



# DARA Basic Training

NAMIBIA-BOTSWANA 2019

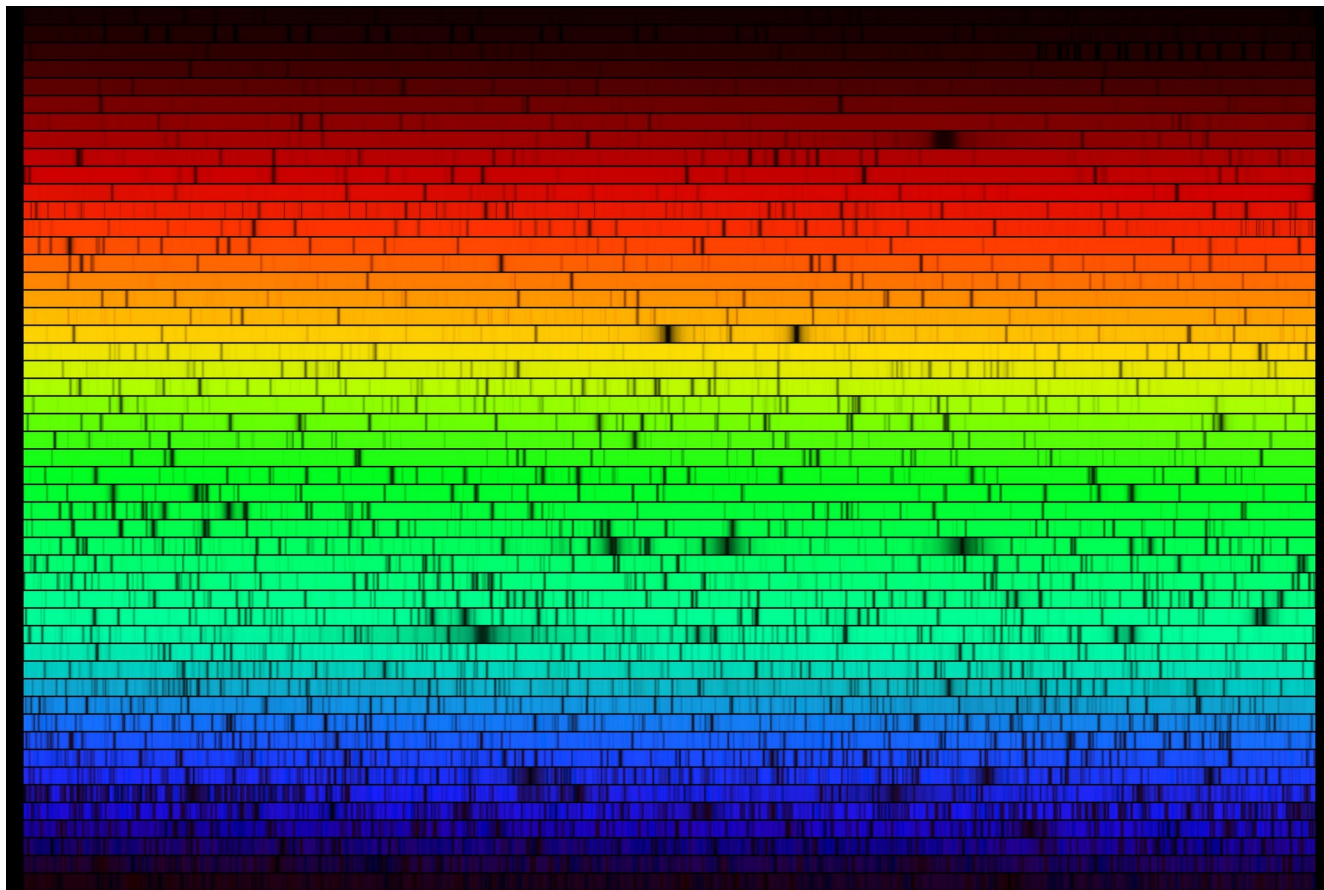
UNIT 1: INTRODUCTION TO ASTROPHYSICS

Windhoek, 7 –18 January 2019

# Stellar Spectra

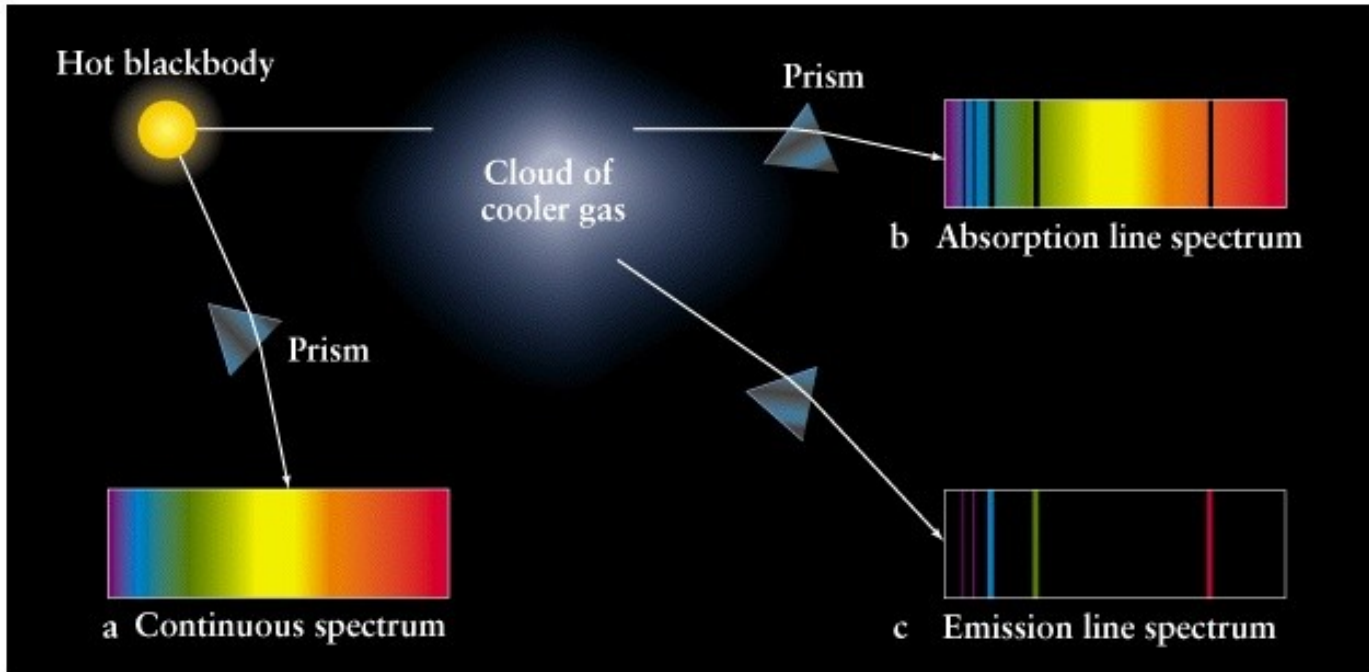
- Absorption lines
  - cause
  - strength
- Temperature dependence
- Classification of stellar spectra
  - Temperature
  - Luminosity

# The Solar Spectrum



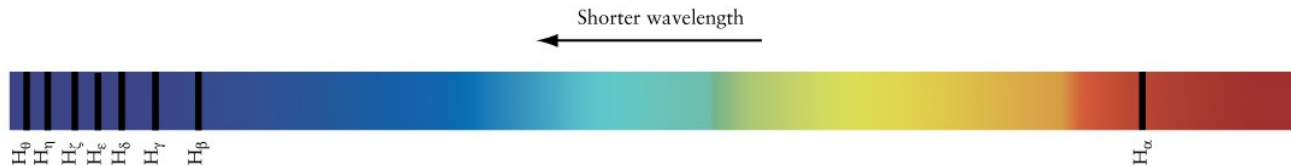
# Absorption Lines

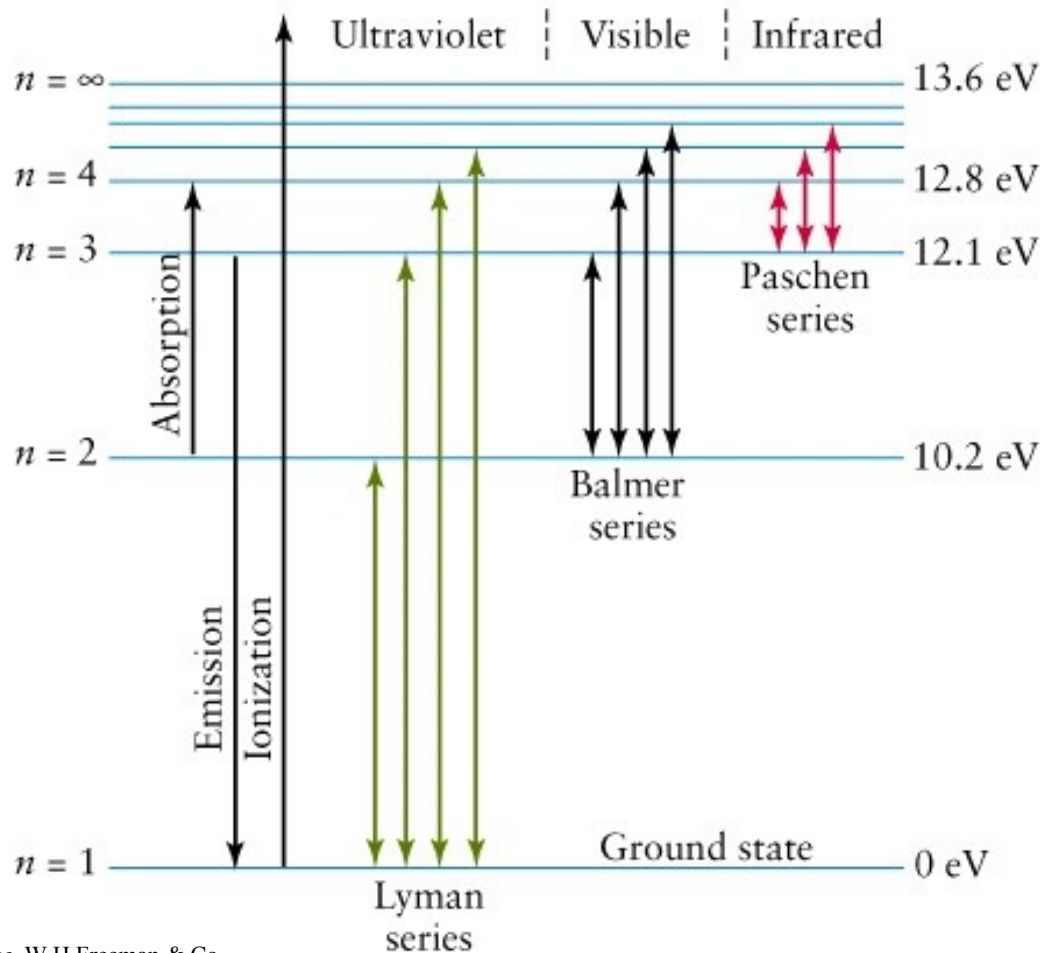
- Absorption lines arise when we view a hot source of continuum radiation through a cooler layer of gas
- Because the temperature drops with height in the atmospheres of stars we view cooler gas against a hotter background



# Stellar Spectra

- Spectra of stars consist of a vast number of absorption lines from different species
- One of the most recognizable is the Balmer series due to atomic hydrogen (H I)
- This series arises from transitions from the  $n=2$  level in H I





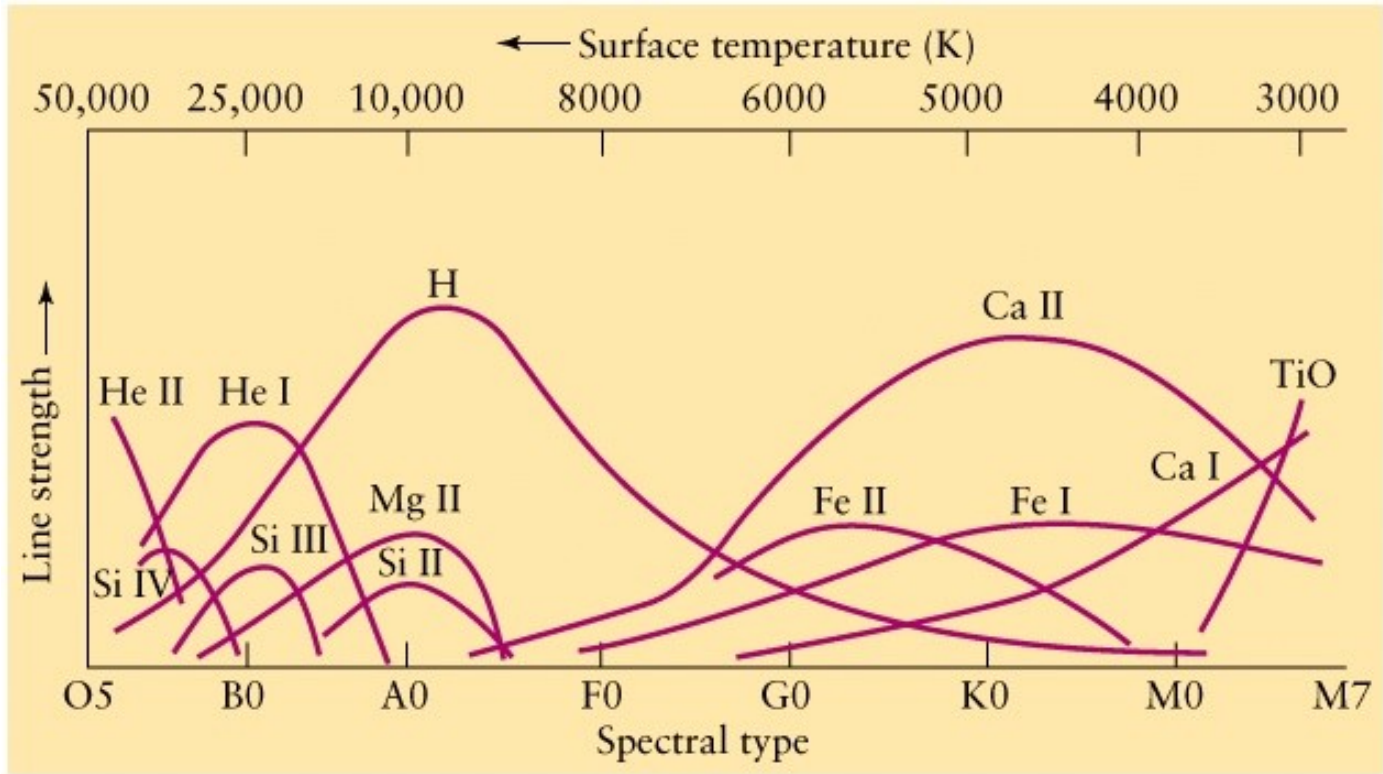
# Absorption Line Strength

- Strength of an absorption line depends on:
  - strength of the particular transition (absorption cross-section), i.e. depends on atomic physics
  - number of particles in the lower state of the transition, i.e. depends on abundance, temperature and density

# Temperature dependence

- the distribution of populations among the energy levels within an atom or ion depends on the temperature
- higher temperatures populate higher levels - excitation
- higher temperatures can also ionize a species, e.g.  $\text{He}^0 \rightarrow \text{He}^+$  or  $\text{He I} \rightarrow \text{He II}$  - ionization

- an absorption line for a species will have a maximum strength at a particular temperature
- at lower temperatures most of the species will be in the ground state
- at higher temperatures most species will become ionized to the next ionization stage



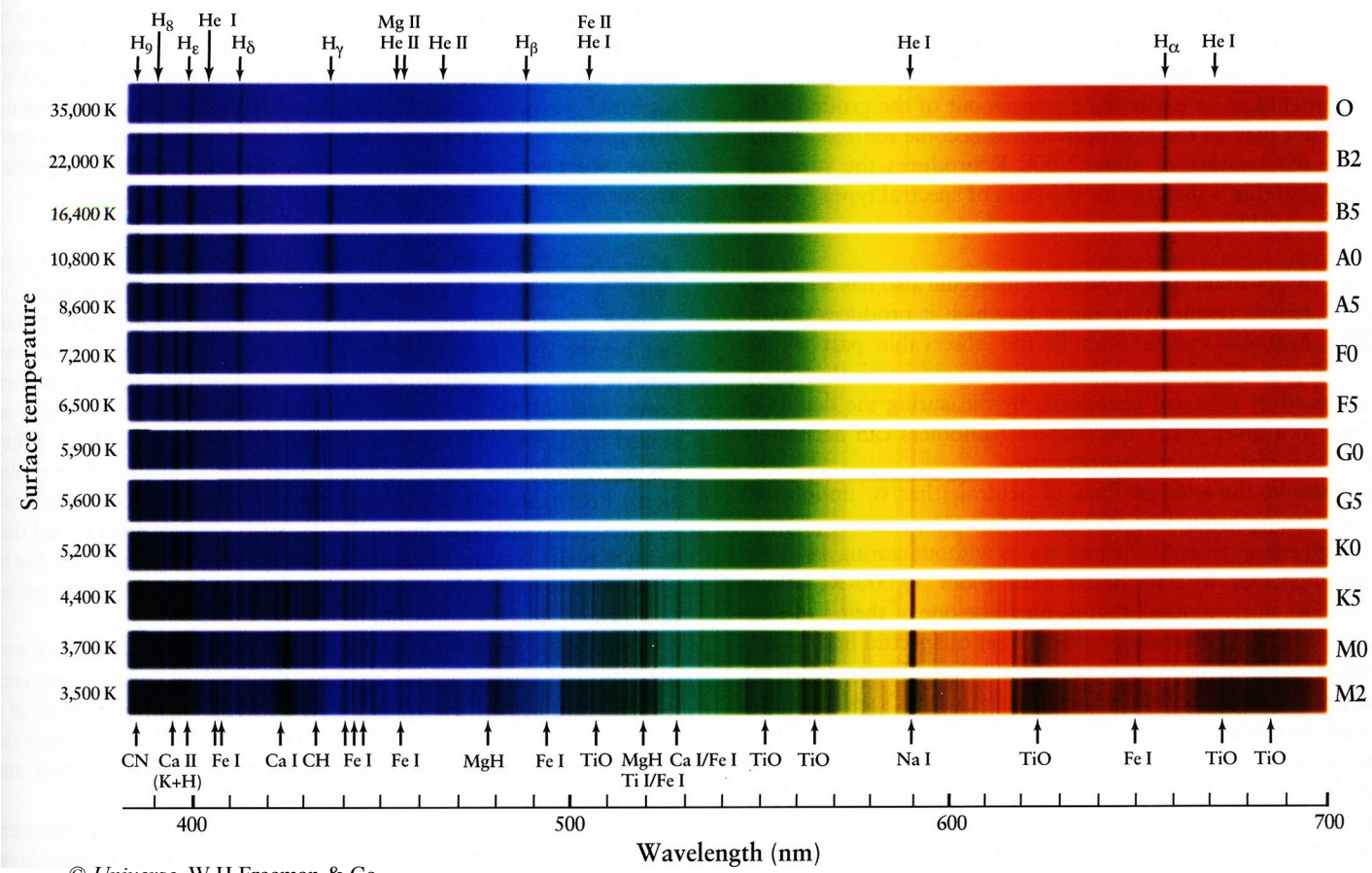
# Spectral Classification

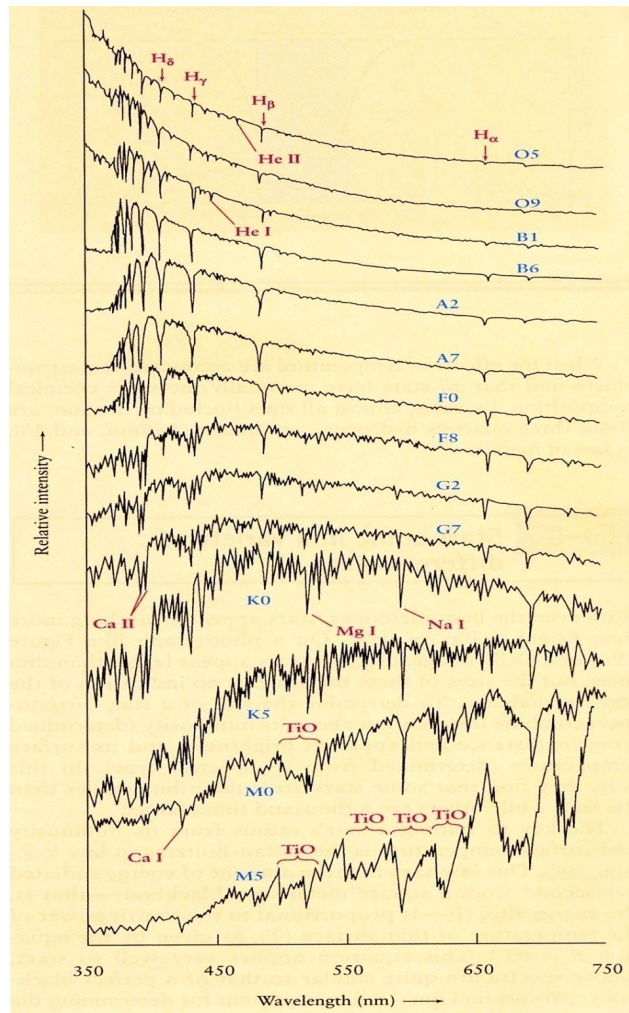
- stellar spectra can be classified into a temperature sequence
- spectral type is denoted by the sequence of letters:

O B A F G K M

early type

late type





- each spectral class is subdivided into 10 subclasses denoted 0→9
- Sun has spectral type G2
- Balmer lines strongest at A0
- A0 stars have  $T_{\text{eff}}=10\,000\text{ K}$ , e.g. Vega

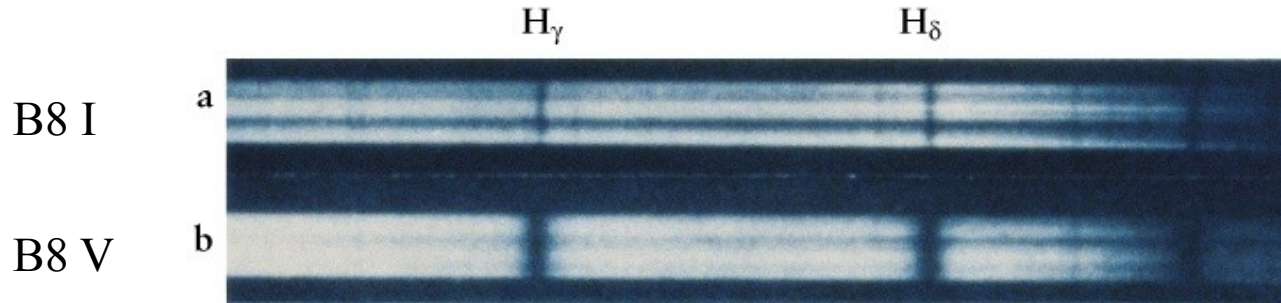
# Luminosity Classification

- More luminous stars with the same temperature must be larger
- if also of similar mass then average density must be lower
- lower density means the width of spectral lines are narrower due to less collisions between atoms
- line widths used for luminosity classification

- Roman numerals used for luminosity classes

I	II	III	IV	V	VI
super- giants	bright giants	giants	sub- giants	MS (dwarfs)	sub- dwarfs

- Sun is a G2 V star



# Summary

- absorption lines in stellar spectra can be used to classify stars
- spectral type is primarily a measure of the effective temperature of the star
- linewidths also indicate whether the star is a dwarf, giant or supergiant