ASTR 4201/5201: STELLAR ASTROPHYSICS AND RADIATION

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GRADING SCHEME

ASTR 4201

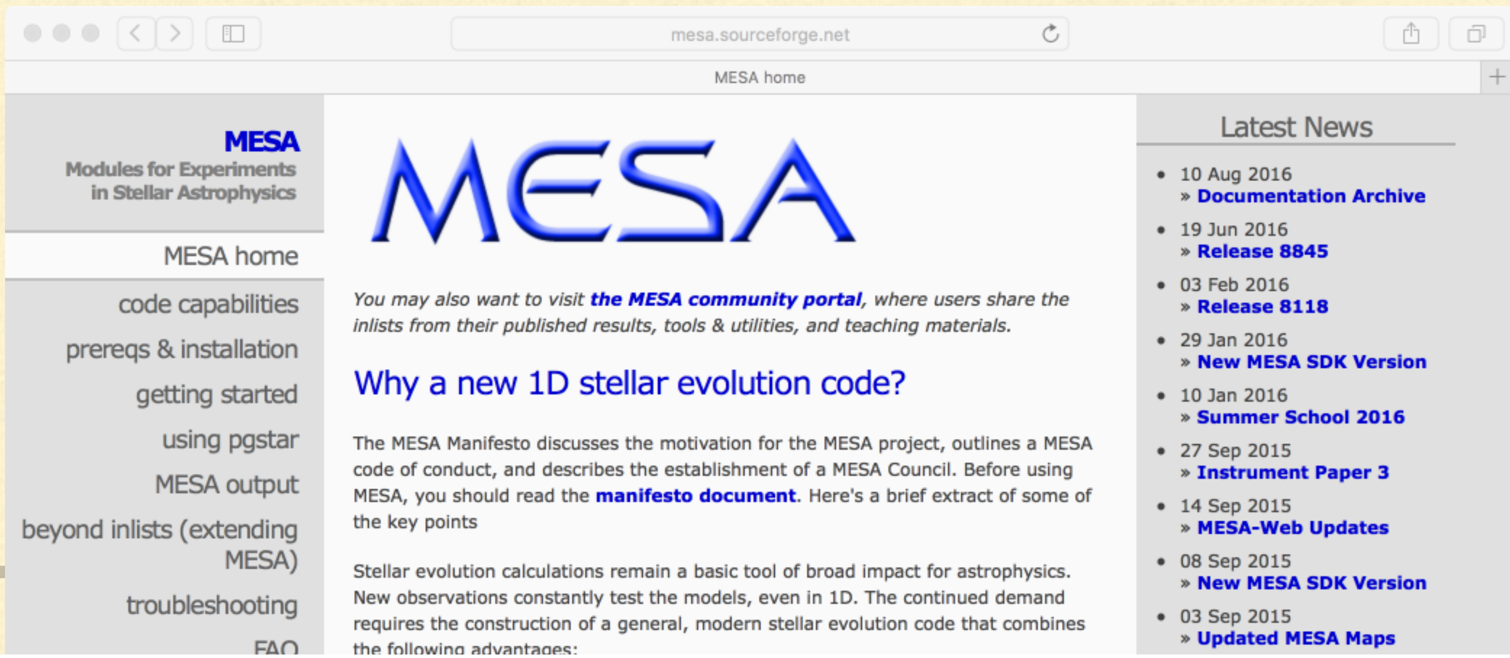
- 50% HW
- 20% Midterm
- 30% Final

ASTR 5201

- 45% HW
- 20% Midterm
- 25% Final
- 10% Project

ASTR 5201 PROJECT

- http://mesa.sourceforge.net
- Grad students will be using the MESA code and will have a project due at the end of the semester with a presentation the final week.
- Details later, but note that this requires access to a Mac or Linux computer.



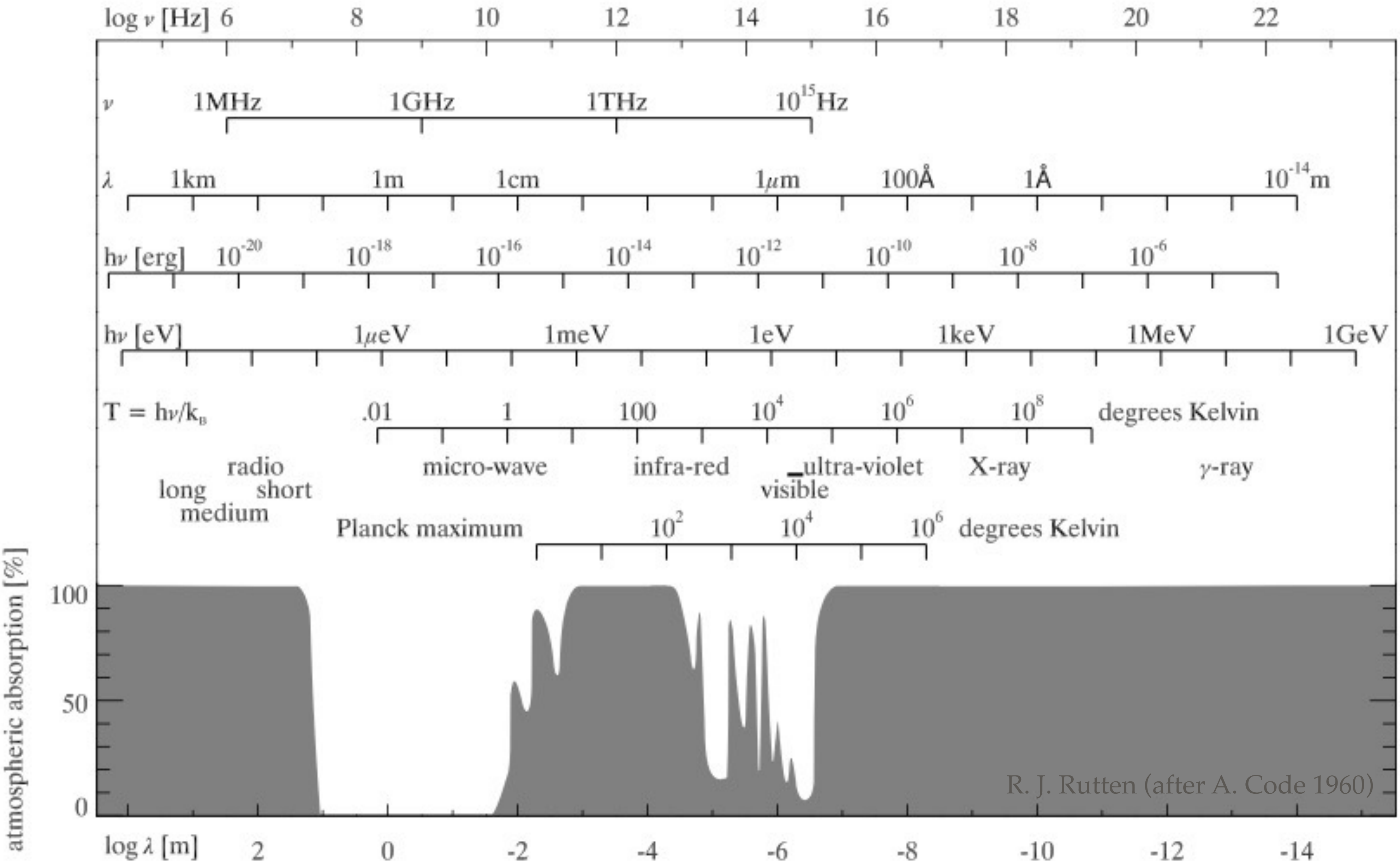
WHAT WILL WE COVER?

Course Description: Introduction to radiative transfer, including radiation mechanisms, and formation of spectral lines; discusses the physics of the cold interstellar medium and its relationship to star formation; and provides an overview of stellar evolution and stellar remnants, including white dwarfs, supernovae, and neutron stars.

- Radiative transfer and mechanisms
- Stellar structure
- Stellar evolution

UNITS

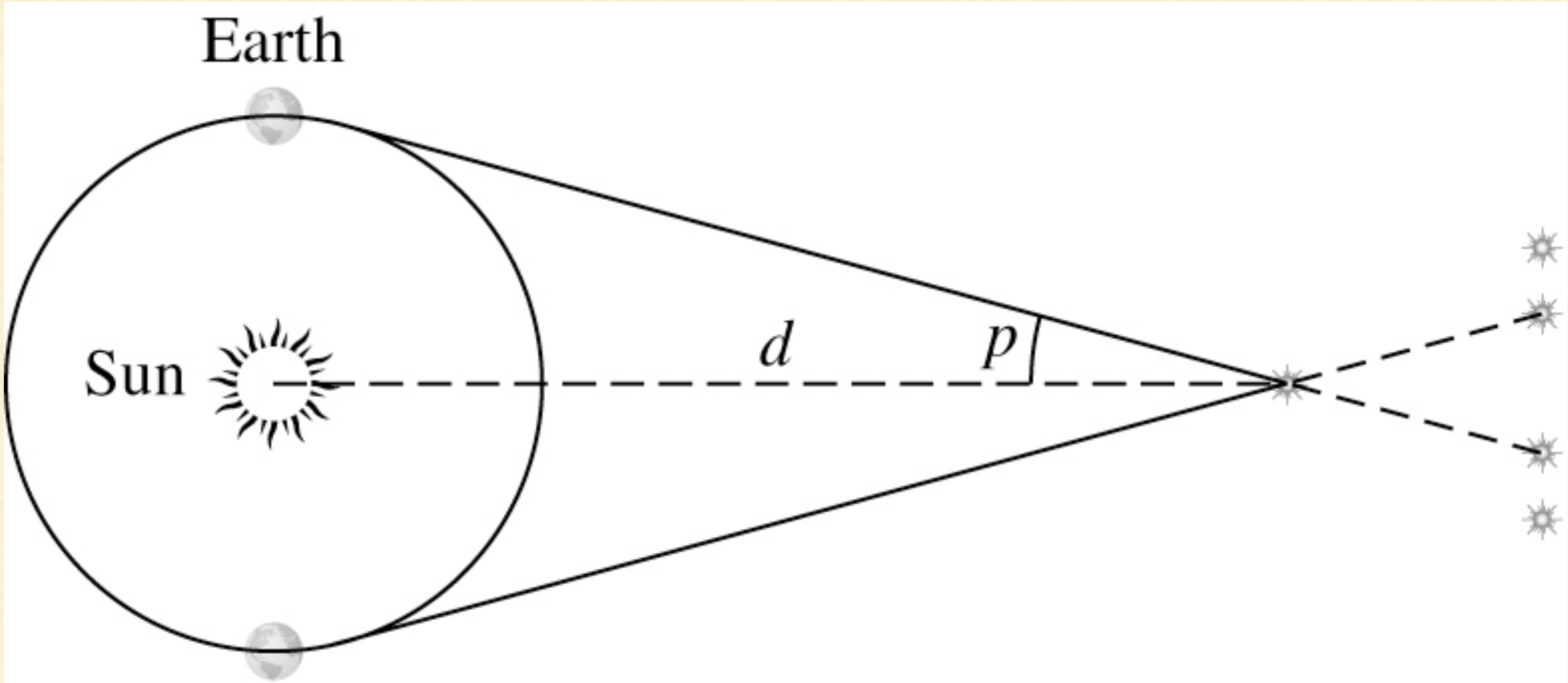
- Astronomers frequently use cgs (e.g., 10^7 erg = 1 J)
  - Note: Carroll & Ostlie use SI (so I will try to standardize on that), but RL and HKT use cgs
- $1\ M_\odot = 1.99 \times 10^{33}$ g $= 1.99 \times 10^{30}$ kg
- $1\ L_\odot = 3.8 \times 10^{33}$ erg/s $= 3.8 \times 10^{26}$ W
- $1\ R_\odot = 6.96 \times 10^{10}$ cm $= 6.96 \times 10^{8}$ m
- $T_\odot = 5777$ K



For UV/optical wavelengths, we use 1 Å = 0.1 nm = 10^{-10} m (so middle of the visible range is ~5500 Å)

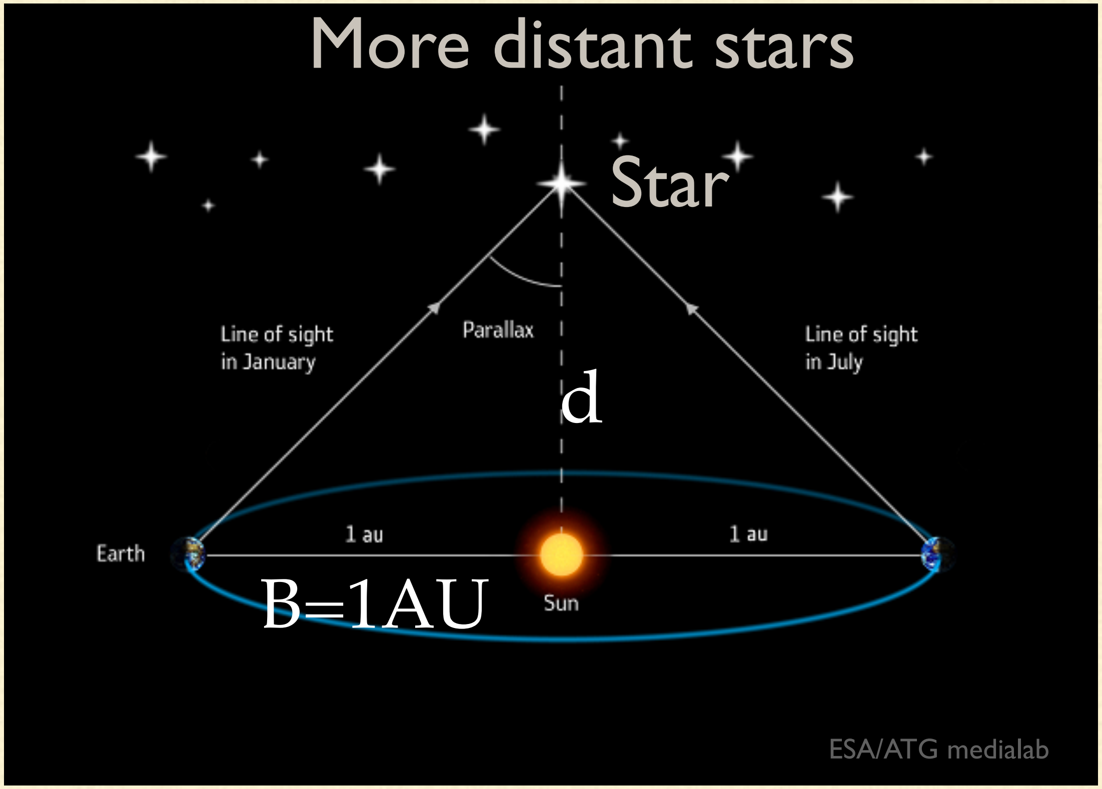
Note: k ~ 8.617×10^{-5} eV K^{-1} and thus where kT falls

PARALLAX



- The positions of nearby stars move relative to more distant stars due to the Earth's orbit around the Sun
- The largest measured parallax (for the nearest star) is 0.77 arc seconds = 0.0002°
- 1 circle = 360 degrees (°) 1 degree = 60 arcminutes (‘) 1 arcminute = 60 arcseconds (“)

TRIGONOMETRIC PARALLAX



$\tan(p) = B/d \approx p$ so $d = B/p$ $(B = 1\text{AU} = 1.5\times10^{11}$ m$)$

$$\boxed{d(\text{pc}) = 1/p('')}$$

parsec = *<u>par</u>*allax arc*<u>sec</u>*ond

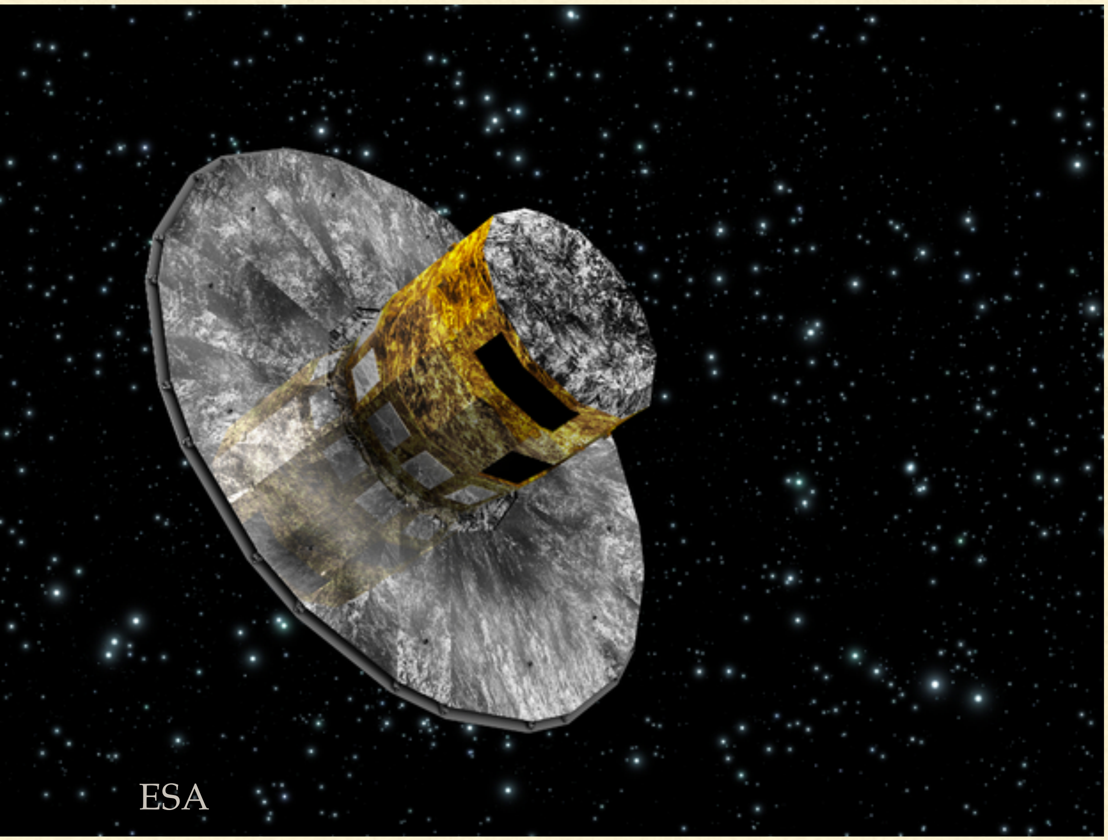
DISTANCES

- A standard unit of distance is the ***parsec***.
- 1 pc = 3.26 light-year = 3.09×10^{16} m
- Sun = 8 kpc from Galactic center;

  nearest galaxy (Sagittarius dwarf) is ~20 kpc;

  nearest big galaxy is M31=Andromeda galaxy at about 780 kpc from us

GAIA



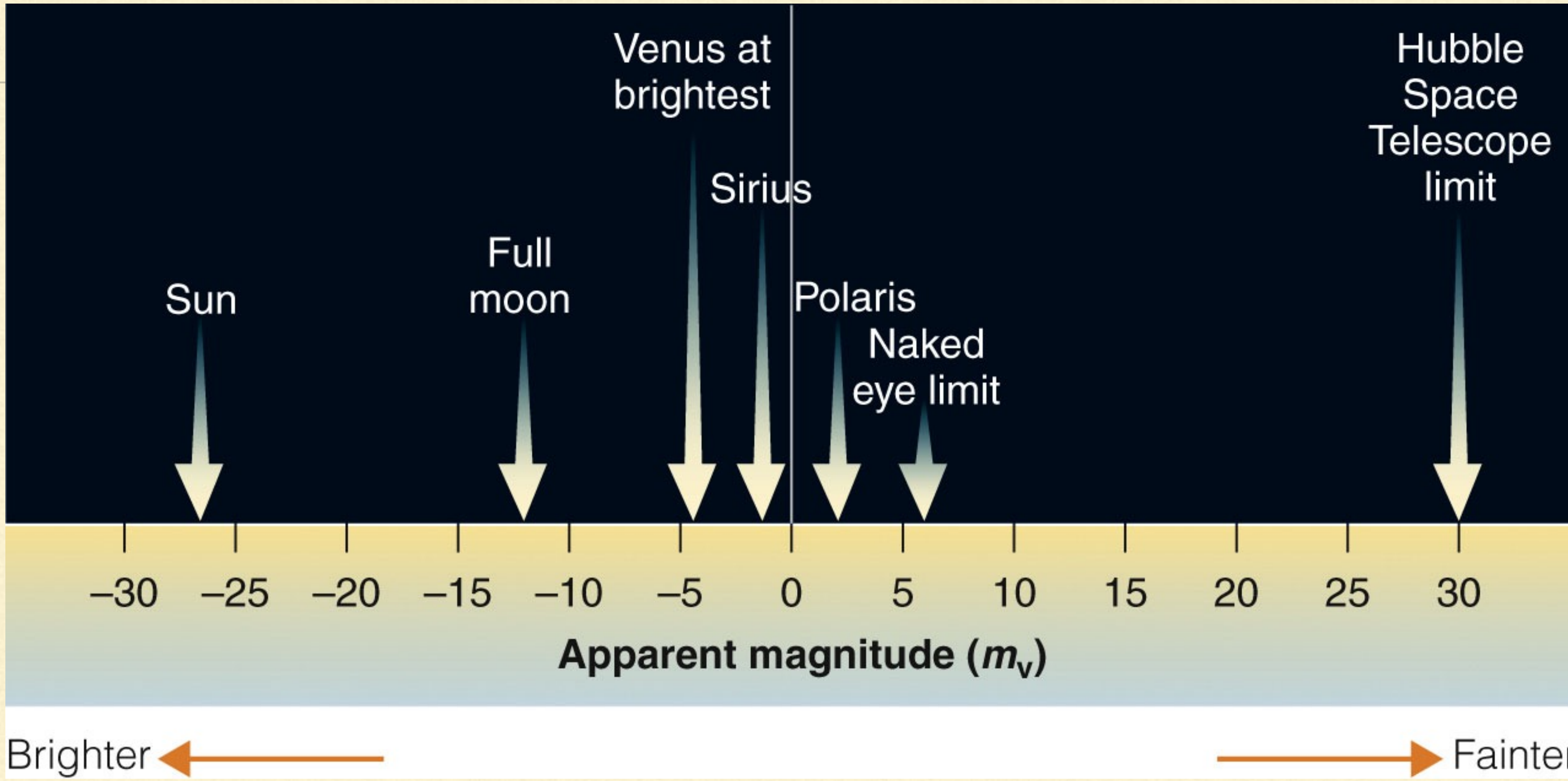
- Launched in 2013 for a 5 yr main mission
- First data release scheduled for September 14th!
- Will measure parallaxes to ~10^9 stars (~1% of the Galaxy)
- Precision of ~20 μarcsec.
- Previous standard was Hipparcos (10^5 stars with 1 milliarcsec precision)

LUMINOSITY AND FLUX

- Luminosity = Energy emitted per unit time (intrinsic quantity of source)
- Flux = Energy per unit time per unit area passing through our detector (i.e., inverse square law: $F=L/4\pi d^2$)
- Magnitudes: $-2.5\ \log_{10}(\text{flux}) + \text{constant}$

  A common choice of normalization is that m(Vega)=0

APPARENT MAGNITUDES



- Logarithmic: 2.5 mags = factor of 10 in flux, smaller numbers are brighter
- usually denoted by lowercase *m*
- Blame the ancient Greeks!

ABSOLUTE MAGNITUDES

- Absolute magnitude (uppercase M) is the apparent mag that a source would have at d=10 pc
- Distance modulus: $m - M = 5 \log_{10} (d/10pc)$
- Solar values: $M_{\odot,bol} = 4.74$ mag $M_{\odot,V} = 4.82$ mag
- Bolometric magnitudes are integrated over wavelength (total emitted flux)

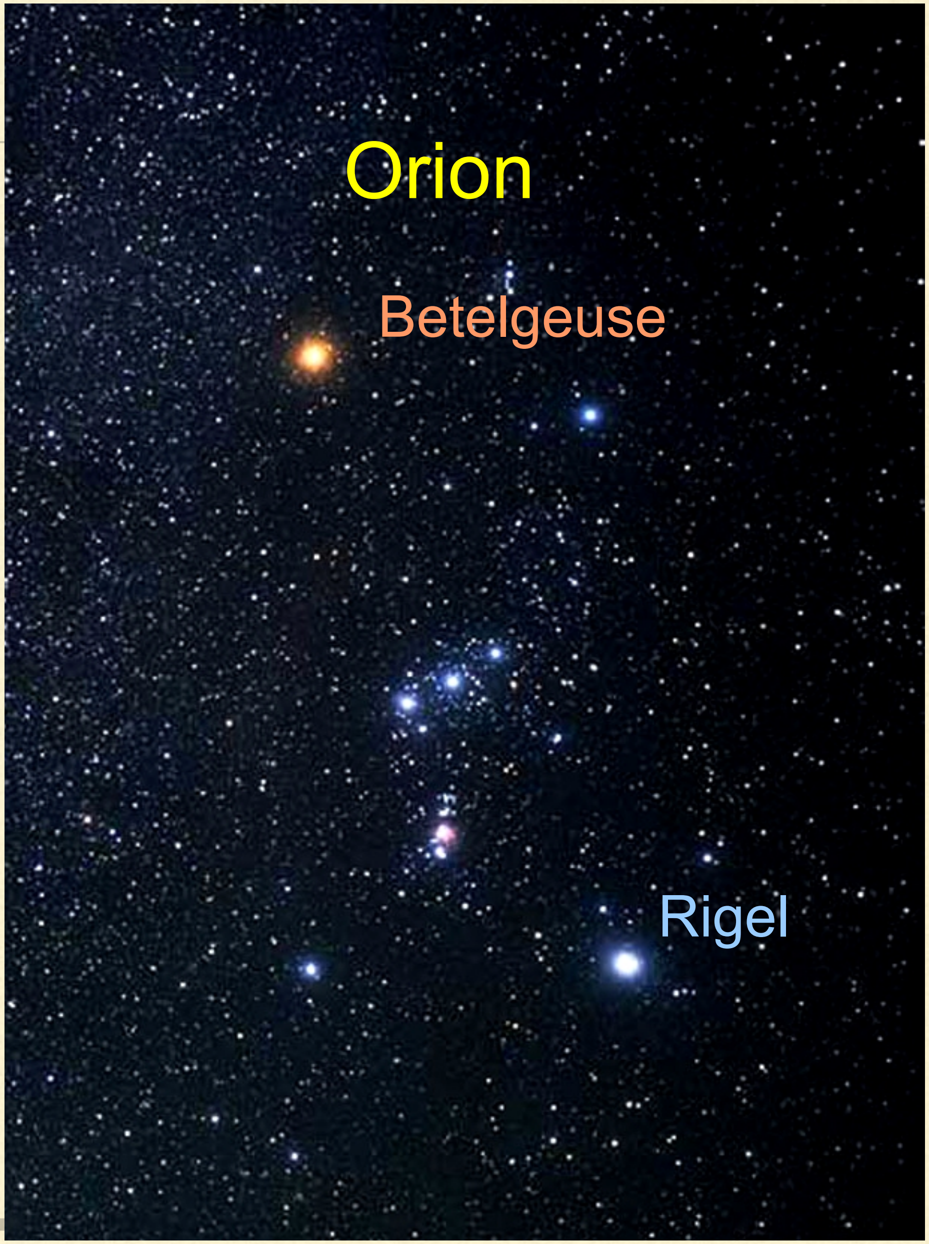
COLOR

Stars appear in different colors,

from blue (like Rigel)

via yellow

to red (like Betelgeuse).



COLOR AND TEMPERATURE

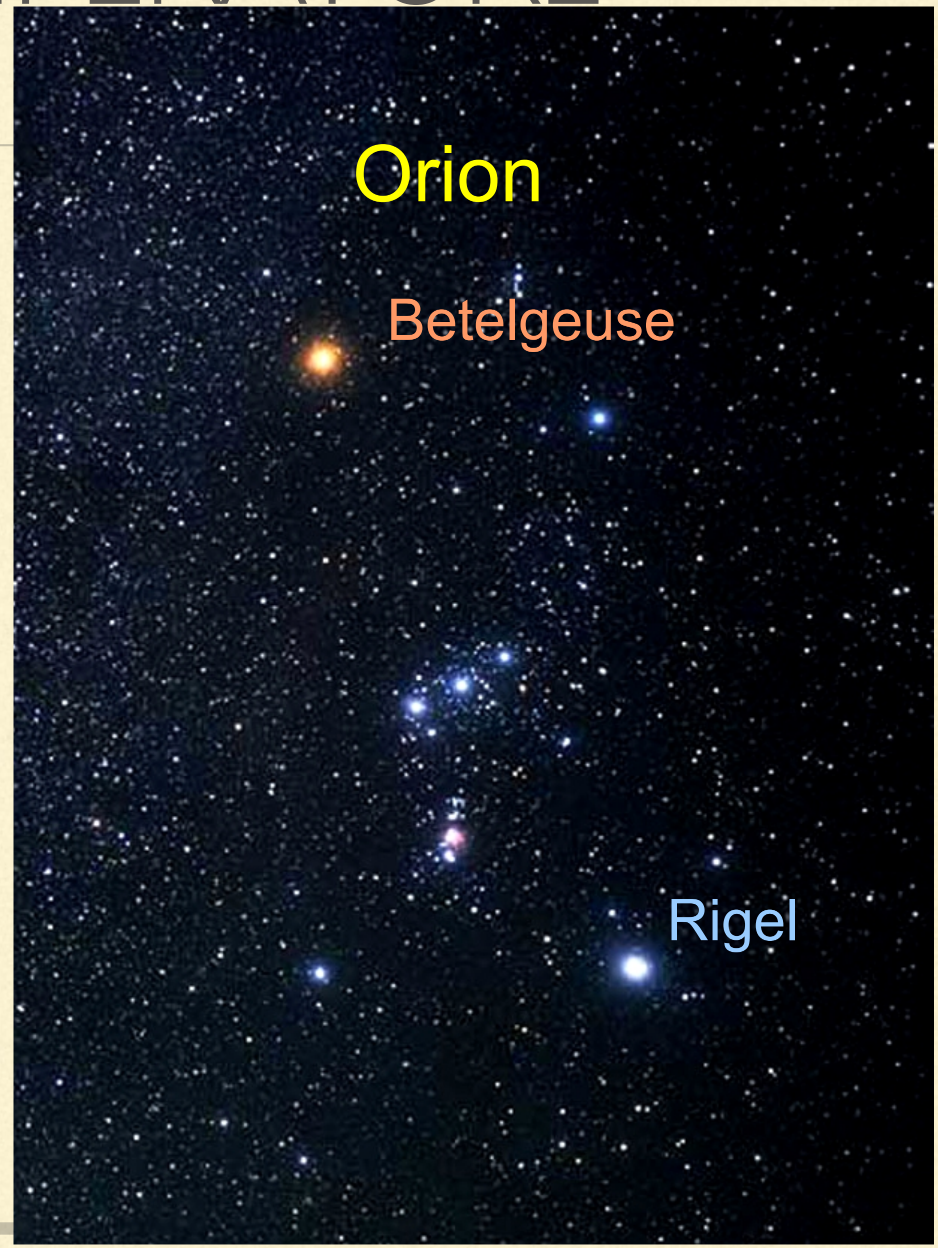
Stars appear in different colors,

from blue (like Rigel)

via yellow

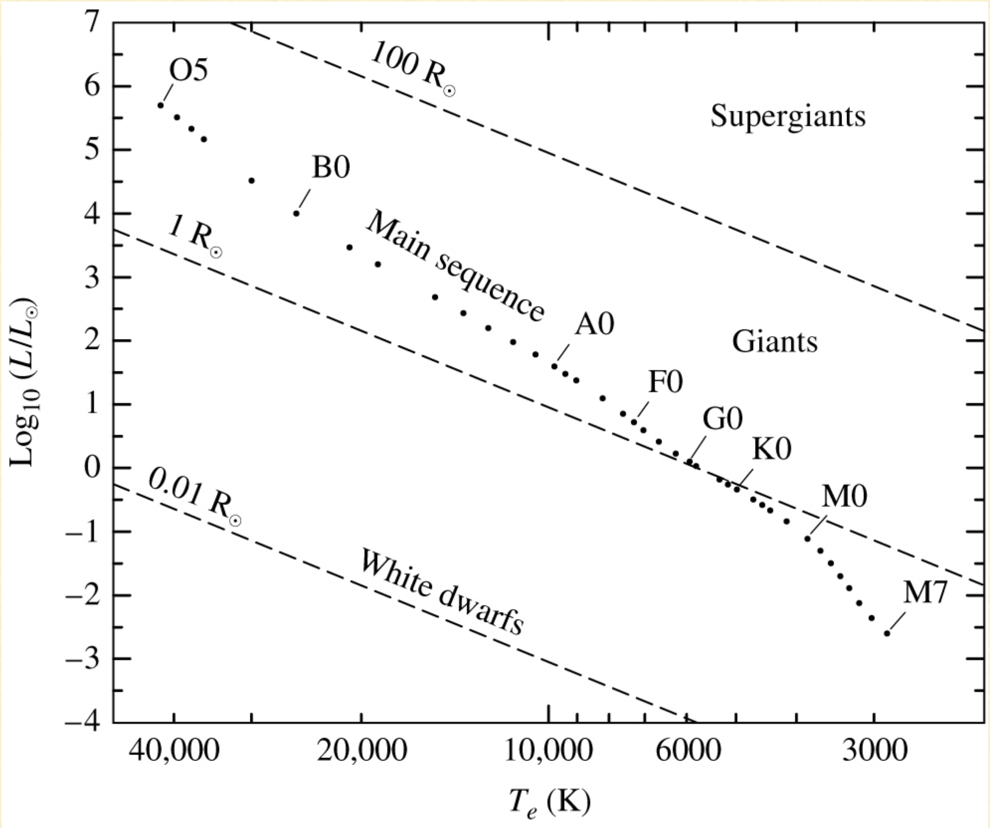
to red (like Betelgeuse).

These colors tell us about the star's temperature.



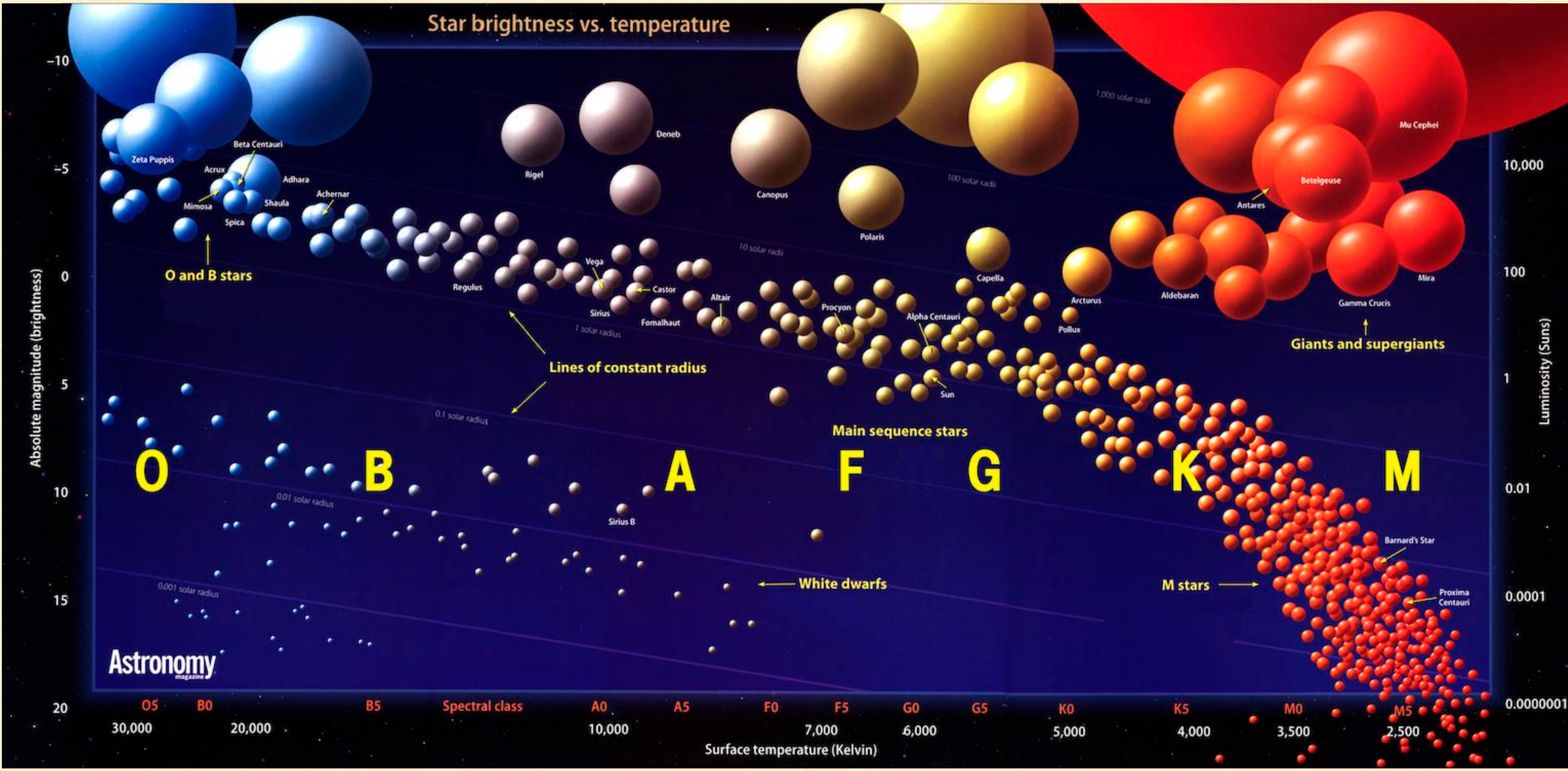
HERTZSPRUNG-RUSSELL DIAGRAM

Or: Magnitude



Or: Color

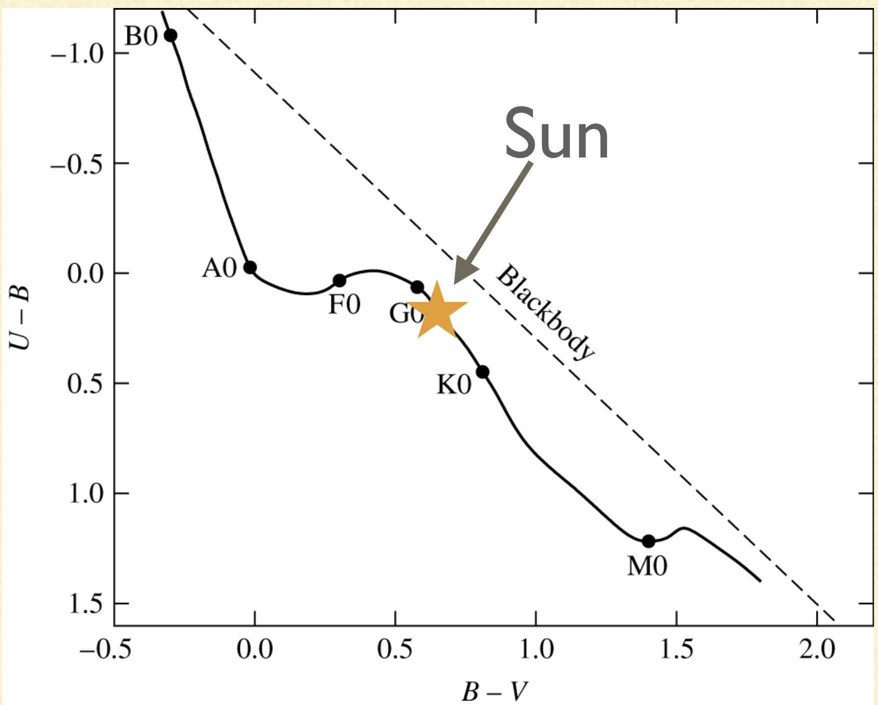
HERTZSPRUNG-RUSSELL DIAGRAM

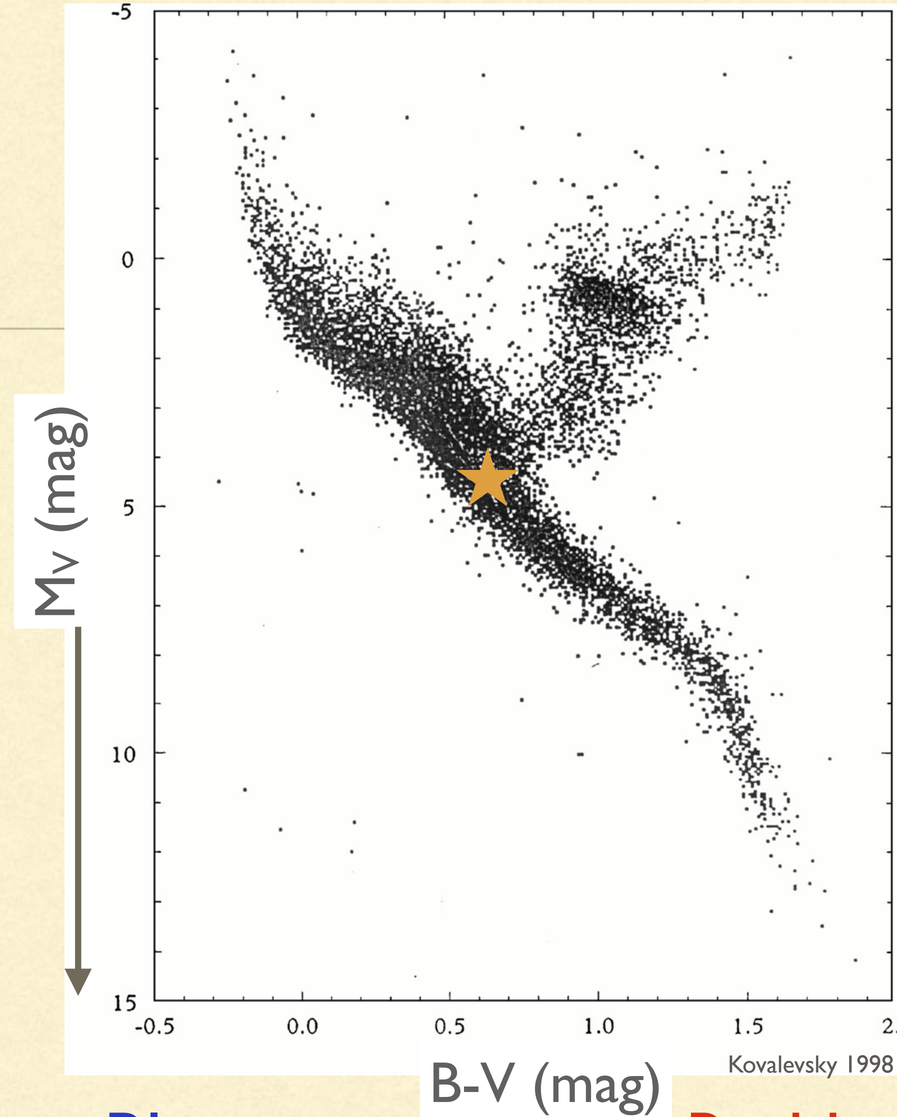


COLORS

Bluer

Redder





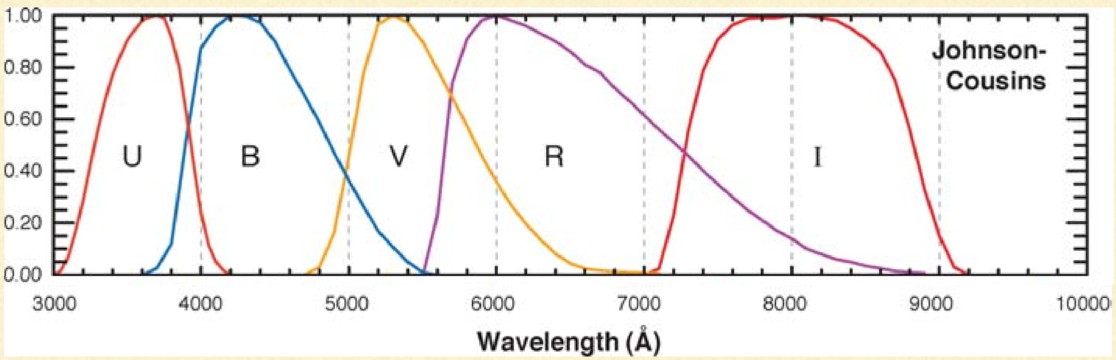
Luminosity

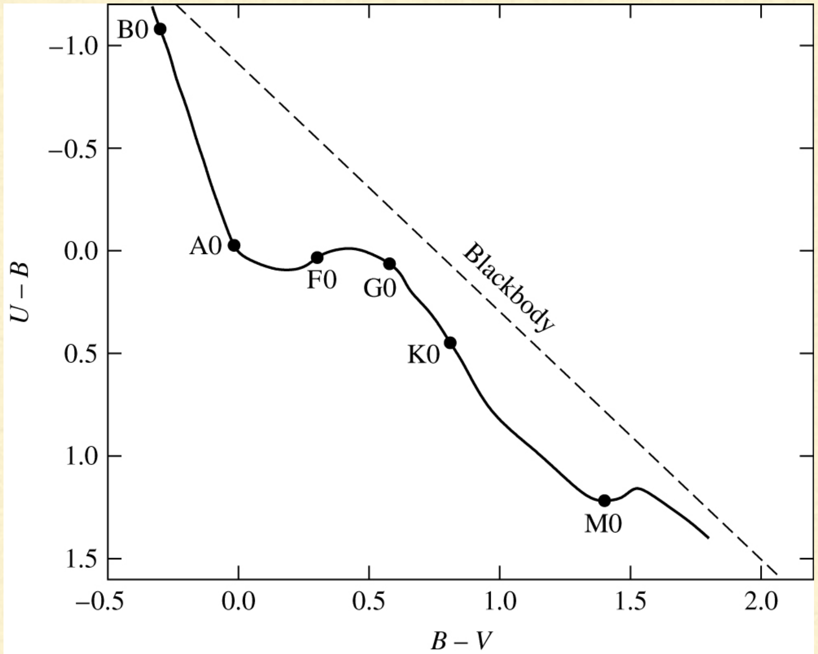
Bluer ⟷ Redder
Hotter ⟷ Cooler

Bluer ⟷ Redder
Hotter ⟷ Cooler

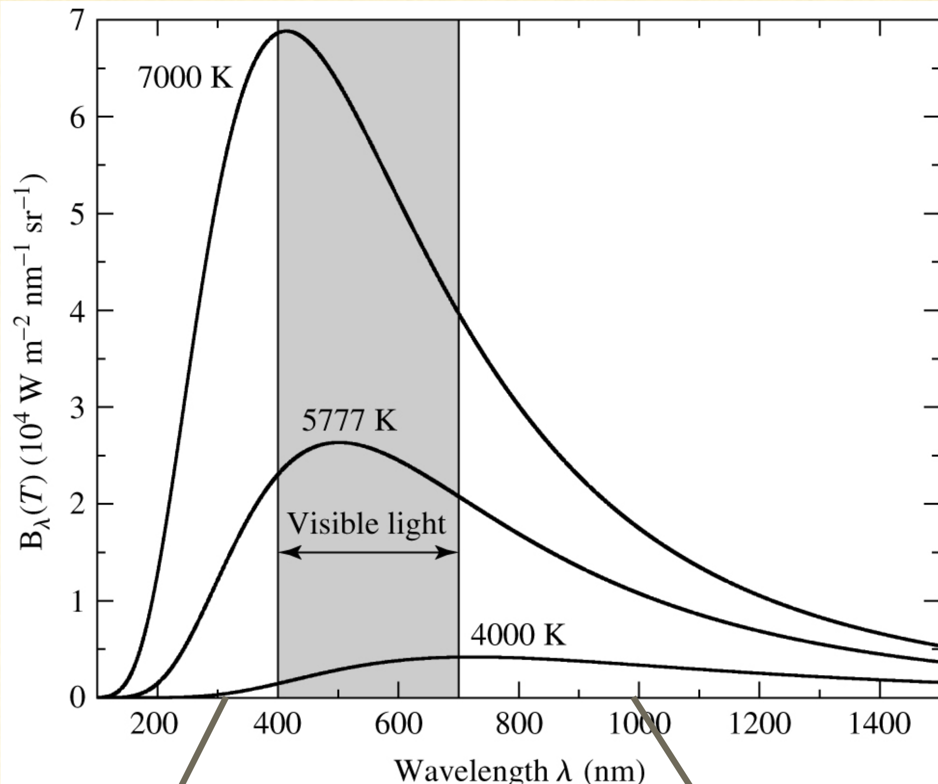
(Hipparcos data for stars within 100 pc)

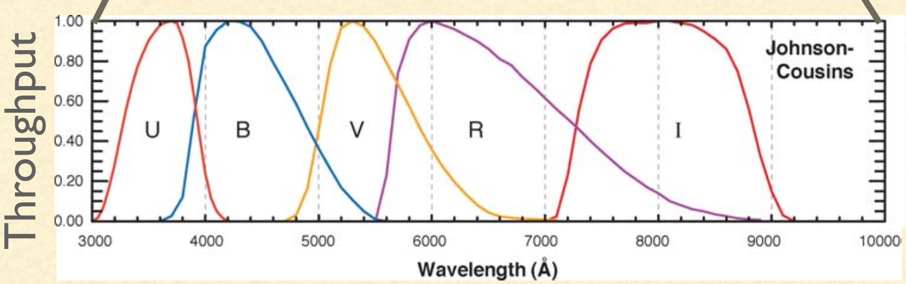
COLORS





A difference in magnitudes = a ratio of fluxes





FILTERS AND COLORS

- We only measure part of the light when we observe through a filter. For example:

  $V = -2.5\log_{10}\left(\int_0^\infty F_\lambda S(V)\, d\lambda\right) + \text{Constant}(V)$

- The bolometric correction is a conversion factor:

  $BC = m_{bol} - V = M_{bol} - M_V$

- For Sun: $M_{\odot,bol} = 4.74$ mag $M_{\odot,V} = 4.82$ mag

  So $BC = -0.08$ mag

COLOR INDEX

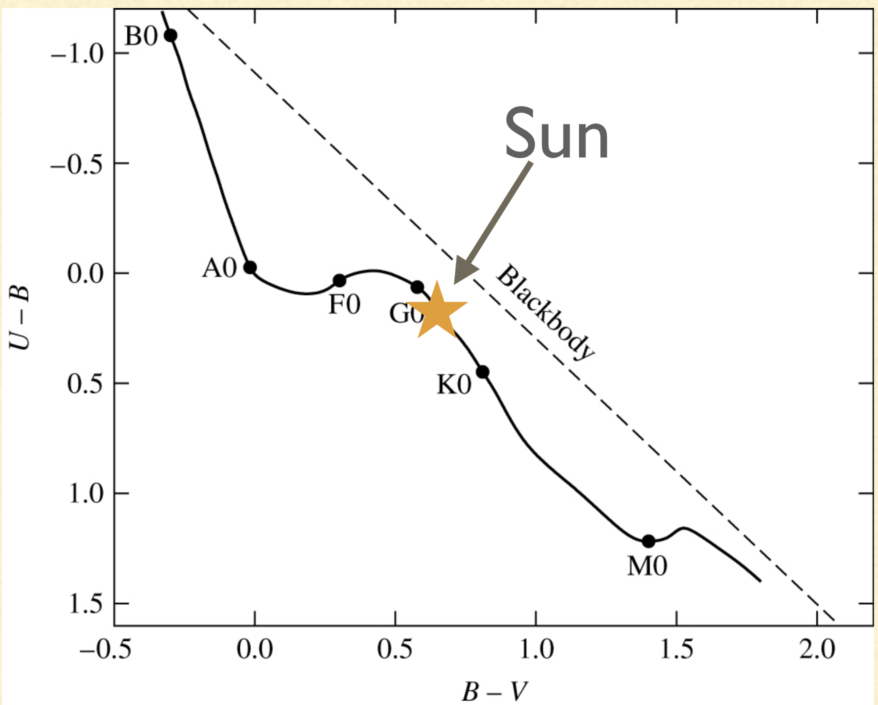
- We can define a *color index* as a difference in magnitudes: e.g., B-V
- Smaller numbers = bluer   Bigger numbers = redder
- For Sun: $M_B = 5.47$ mag $M_V = 4.82$ mag

——> so B-V = 0.65 mag

- Stars with similar T_{color} will have similar color index B-V
- Remember: differences in magnitudes = ratio of fluxes
  - so a color index is independent of how bright a source is

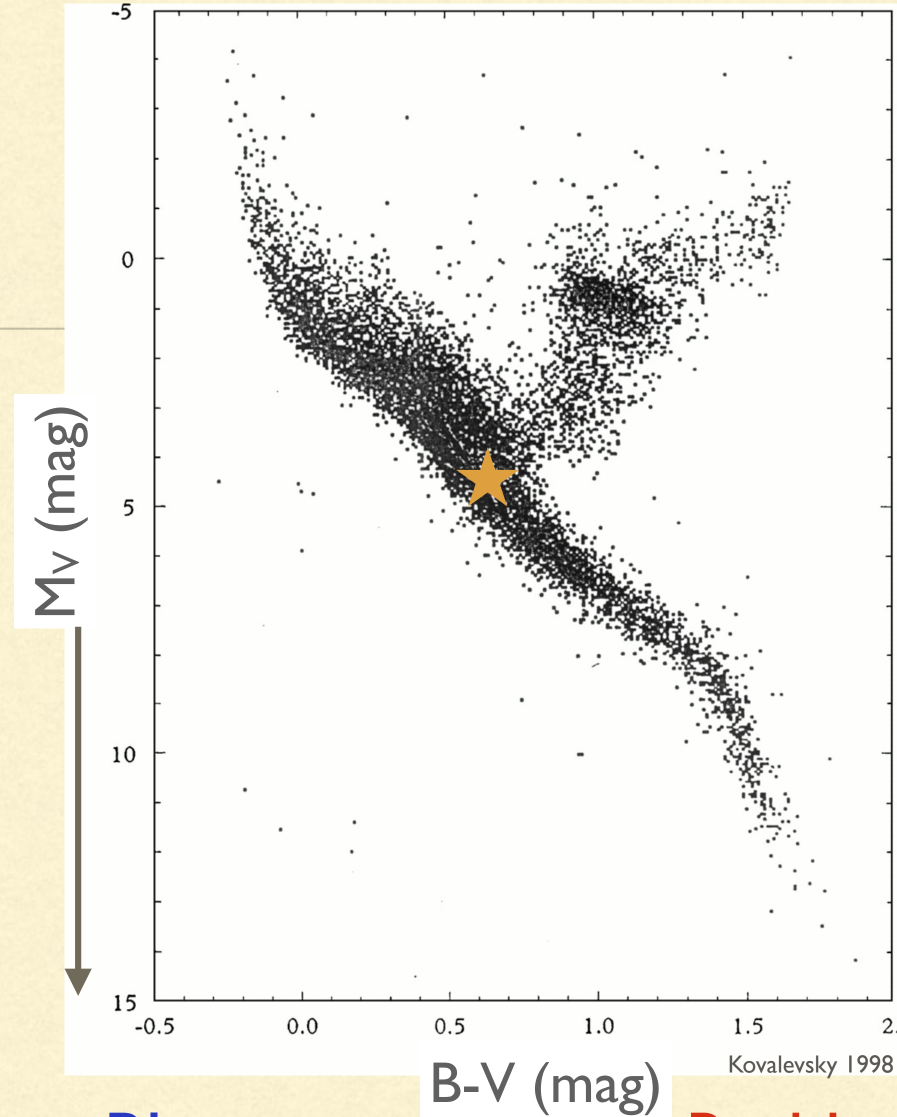
COLORS

Redder ↔ Bluer



Bluer ↔ Redder

Hotter ↔ Cooler



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