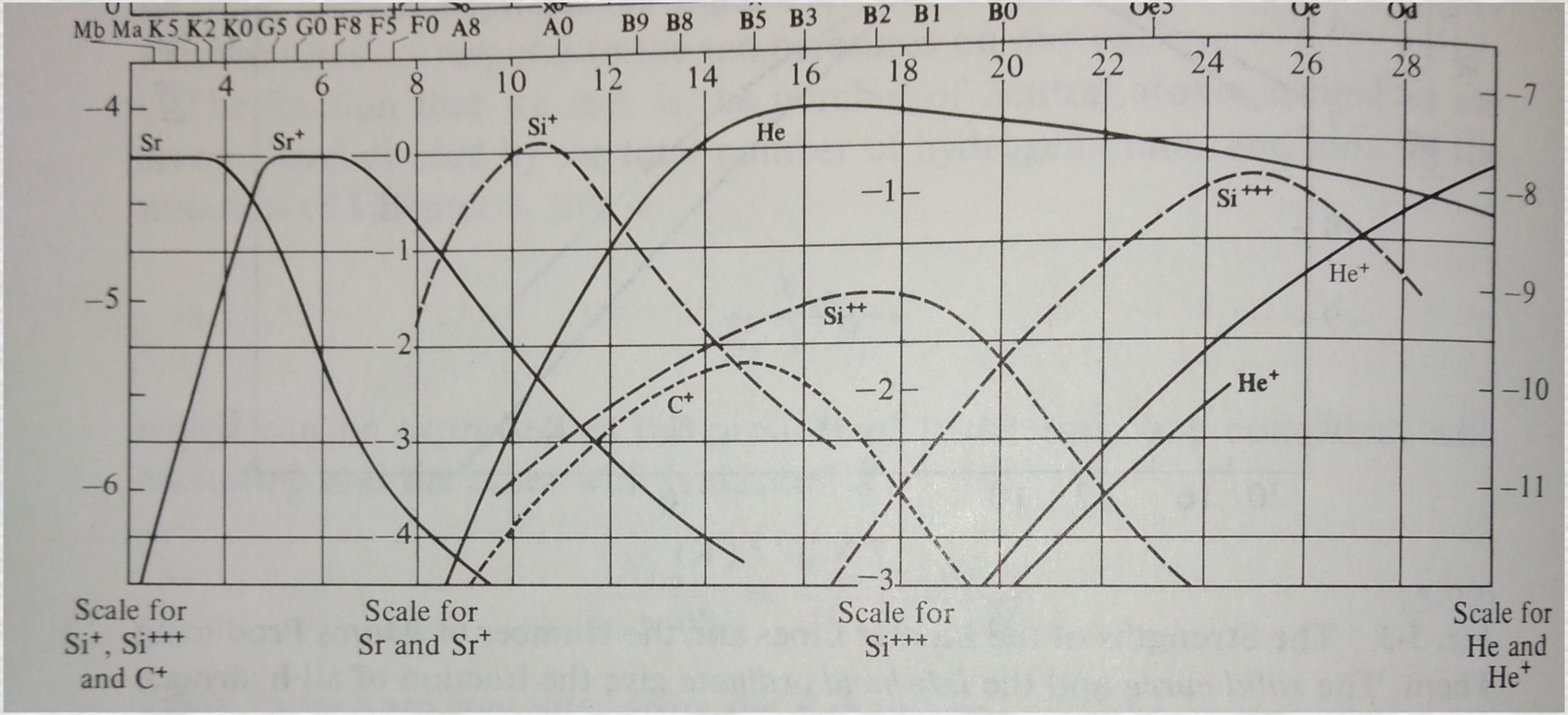
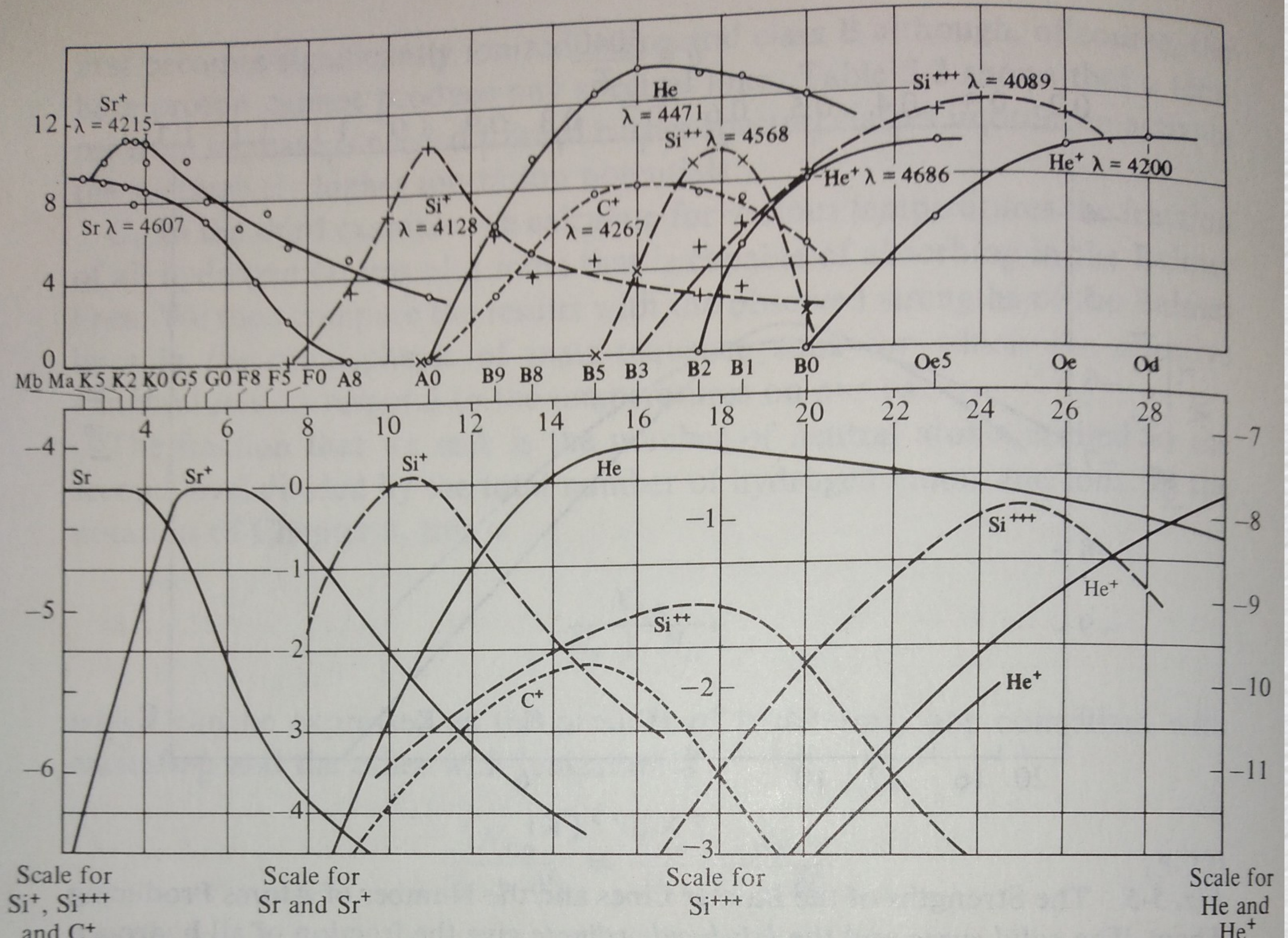



*Fig. 5-6* The Strengths of Selected Lines along the Spectral Sequence.
*Upper diagram:* The variations of the observed intensities with spectral type. The abscissae are obtained from the Henry Draper Catalogue. The ordinates are expressed on an arbitrary scale.




*Lower diagram:* The computed values of the logarithms of the fractional concentrations, assuming $P_e = 131$ dyne cm$^{-2}$. The temperature scale is expressed in units of $10^3$ °K and is adjusted to the abscissa of the upper diagram so as to obtain the best fit of the maxima of the corresponding curves. [After C. H. Payne, 1924, (231), p. 3.]

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*Upper diagram:* The variations of the observed intensities with spectral type. The abscissae are obtained from the Henry Draper Catalogue. The ordinates are expressed on an arbitrary scale.
*Lower diagram:* The computed values of the logarithms of the fractional concentrations, assuming $P_e = 131$ dyne cm$^{-2}$. The temperature scale is expressed in units of $10^3$ °K and is adjusted to the abscissa of the upper diagram so as to obtain the best fit of the maxima of the corresponding curves. [After C. H. Payne, 1924, (231), p. 3.]

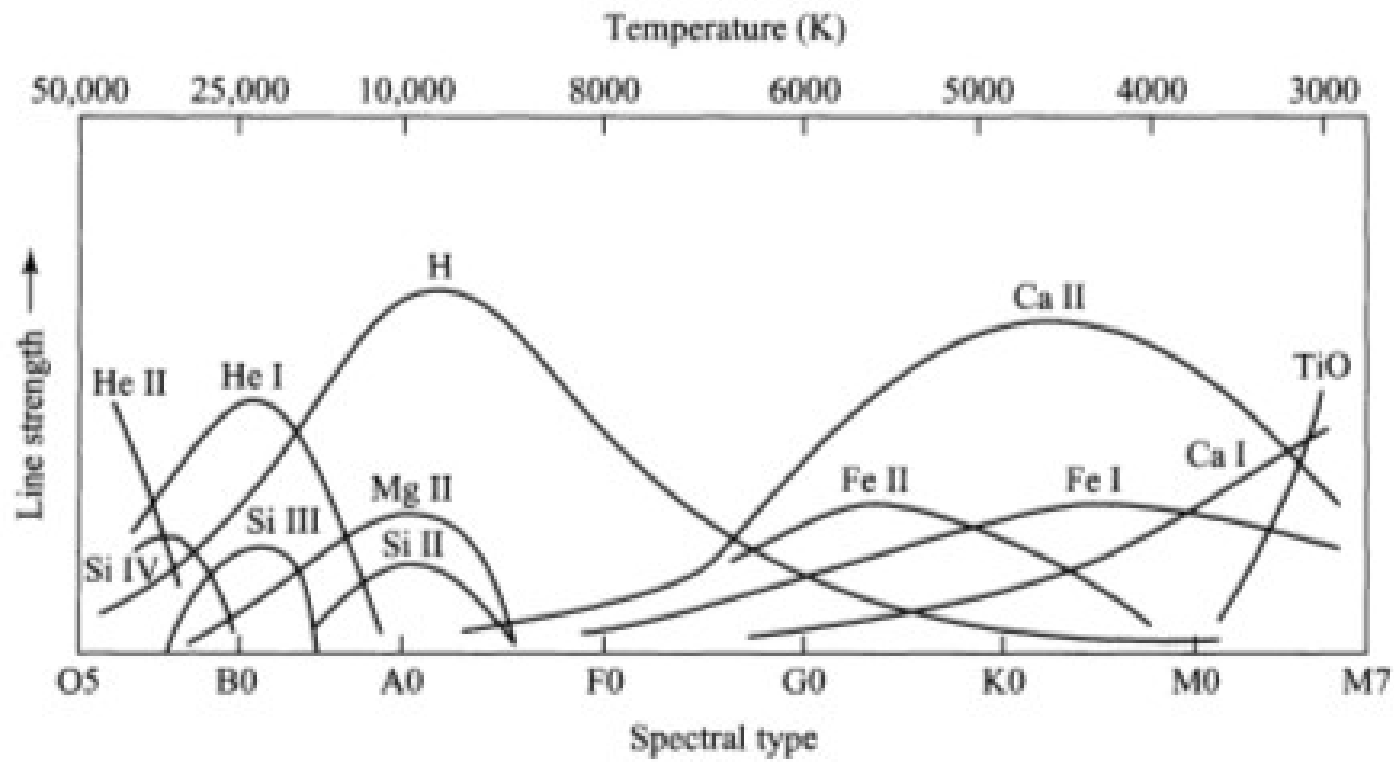



**FIGURE 8.11** The dependence of spectral line strengths on temperature.

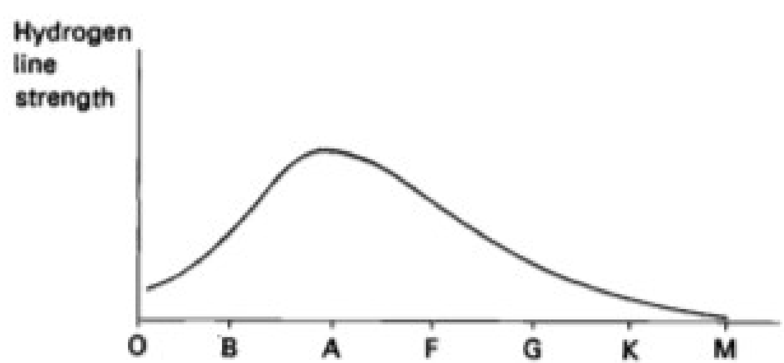
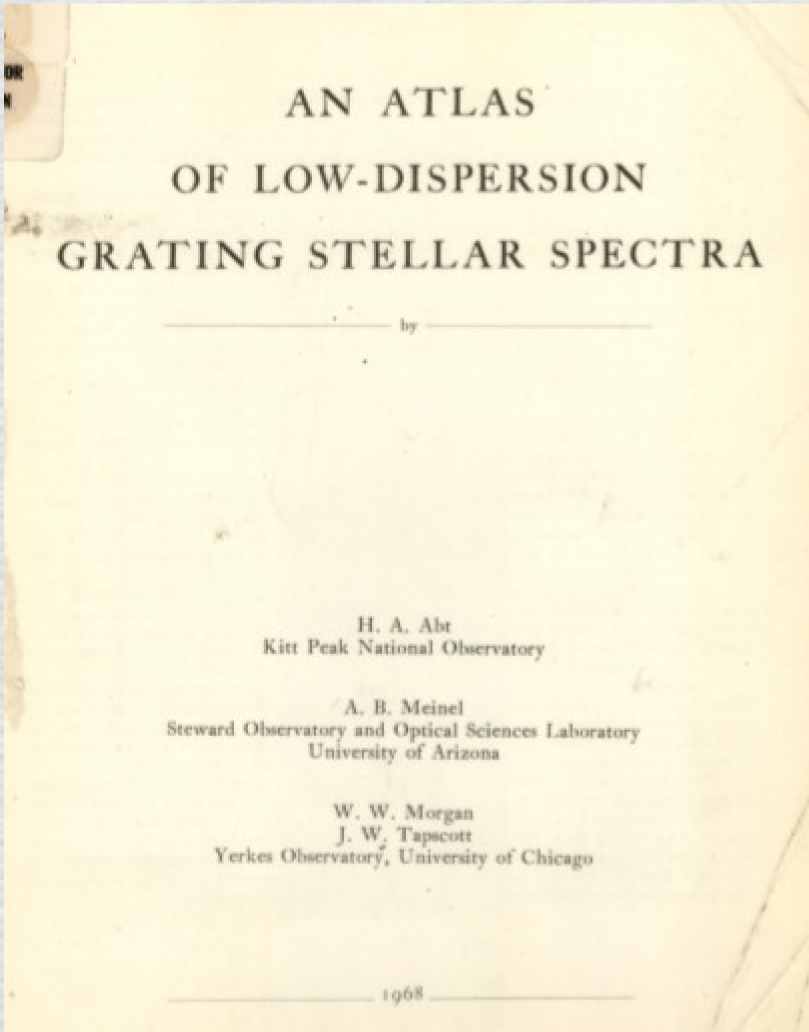



Fig. 10.5. We show schematically the dependence of the hydrogen line strength on the spectral type. When going from the O type stars to later spectral types the hydrogen line strength first increases until we get to the spectral type AO, for later spectral types it decreases.



AN ATLAS

OF LOW-DISPERSION

GRATING STELLAR SPECTRA

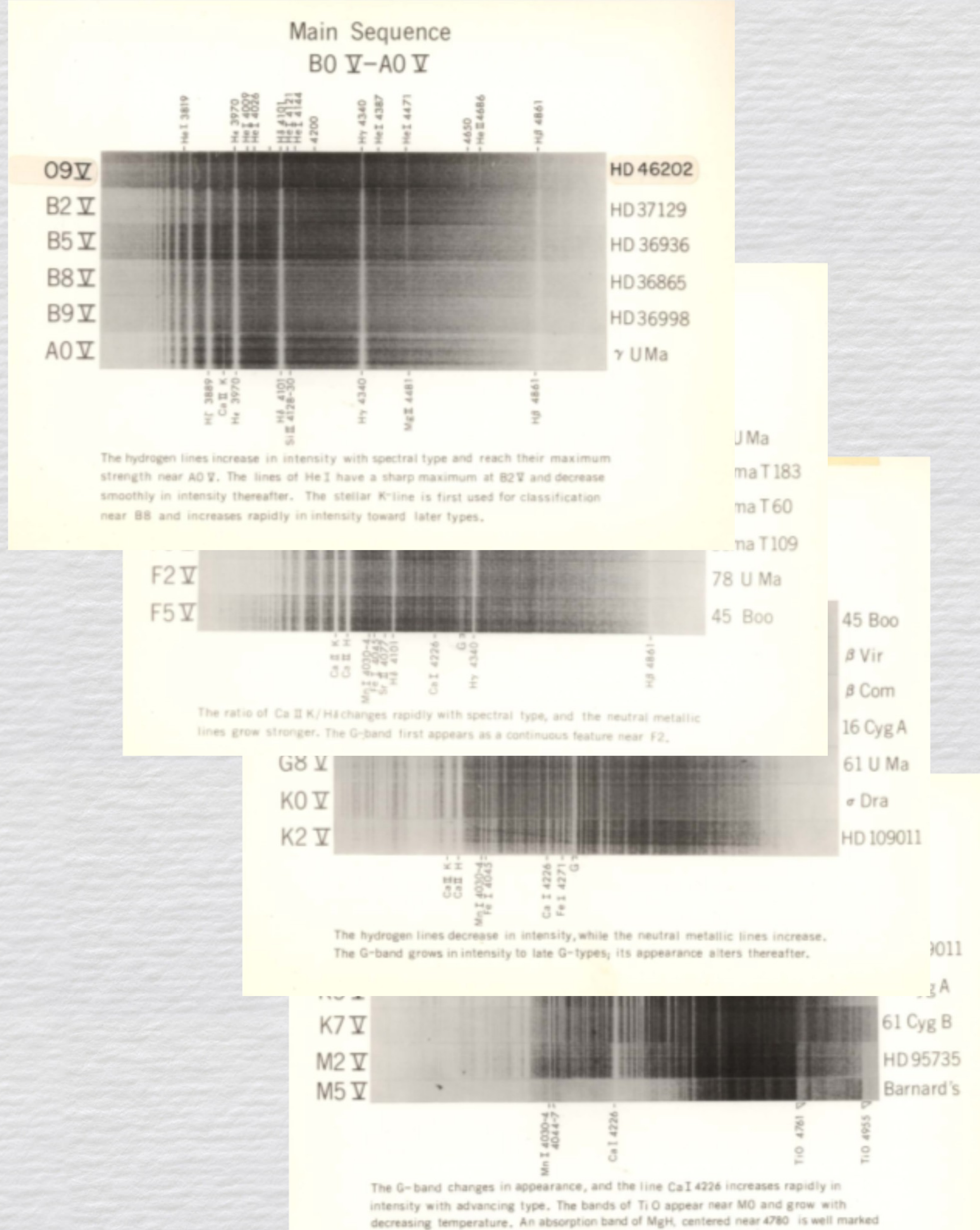
by

H. A. Abt
Kitt Peak National Observatory

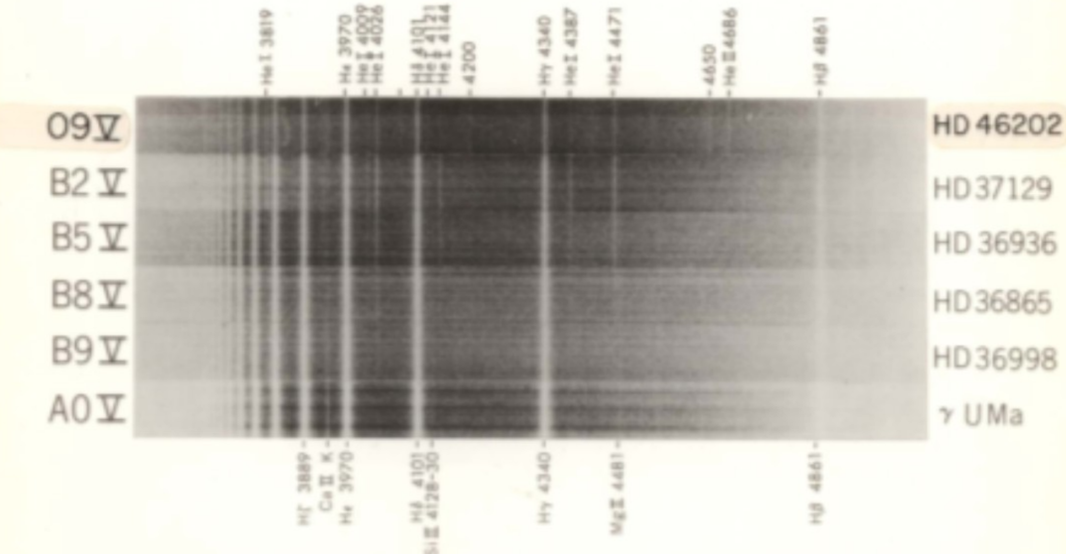
A. B. Meinel
Steward Observatory and Optical Sciences Laboratory
University of Arizona

W. W. Morgan
J. W. Tapscott
Yerkes Observatory, University of Chicago

1968

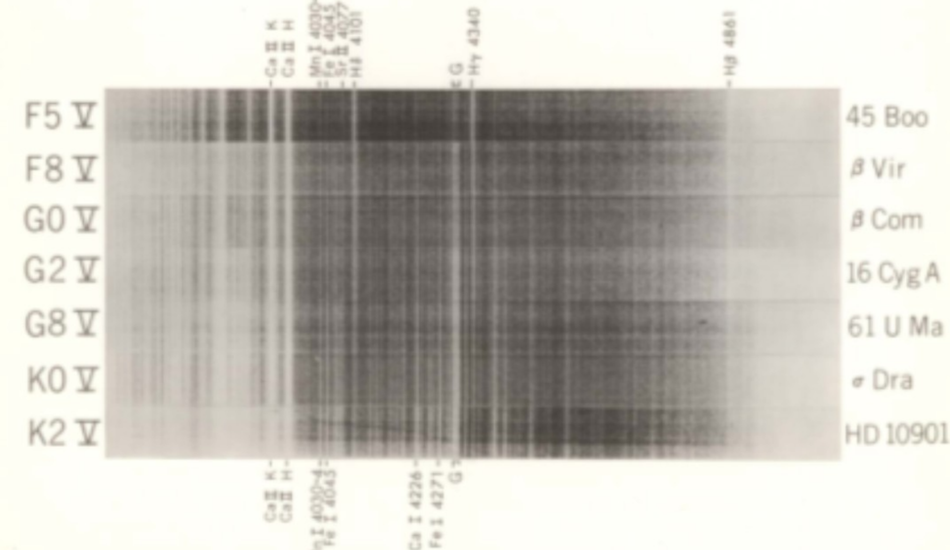


## Main Sequence
## B0 V–A0 V



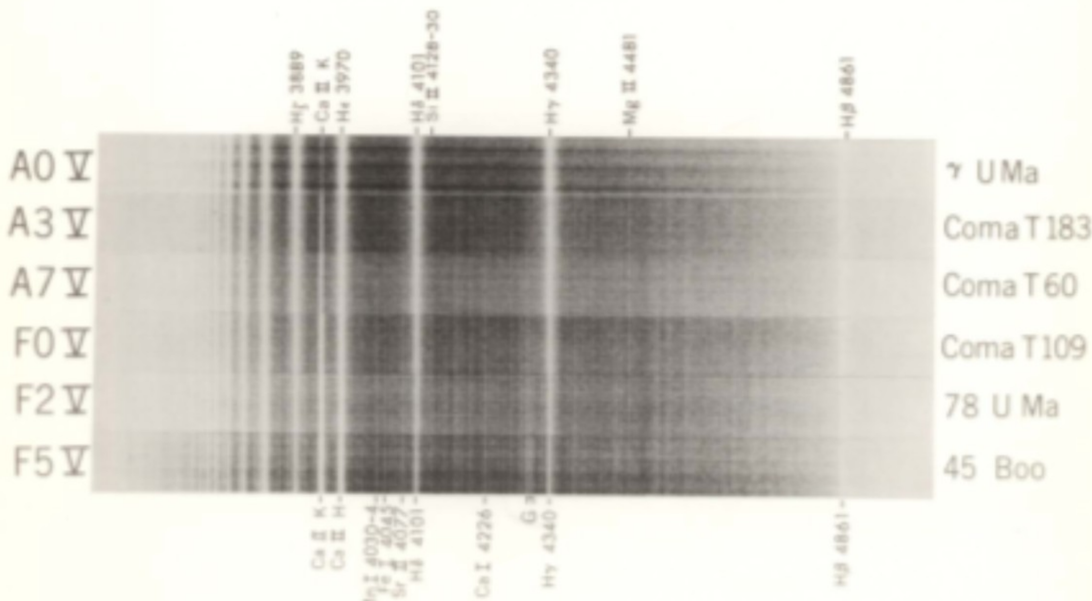

The hydrogen lines increase in intensity with spectral type and reach their maximum strength near A0 V. The lines of He I have a sharp maximum at B2 V and decrease smoothly in intensity thereafter. The stellar K-line is first used for classification near B8 and increases rapidly in intensity toward later types.

## Main Sequence
## F5 V–K2 V



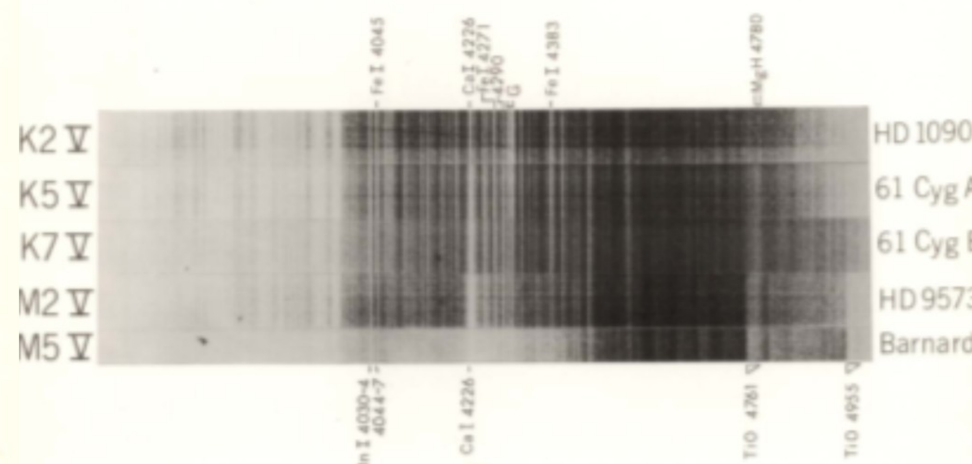

The hydrogen lines decrease in intensity, while the neutral metallic lines increase. The G-band grows in intensity to late G-types; its appearance alters thereafter.

## Main Sequence
## A0 V–F5 V



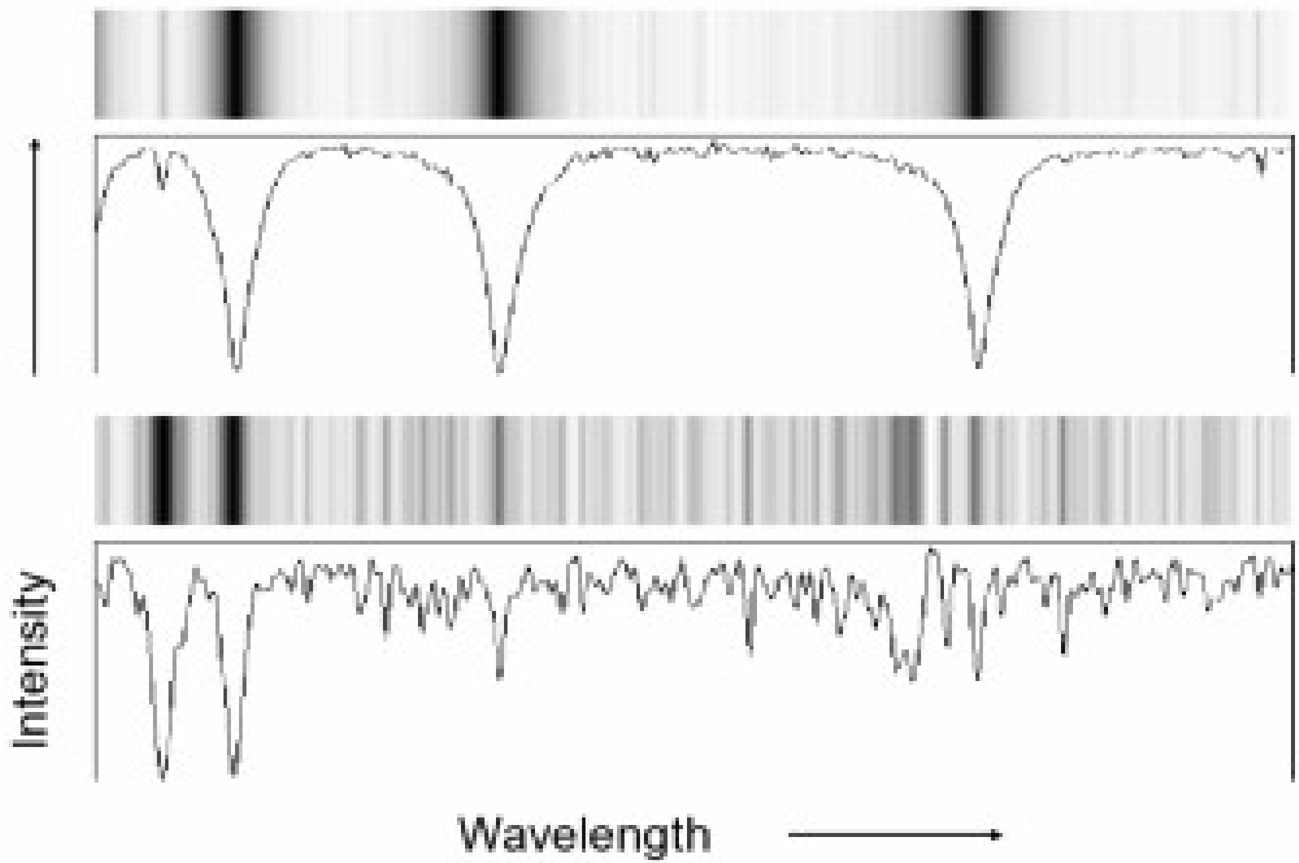

The ratio of Ca II K/Hε changes rapidly with spectral type, and the neutral metallic lines grow stronger. The G-band first appears as a continuous feature near F2.

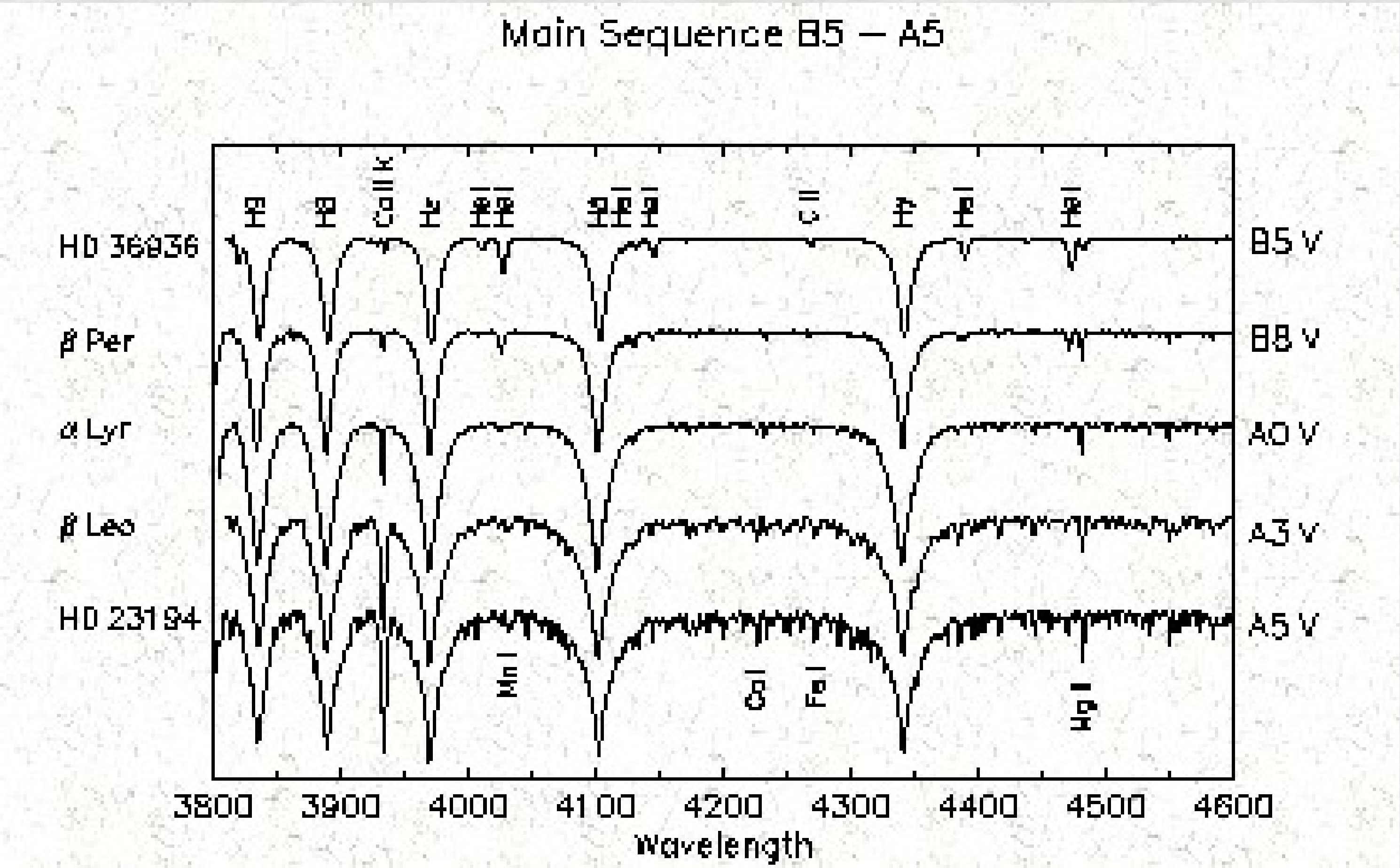
## Main Sequence
## K2 V–M5 V




The G-band changes in appearance, and the line Ca I 4226 increases rapidly in intensity with advancing type. The bands of TiO appear near M0 and grow with decreasing temperature. An absorption band of MgH, centered near 4780 is well marked in late K-type dwarfs; it is blended with the TiO absorption near 4761 in the M dwarfs. The MgH band is an important luminosity discriminant.

# Digital spectrum





Main Sequence B5 – A5
HD 36936
β Per
α Lyr
β Leo
HD 23194
B5 V
B8 V
A0 V
A3 V
A5 V
Ca II k
C II
Mn I
Fe I
Mg II
3800
3900
4000
4100
4200
4300
4400
4500
4600
Wavelength

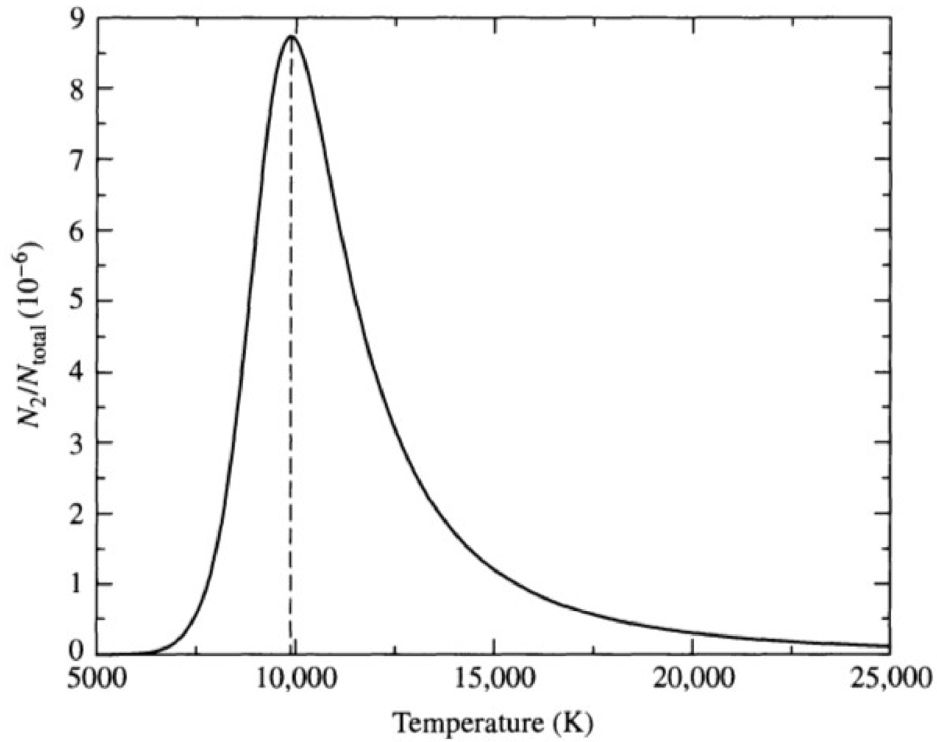



**FIGURE 8.9** $N_2/N_{\text{total}}$ for hydrogen from the Boltzmann and Saha equations, assuming $P_e =$ 20 N m$^{-2}$. The peak occurs at approximately 9900 K.

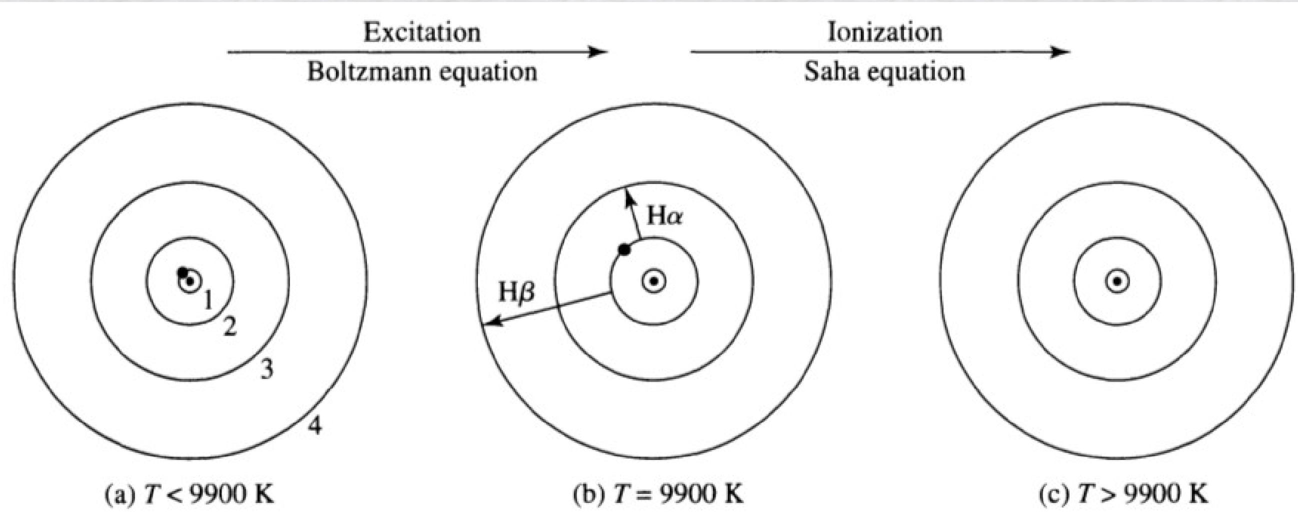



**FIGURE 8.10** The electron's position in the hydrogen atom at different temperatures. In (a), the electron is in the ground state. Balmer absorption lines are produced only when the electron is initially in the first excited state, as shown in (b). In (c), the atom has been ionized.

THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 81:865–881, 1992 August


# A NEW LIBRARY OF STELLAR OPTICAL SPECTRA

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*Received 1991 August 12; accepted 1992 January 10*

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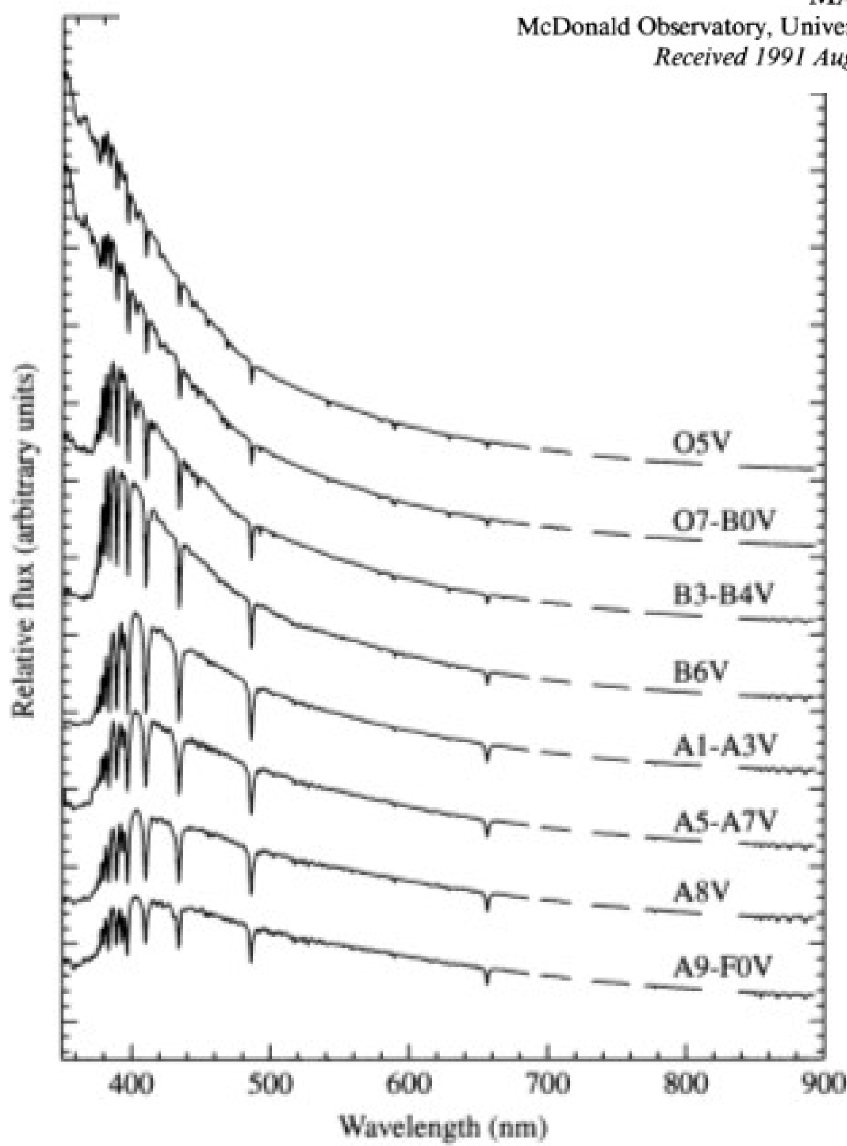
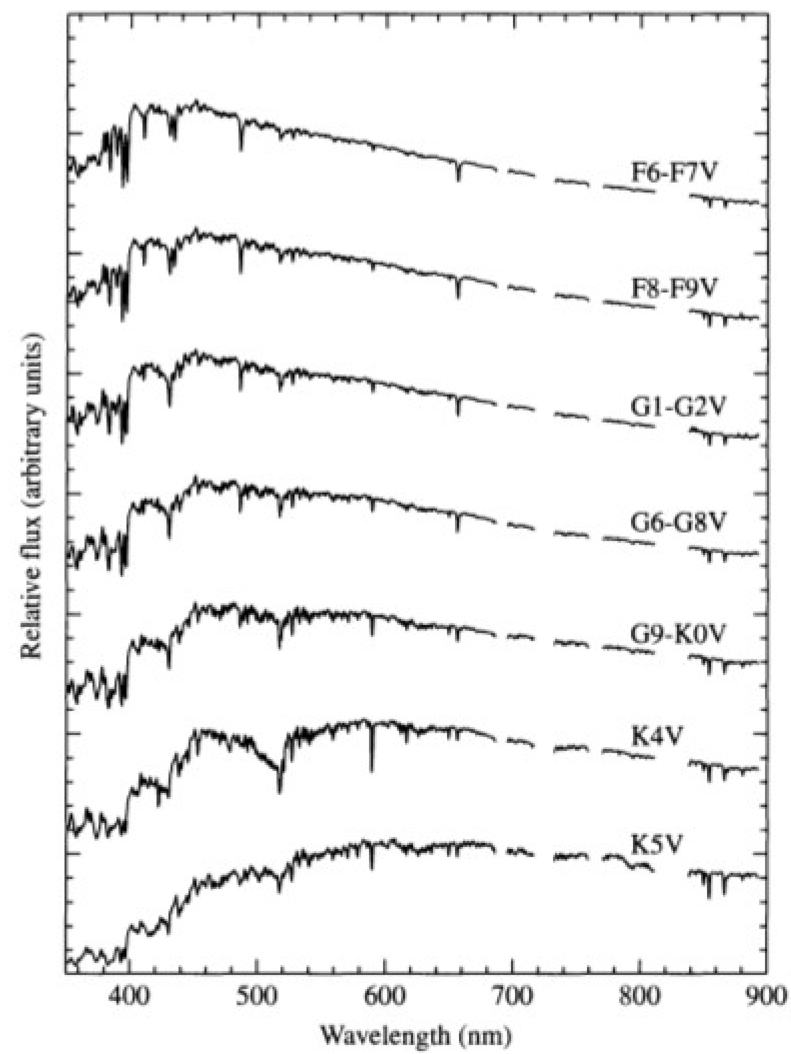
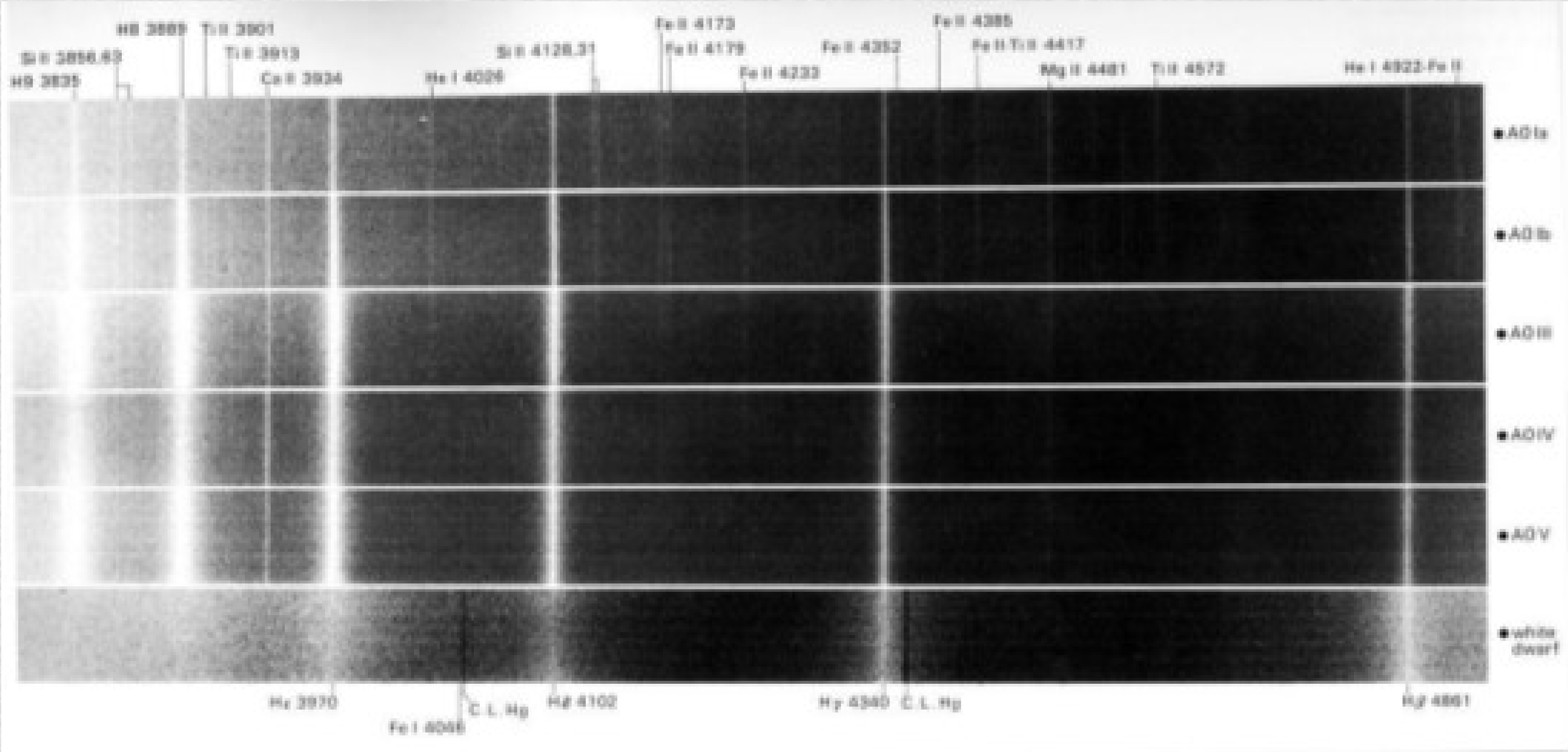


# Estrellas del = tipo espectral, diferentes anchos de líneas



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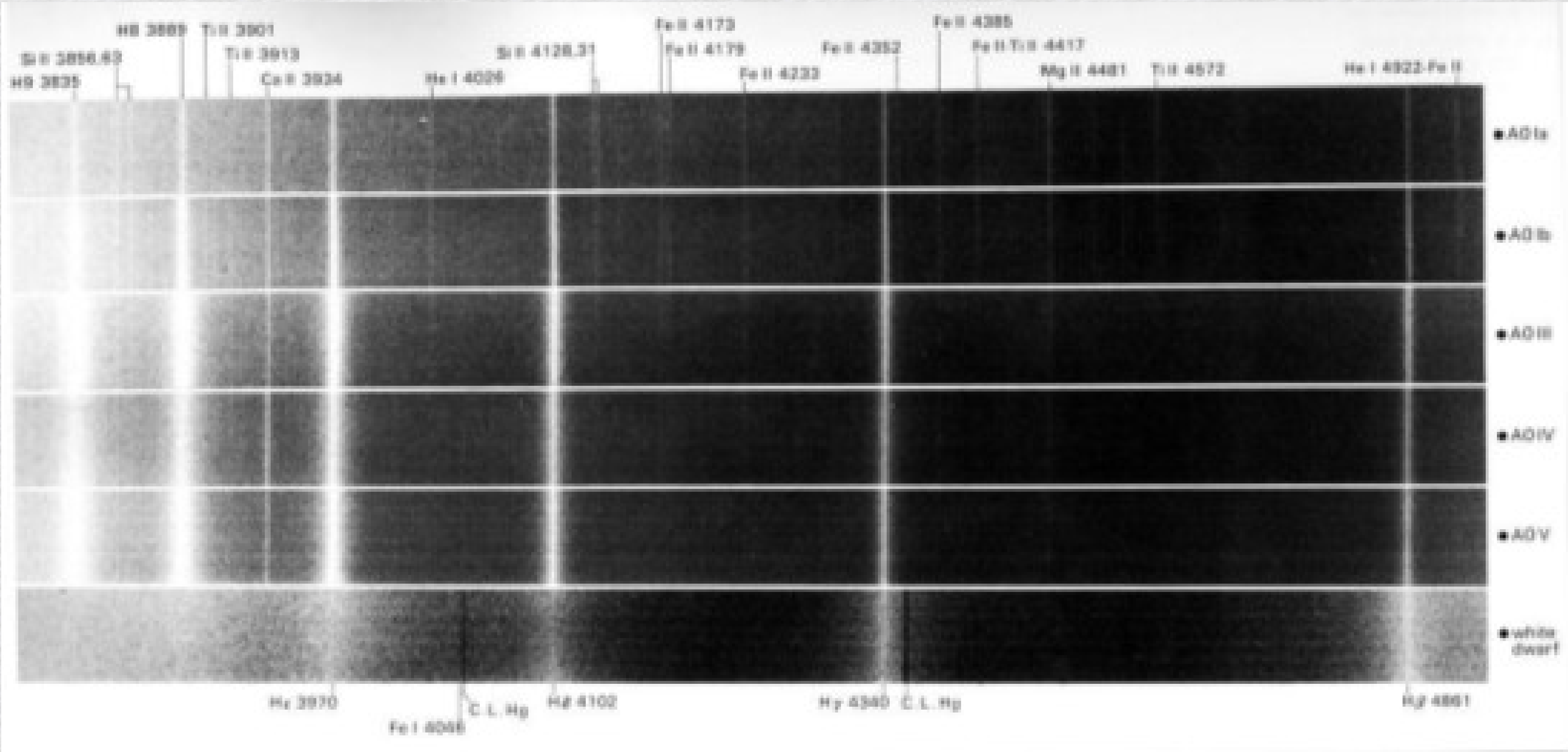
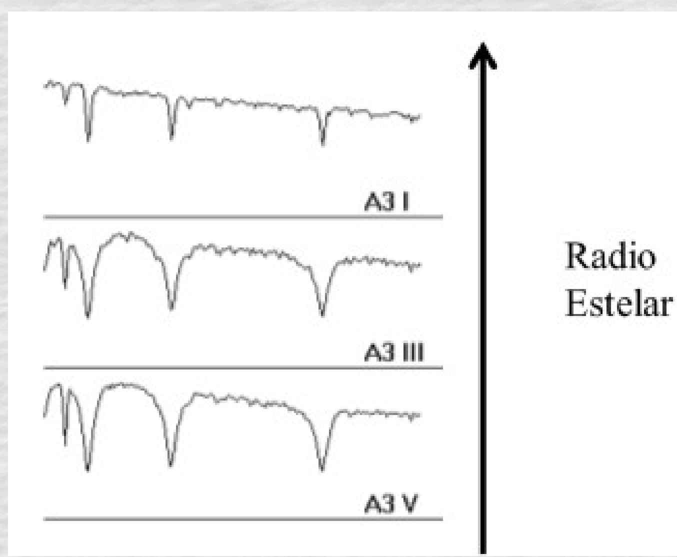
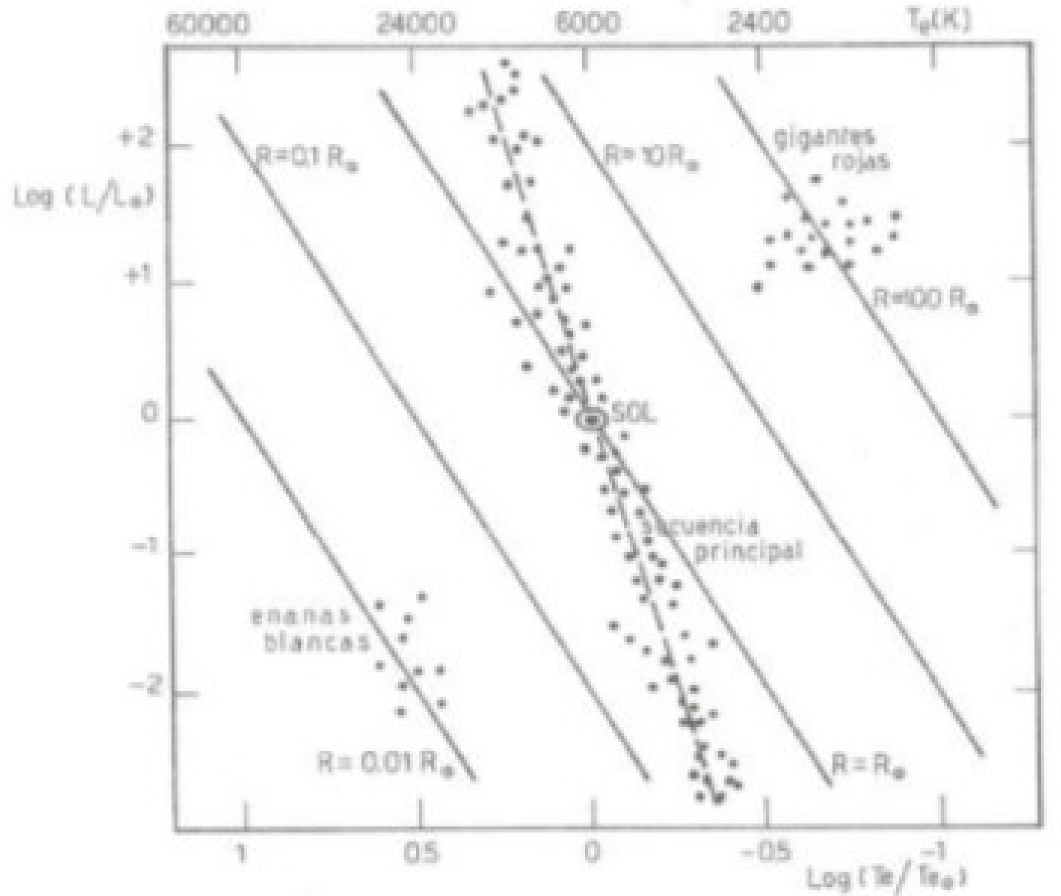





$$\text{Log } L/L_{sol} = 2 \text{ Log } R/R_{sol} - 4 \text{ Log } Teff/Teff_{sol}$$

- $L = 4\pi\sigma R^2 T_{eff}^{\ 4}$
- $L_{sol} = 4\pi\sigma R_{sol}^{\ 2} T_{eff\text{-}sol}^{\ 4}$

Astrophys. monographs, Univ. Chicago Press (1943)

# AN ATLAS OF STELLAR SPECTRA

## WITH AN OUTLINE OF SPECTRAL CLASSIFICATION

Morgan * Keenan * Kellman

https://ned.ipac.caltech.edu/level5/ASS_Atlas/frames.html

Astrophys. monographs, Univ. Chicago Press (1943)

# AN ATLAS OF STELLAR SPECTRA

## WITH AN OUTLINE OF SPECTRAL CLASSIFICATION

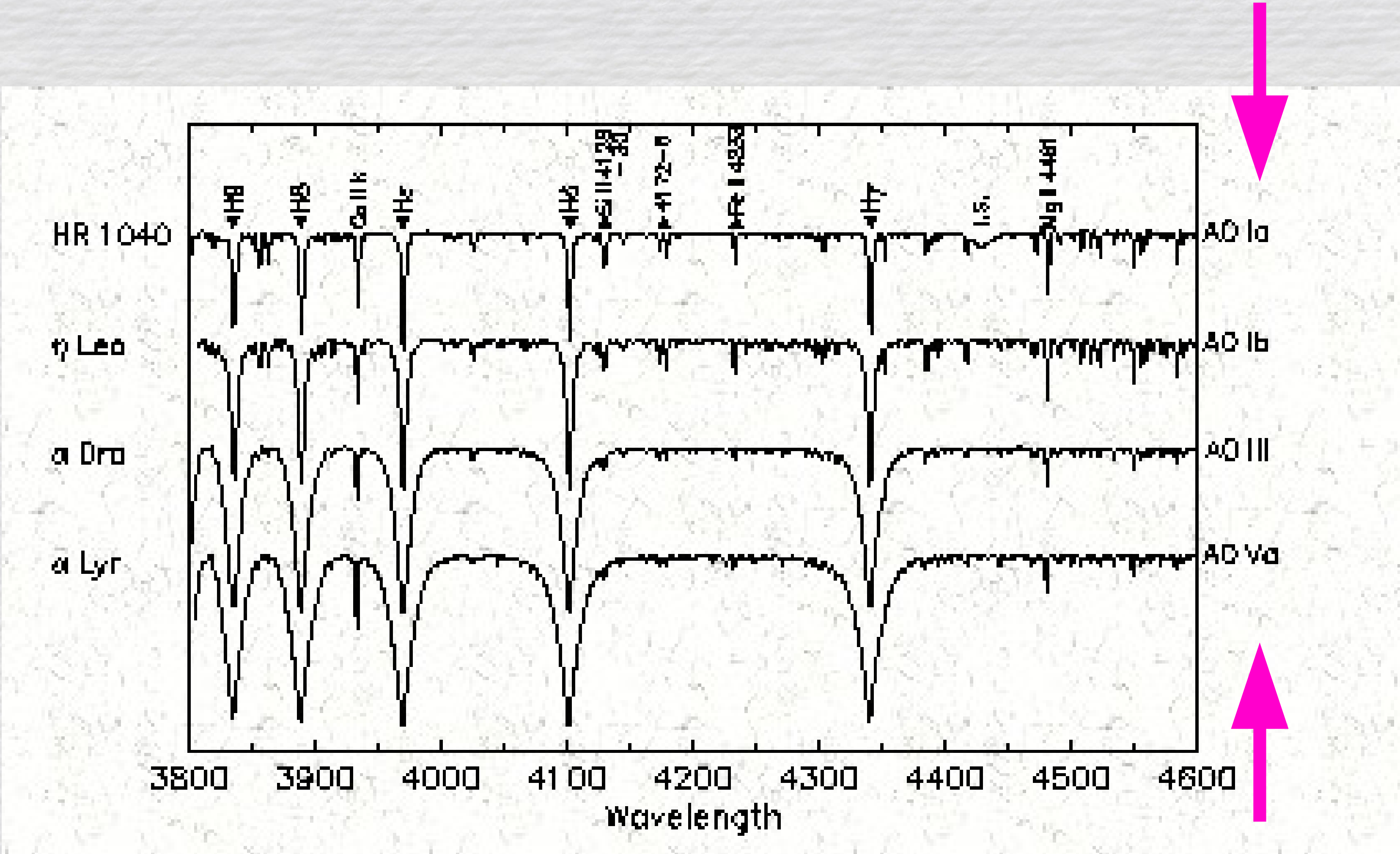
**Morgan * Keenan * Kellman**

La clasificación de Harvard toma en cuenta la temperatura, pero para tener una mejor clasificación debemos tomar en cuenta la **luminosidad** de las estrellas.

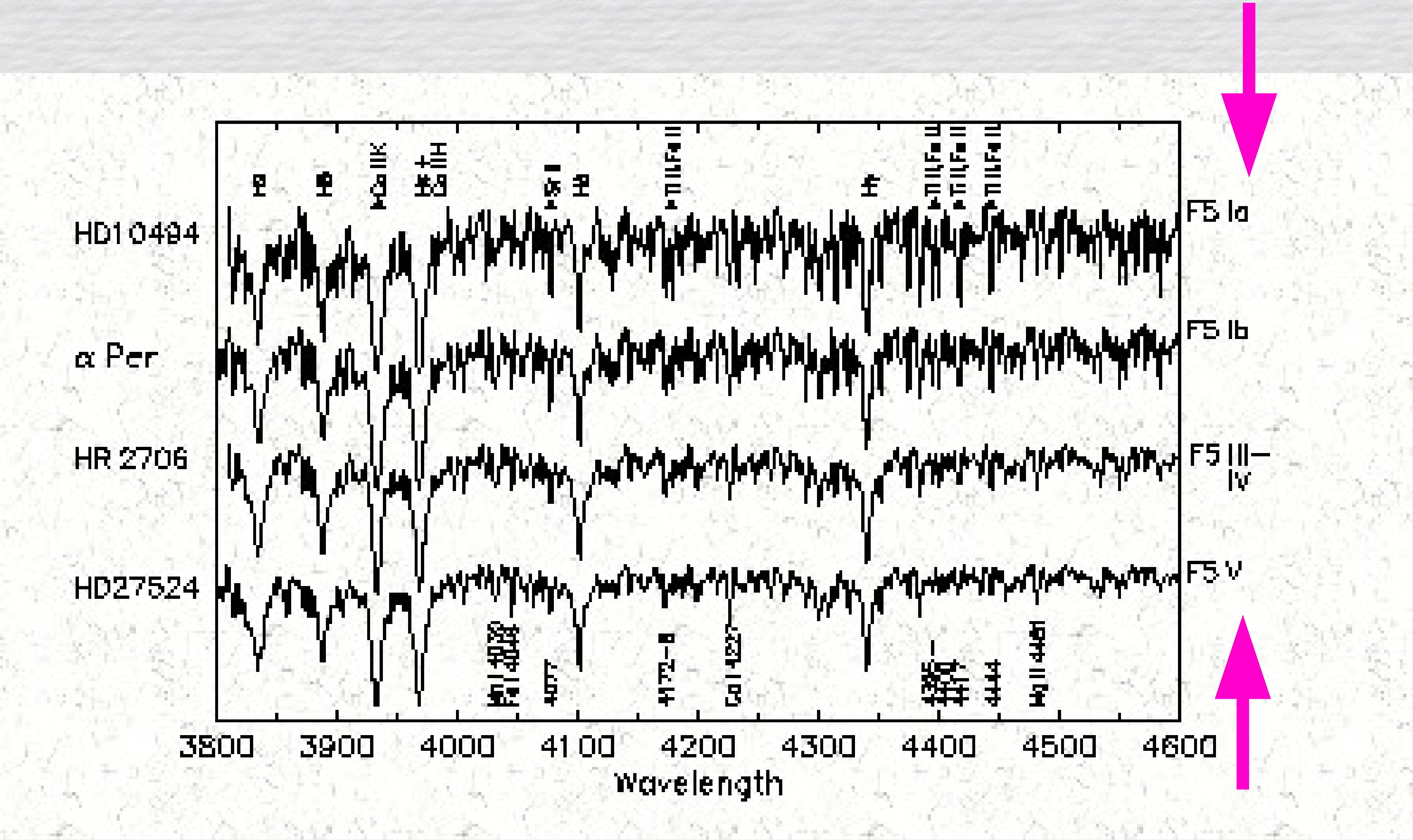
La clasificación bidimensional (T,L) fue propuesto por W. W. Morgan, P.C. Keenan y E. Kellman del observatorio de Yerkes (se le conoce como sistema MKK o clasificación de Yerkes).

La versión modificada posterior de este sistema se conoce como MK.

# Luminosity effects at A0



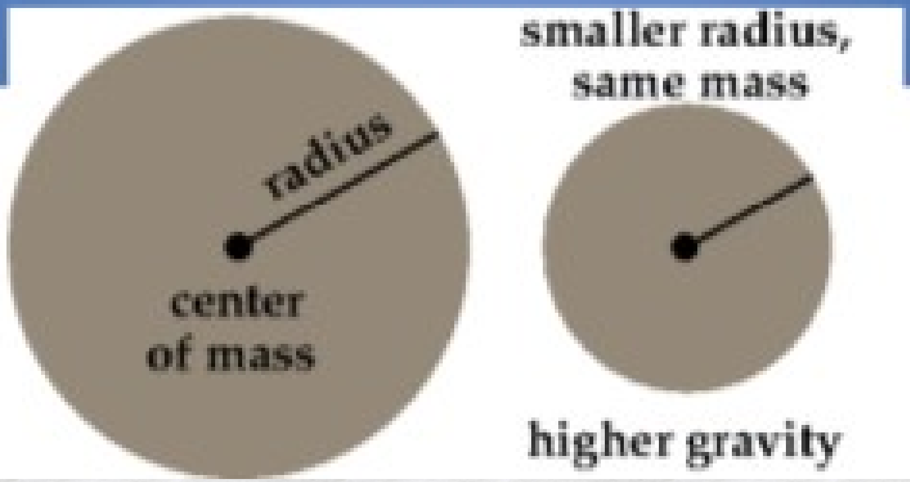
# Luminosity effects at F5



La clase de luminosidad se define a partir de líneas espectrales que dependen fuertemente de la gravedad superficial estelar, que está fuertemente relacionada con la luminosidad.

La aceleración gravitacional de estrellas de la misma masa, es mayor en una estrella enana que en una gigante:

$$g = GM/R^2$$



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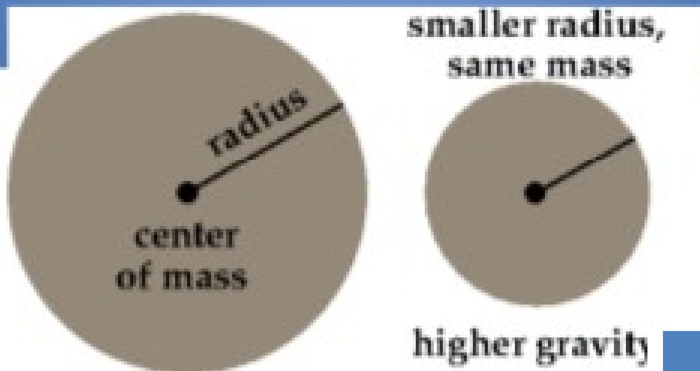
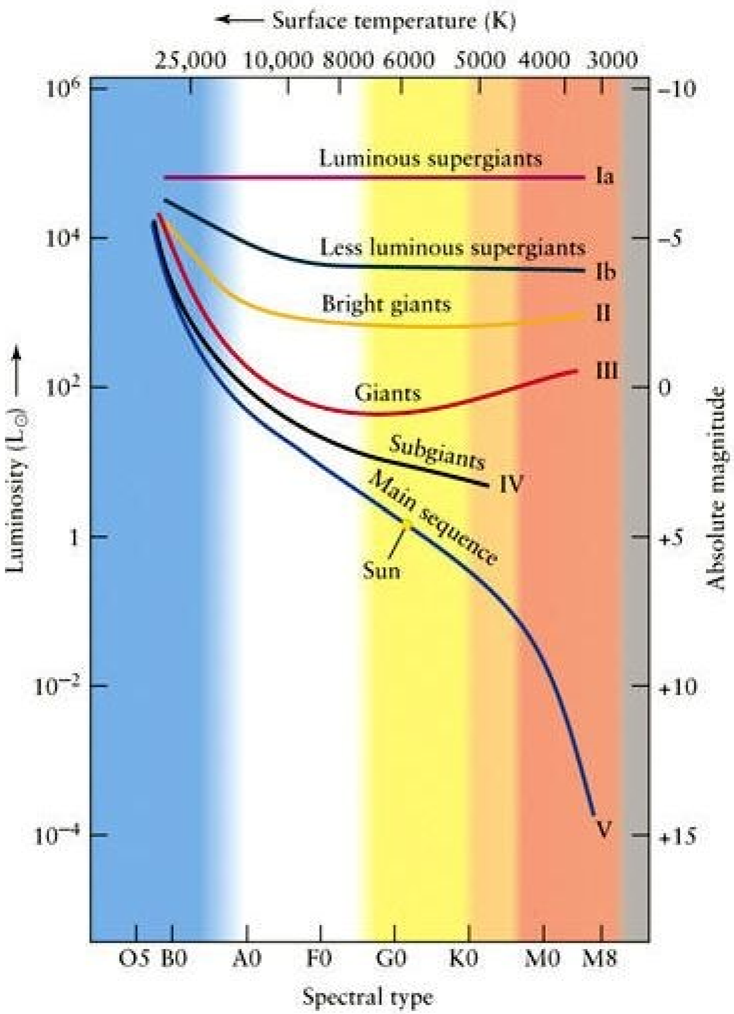



| Tipo | Clase de Luminosidad | Log g |
|---|---|---|
| Enanas | V | 4.5 |
| Sub-gigantes | IV | 3 |
| Gigantes Normales | III | 1.5 |
| Gigantes Brillantes o Luminosas | II | 0.5 |
| Super-Gigantes | I | -0.5 |

**TABLE 8.3** Morgan–Keenan Luminosity Classes.

| Class | Type of Star |
|---|---|
| Ia-O | Extreme, luminous supergiants |
| Ia | Luminous supergiants |
| Ib | Less luminous supergiants |
| II | Bright giants |
| III | Normal giants |
| IV | Subgiants |
| V | Main-sequence (dwarf) stars |
| VI, sd | Subdwarfs |
| D | White dwarfs |



Morgan–Keenan Luminosity Classes.

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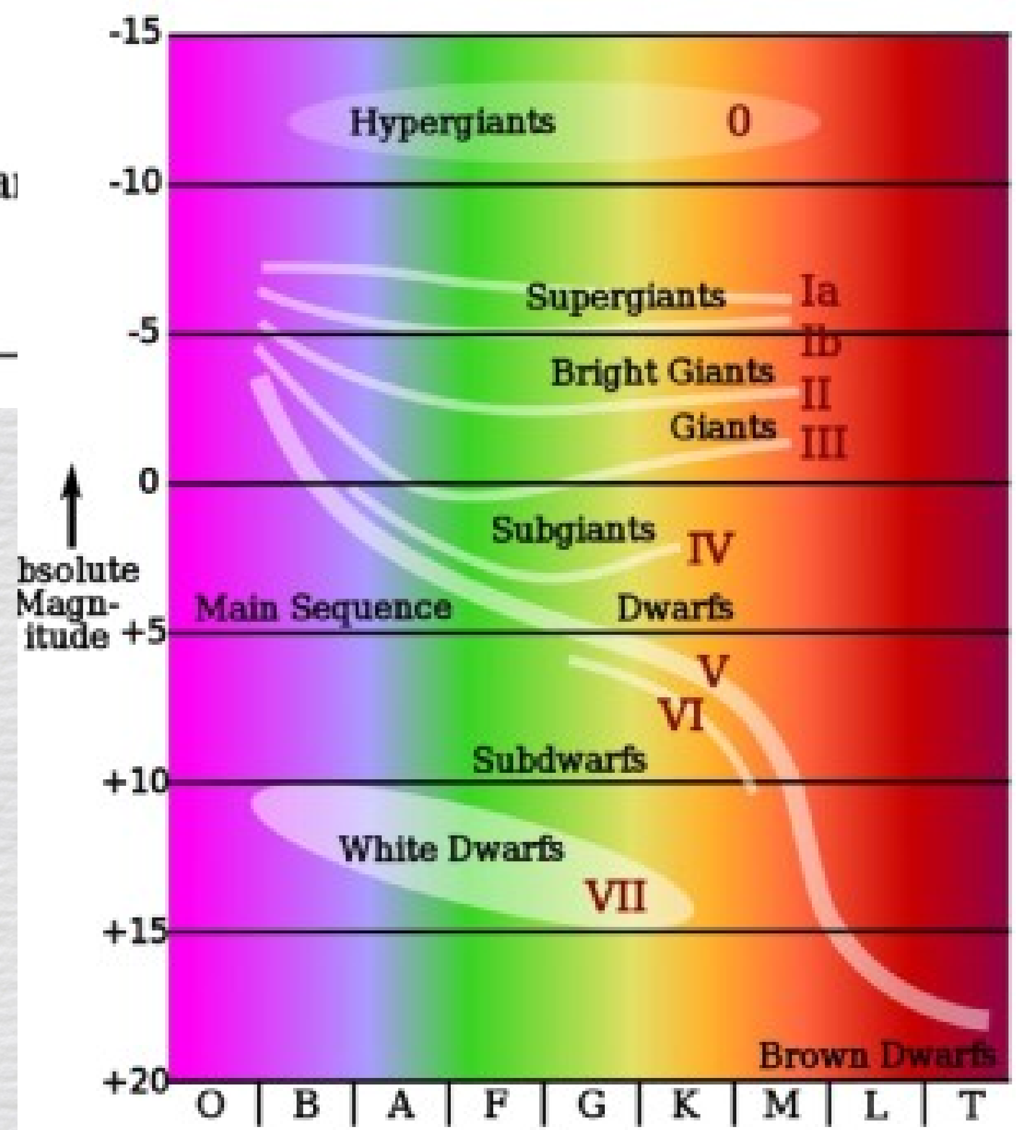
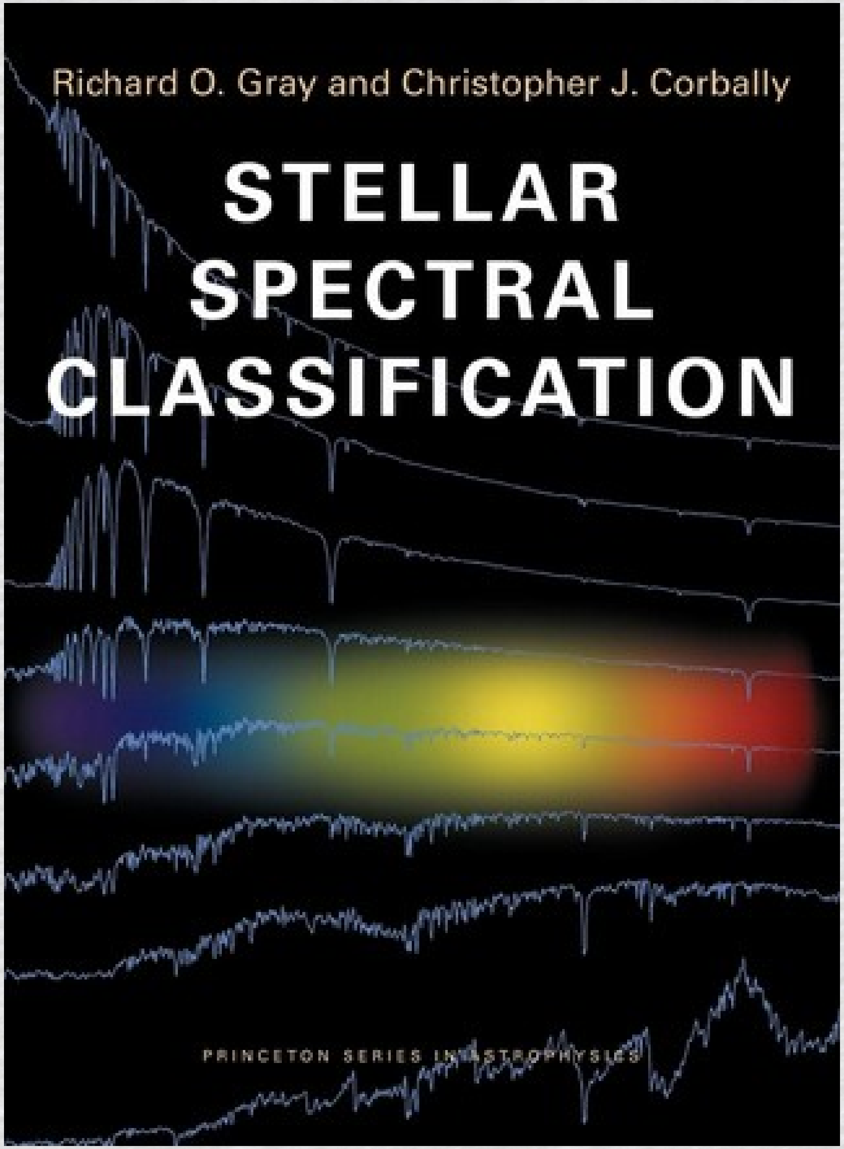


https://ned.ipac.caltech.edu/level5/Gray/frames.html



# The Sun is a Mass of Incandescent Cats.


www.womenyoushouldknow.net/category/women-in-science/