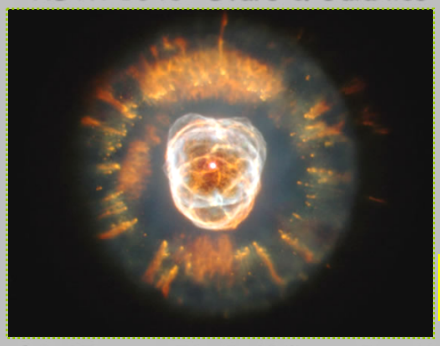
ASTR 1040: Stars & Galaxies



Eskimo Planetary Nebula

Prof. Juri Toomre TAs: Peri Johnson, Ryan Horton

Lecture 10 Thur 15 Feb 2018

zeus.colorado.edu/astr1040-toomre

Topics for Today & Tues

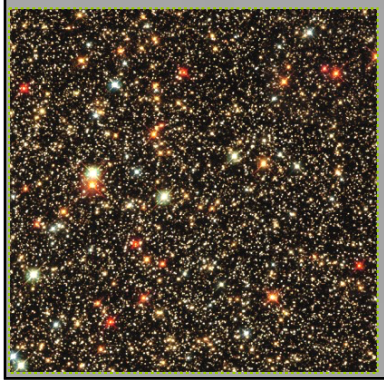
- What can we measure in other stars?
- How do we begin to classify other stars?
- Vital work by Annie Jump Cannon in devising a sensible "spectral sequence" for stars
- Why temperature and spectral lines are closely linked in classifying stars O B A…M

Logistics

- Read Chap 15.1: Properties of Stars with some care -- will need to work on HW #5
- First Mid-Term Exam in class today (11:20am) -- 50 minutes
- Homework #4 due today, new HW #5 out
- Please pickup earlier graded HWs, if not already

Northern Lights (Aurora Borealis)

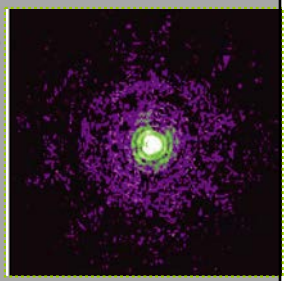
Chap 15 – SURVEYING THE STARS



- Measuring stellar luminosities
- Measuring distances
- Measuring temperatures

Often only seeing a point of light

- Stars are so small compared to their distance that we almost never have the resolution to see their sizes and details directly – "point sources"
- We deduce everything by measuring the amount of light (brightness) at different wavelengths (color, spectra)



So what can we find out about other stars?

APPARENT BRIGHTNESS

POSITION

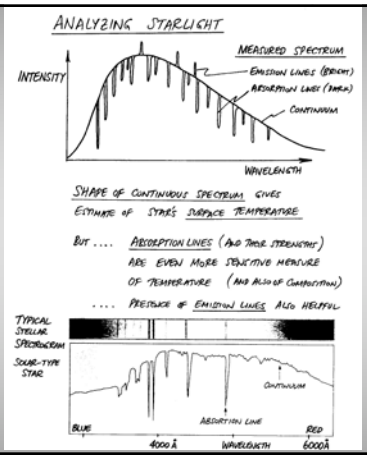
SPECTRUM

WHAT CAN WE MEASURE IN OTHER STARS?

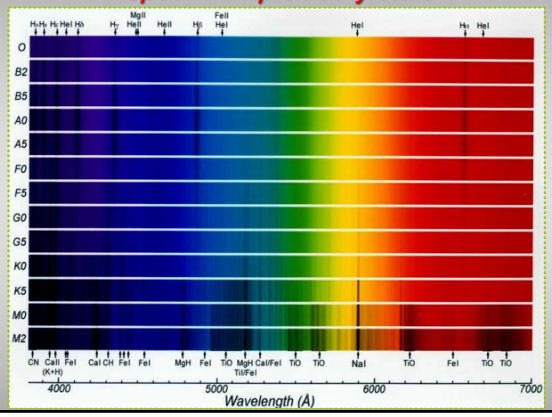
1. APPARENT BRIGHTNESS (OR INTENSITY)
   MEASURED IN FUNNY UNITS CALLED "MAGNITUDES"
   ⇒ LUMINOSITY, IF KNOW DISTANCE
   RECALL INVERSE SQUARE LAW ...
   BRIGHTNESS OF POINT SOURCE $\sim \frac{1}{(\text{DISTANCE})^2}$
2. POSITION (AND CHANGES OF IT WITH TIME)
   - PARALLAX ⇒ DISTANCE
   - PROPER MOTION
3. SPECTRUM (MEASURE ITS SHAPE & SPECTRAL LINES)
   ⇒ TEMPERATURE OF SURFACE
   ⇒ COMPOSITION (WHICH ELEMENTS CAN BE SEEN)
   VIA DOPPLER SHIFT OF LINES: RADIAL VELOCITY ROTATION
   VIA ZEEMAN SPLITTING OF LINES: MAGNETIC FIELDS

Measuring Surface TEMPERATURE

Shape of spectrum good ... but spectral lines much better



Spectra help classify stars



OBAFGKM ?!?

- Spectral (color) classification

O = bluest, hottest

G = yellow (Sun)

M = reddest, coolest

A bit of history: Classifying Stars

World War I, Harvard College observatory

Women were hired by Pickering as "calculators" to help with a new survey of the Milky Way

Most had studied astronomy, but were not allowed to work as scientists

Devising the strange temperature code

- Original classification of spectra (1890) was:

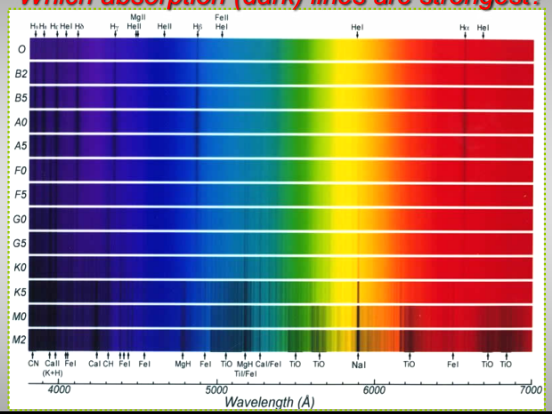
A = strongest hydrogen feature

B = less strong hydrogen ...C, D, etc.

- Annie Jump Cannon realized that a different sequence made more sense (~1910)

→ O B A F G K M !!

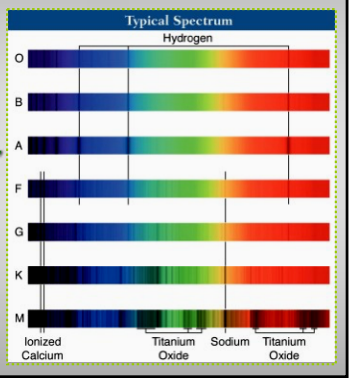
Which absorption (dark) lines are strongest?



Spectral Classification: O B A F G K M

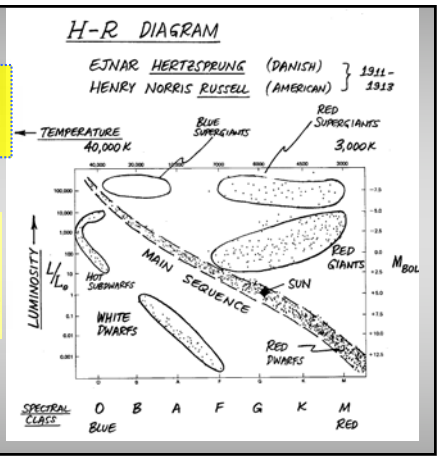
Which ABSORPTION lines are strongest

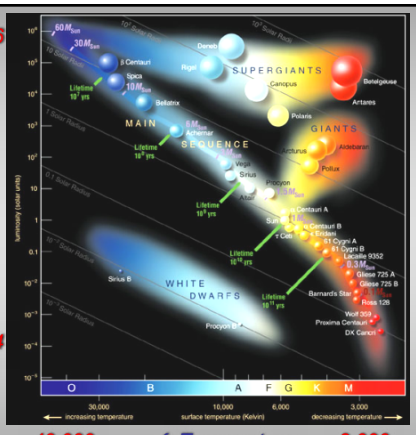
- *Hottest stars: O B* — *ionized helium only*
- *Hot stars: A F* — *helium, hydrogen*
- *Cooler stars: G* — *hydrogen, heavier atoms*
- *Coolest stars: M* — *molecules, (complex absorption bands)*



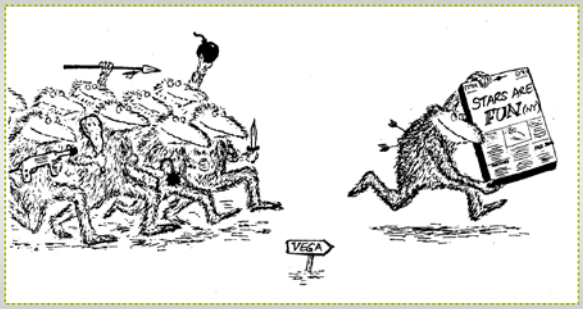
Hertzsprung-Russell (H-R) Diagram

Luminosity (magnitude) vs Spectral class (temperature)





First Mid-Term Exam



Rules of the Game

- Closed book, closed notes, can use double-sided handwritten "crib sheet"; 50 minutes
- *Print your name and student ID on top of pages 1 and 6 of exam sheets*
- *Print and encode your name and student ID on scan sheet (and nothing else)*
- Use # 2 (soft) pencil for marking your answers on scan sheet ($ 1 buys you a pencil !)
- *Respond carefully to Essay Question 46, with full and lucid sentences (even a sketch or two)*