Today's Topics

Monday, October 26, 2020 (Week 10, lecture 27) – Chapters 17, 18.

A. Solar fusion

B. Observing the stars: brightness

C. Star color

D. Luminosity

Solar Fusion: proton-proton chain

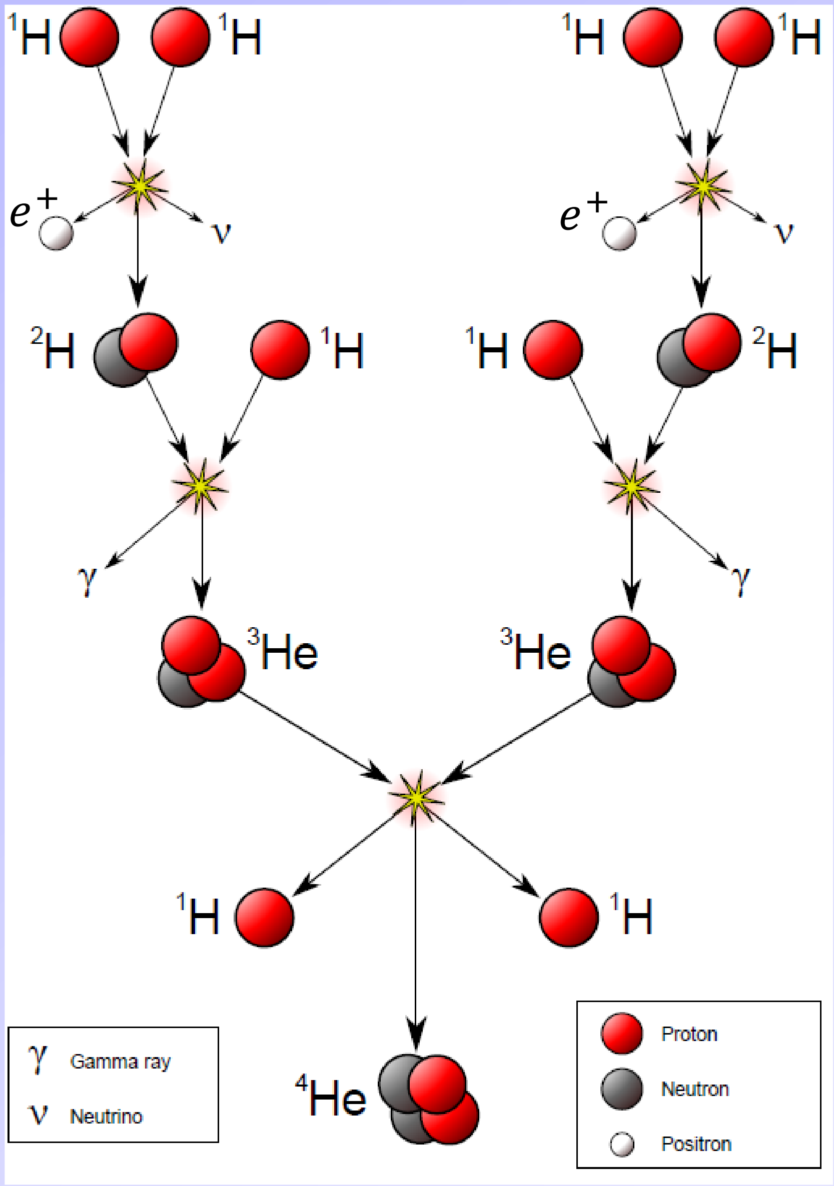
(Note: 1 eV = 1.602 $\times$ 10^{-19} J)

9 billions years
weak force

4 seconds
strong force

400 years
strong force

(see also Sept. 20 lecture)



2×1.442 MeV

$2 \times (0.42 + 2 \times 0.511)$ MeV
$\boldsymbol{e^+}$ **mass**

\+ 2×5.49 MeV

\+ 12.86 MeV

= 26.7 MeV total

= 4.28×10^{-12} J

By Sarang - Own work, Public Domain,
https://commons.wikimedia.org/w/index.php?curid=51118538

Einstein: Mass & Energy

$$Energy = E = mc^2$$

mass

c = speed of light

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Mass of ^{4}He nucleus: $m_{He} = 6.6447\times10^{-27}$ kg

Note:

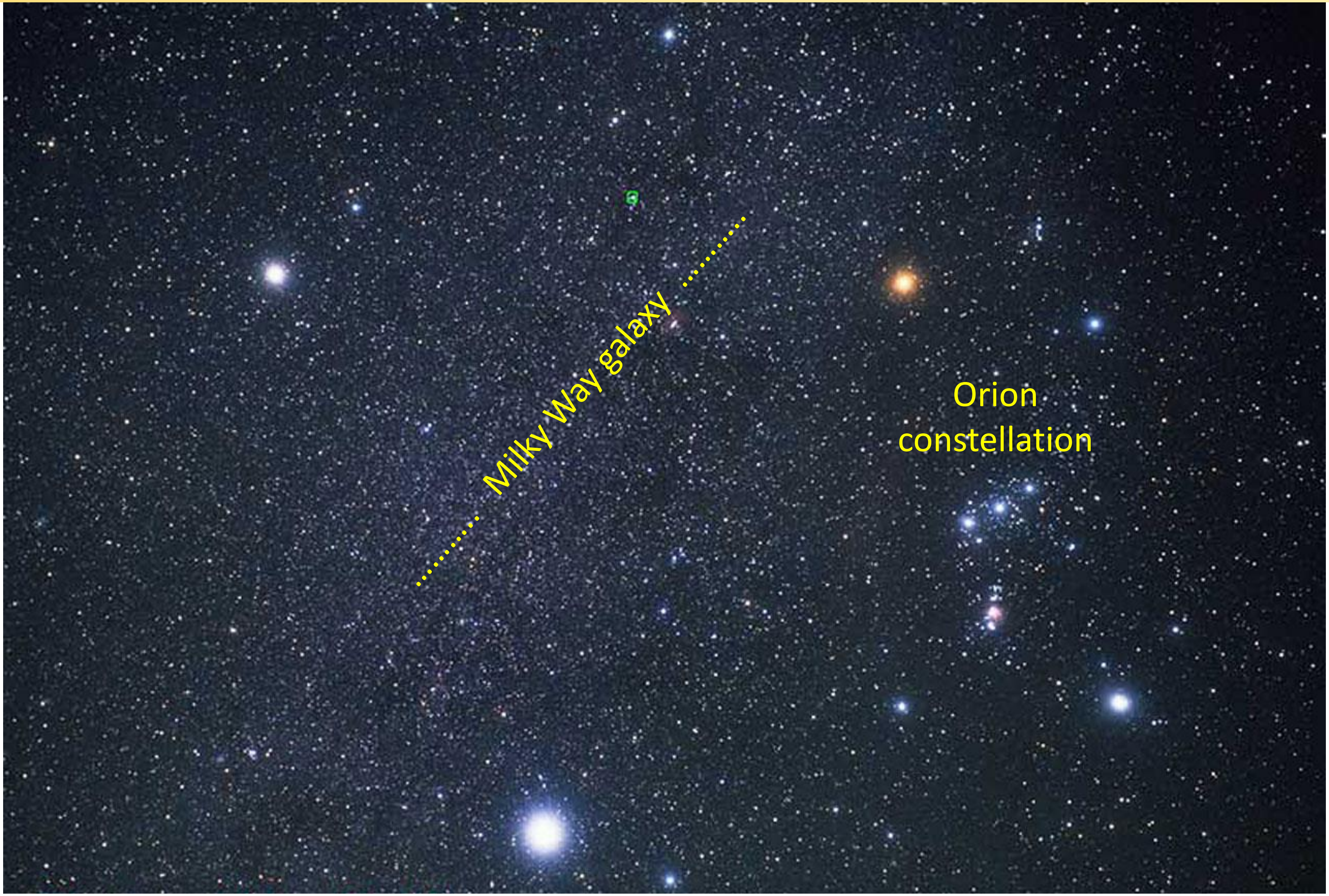
$4m_p - m_{He} = 4.65\times10^{-29}$ kg

difference is due to two positrons !

Observing the Stars

By Hubble European Space AgencyCredit: Akira Fujii - http://www.spacetelescope.org/images/heic0206j/ (watermark was cropped), Public Domain, https://commons.wikimedia.org/w/index.php?curid=5246351

Observing the Stars



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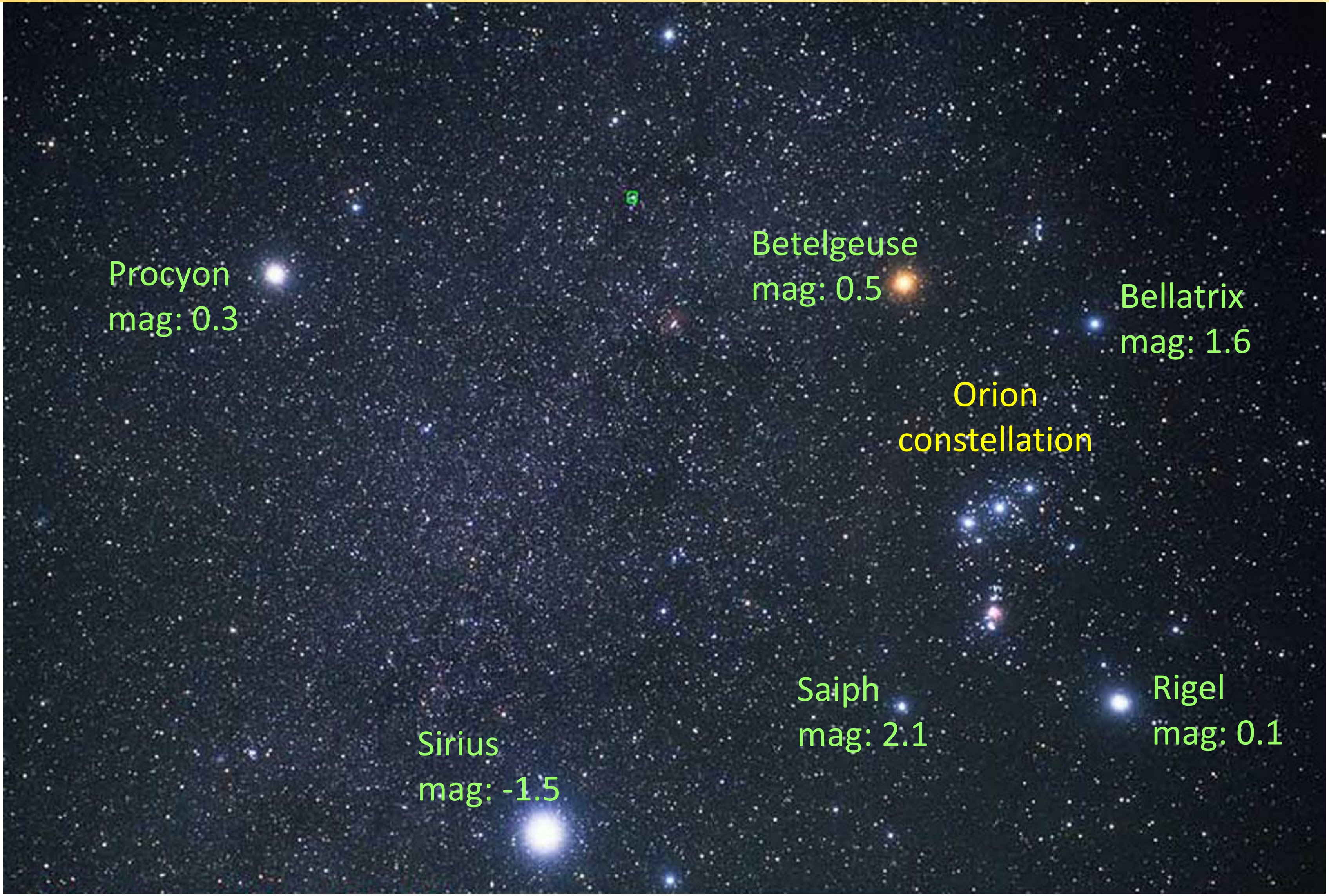

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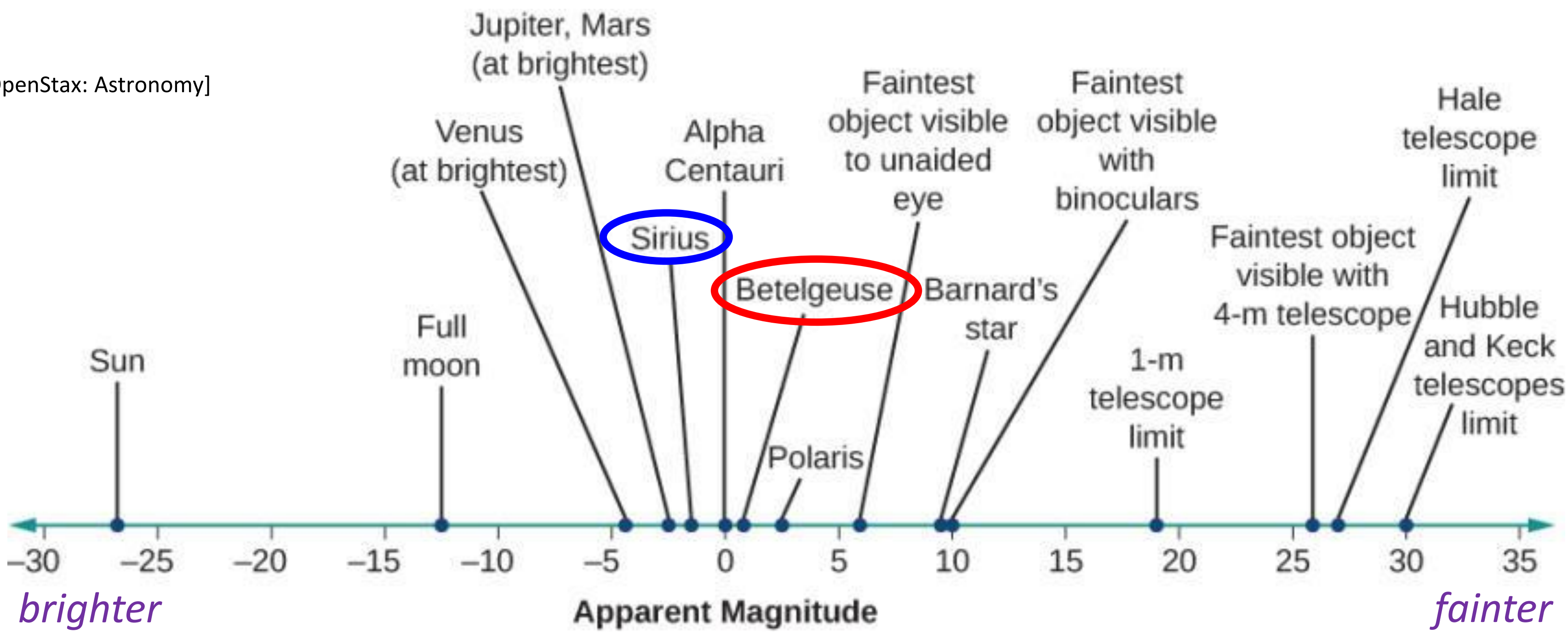
Apparent Magnitude
Logarithmic brightness scale

[OpenStax: Astronomy]



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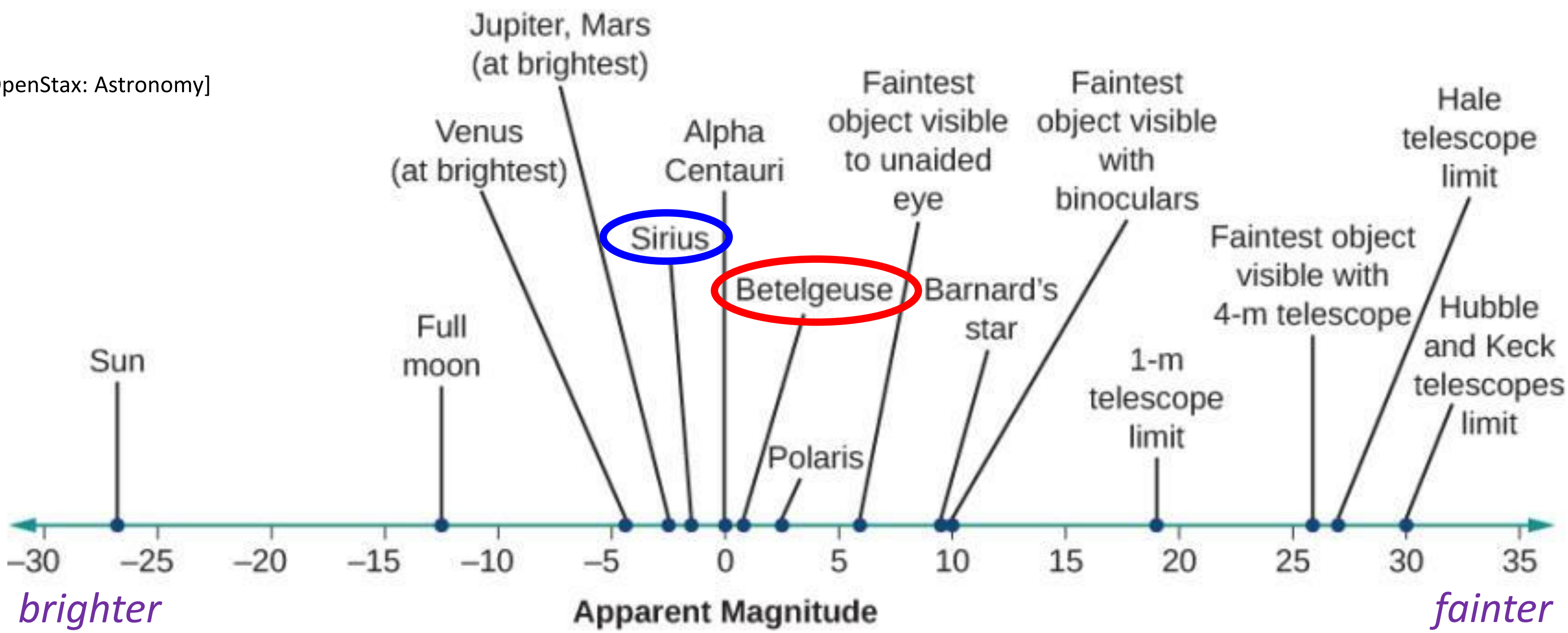

Apparent **brightness** is proportional to optical energy/power incident on detector/eye.

Human eyes are **logarithmic** detectors of brightness, so they measure **magnitude**.

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Logarithmic brightness scale

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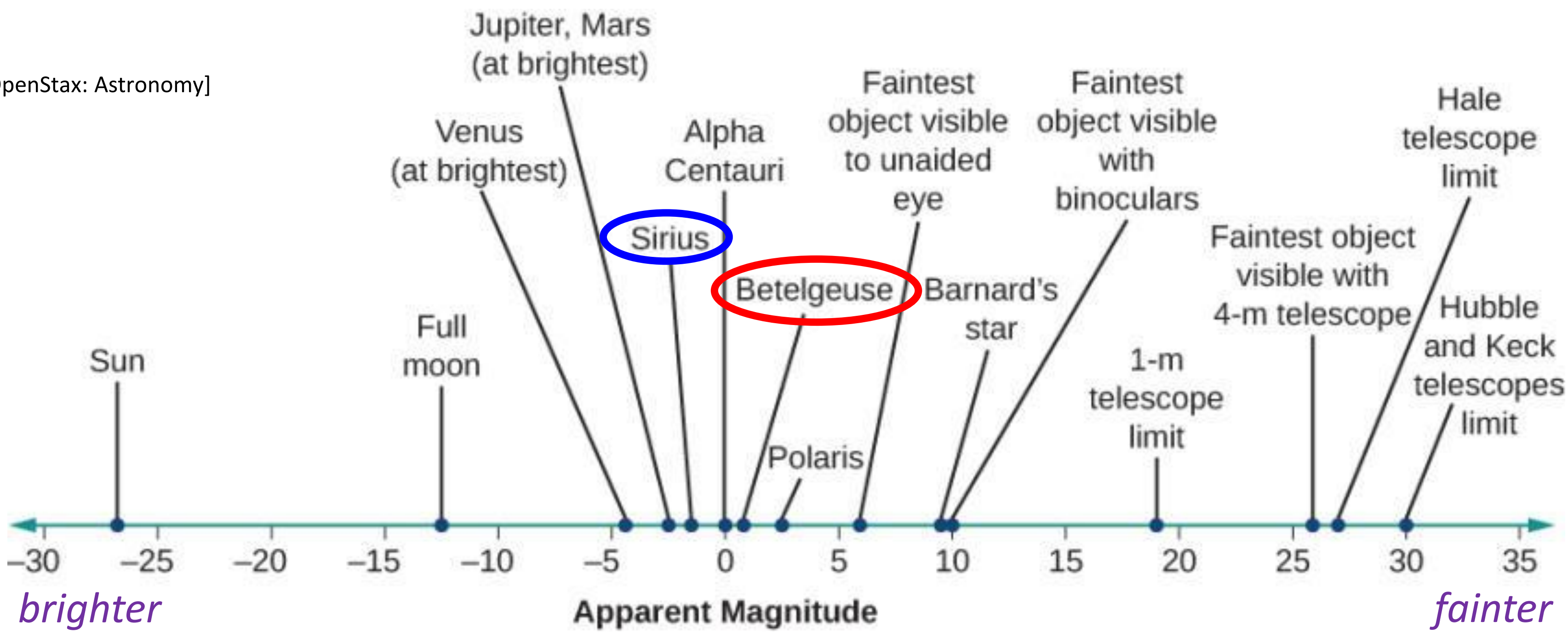

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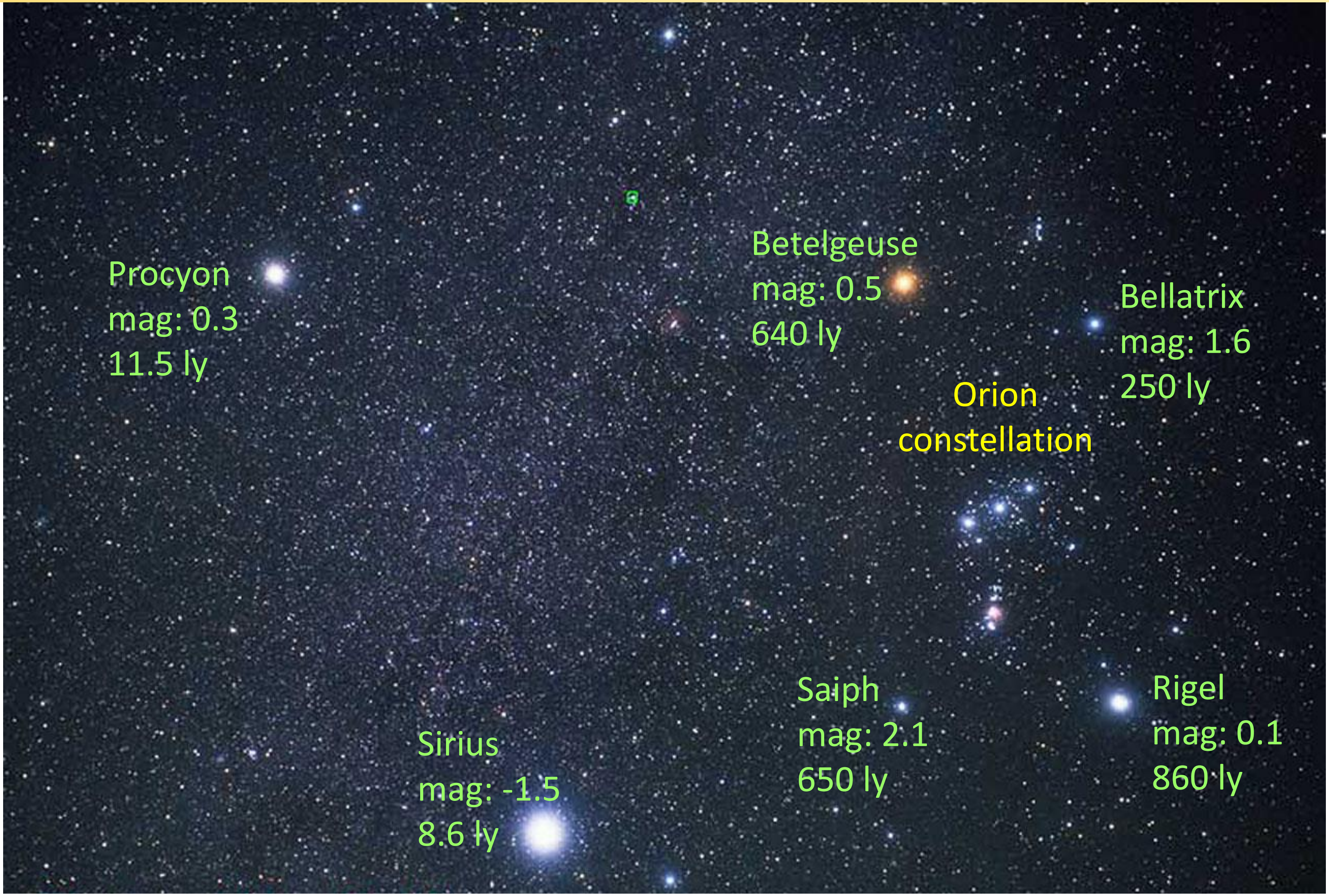
Δmagnitude = m_1-m_2 = 1 corresponds to a factor of 2.512 change in brightness

$$\Delta brightness = \frac{b_2}{b_1} = 2.512^{\Delta m} = 2.512^{(m1-m2)}$$

Observing the Stars



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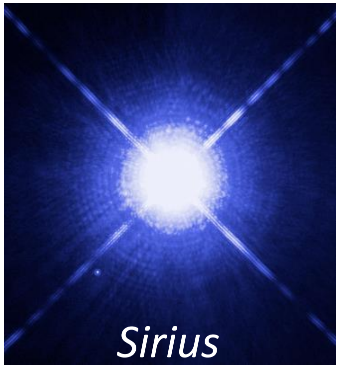
Apparent Brightness vs Luminosity



[By NASA, ESA, H. Bond (STScI), and M. Barstow (University of Leicester)]

Luminosity *(definition)*

Total **power** output of a star.

energy per second

Distance of Star: The farther away a star is, the dimmer it will appear.

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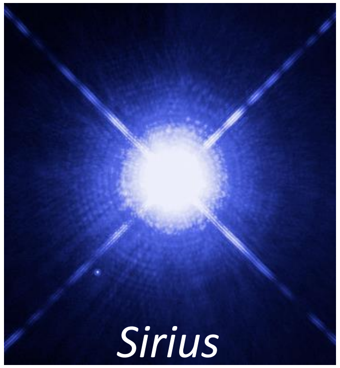

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$$apparent\ brightness \propto \frac{Luminosity}{distance^2}$$

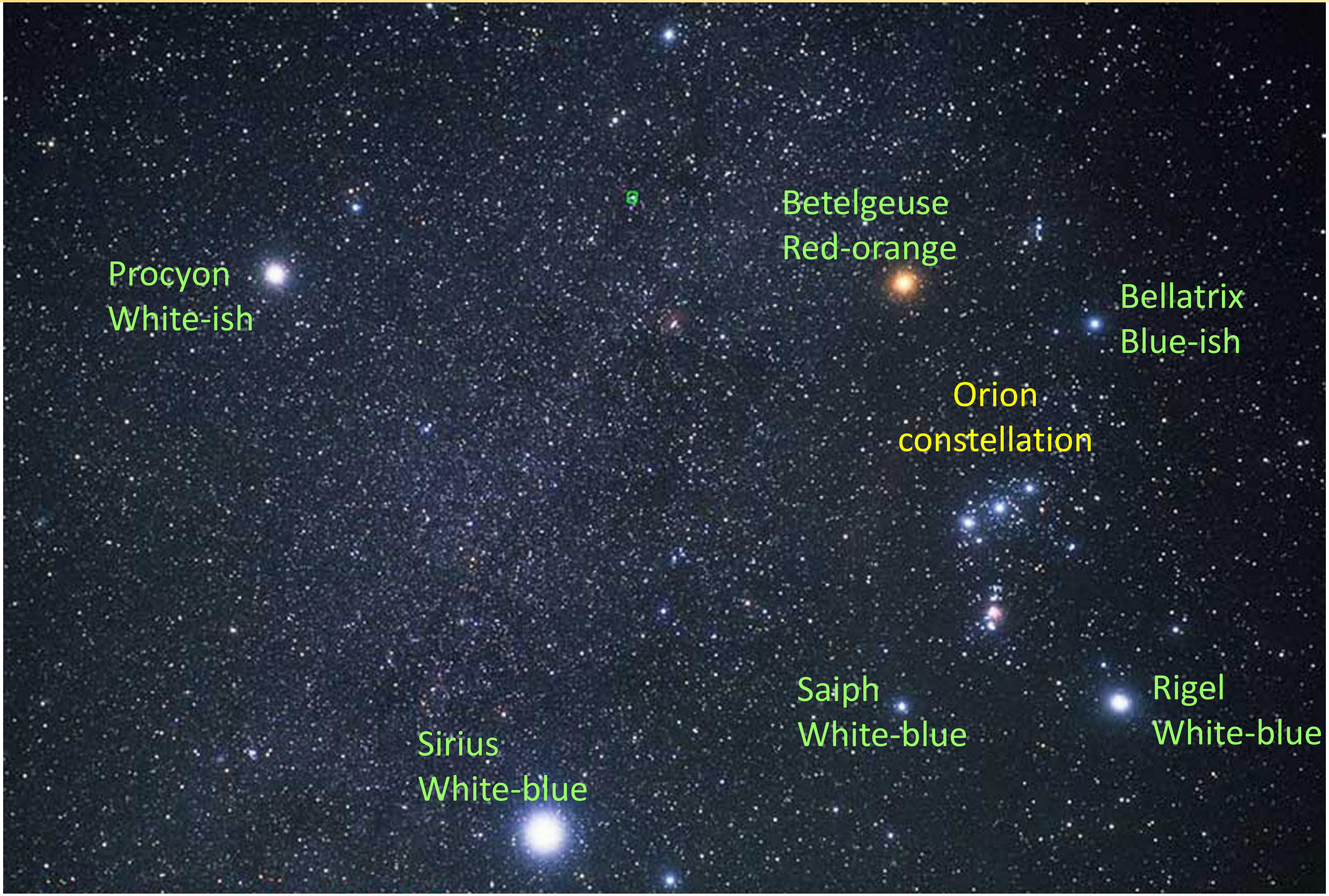
Dim Stars

A star may appear **dim** because it has **low luminosity**, or/and because it is **further away**.

Bright Stars

A star may appear **bright** because it has **high luminosity**, or/and because it is **closer** to us.

Star Color



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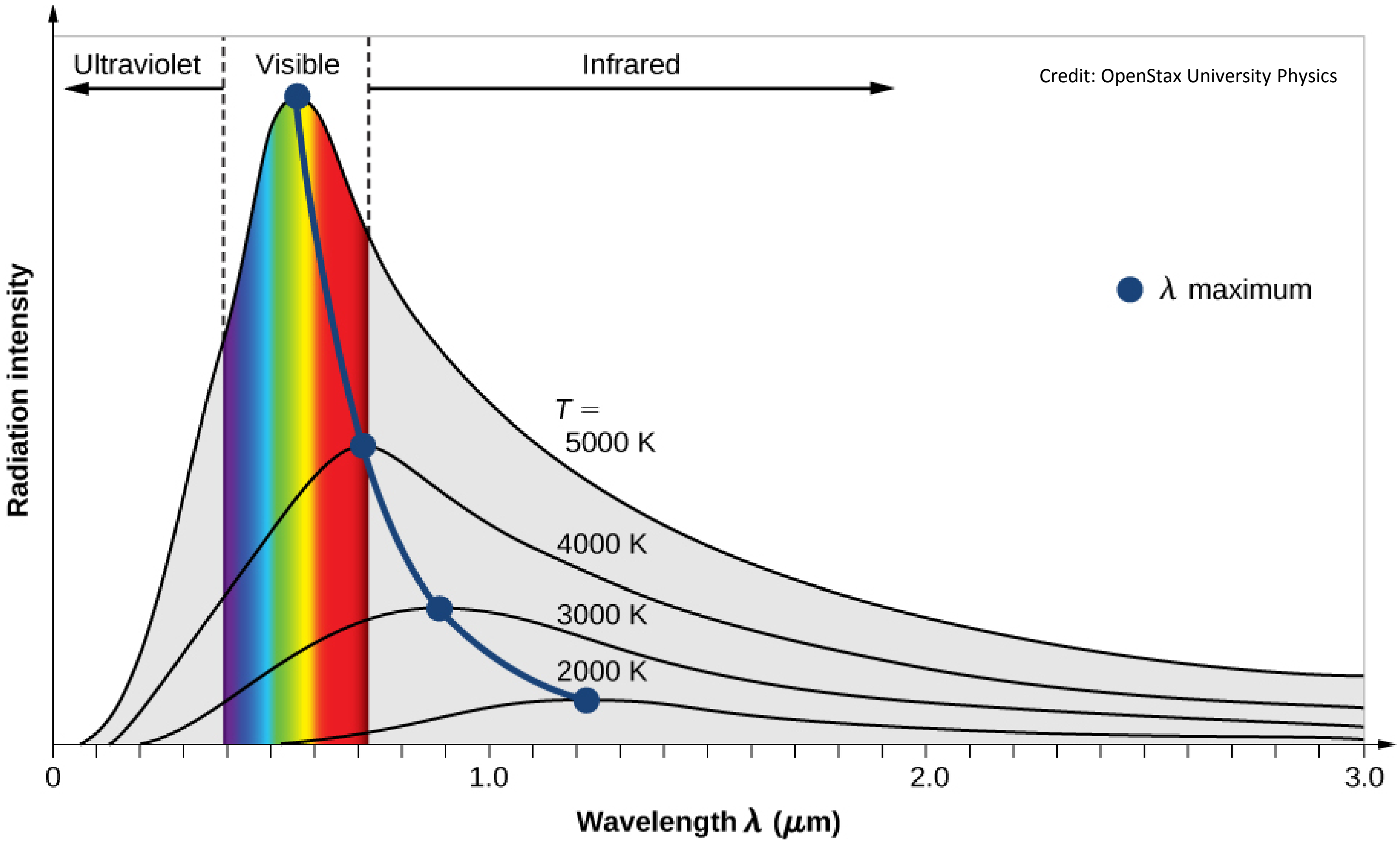
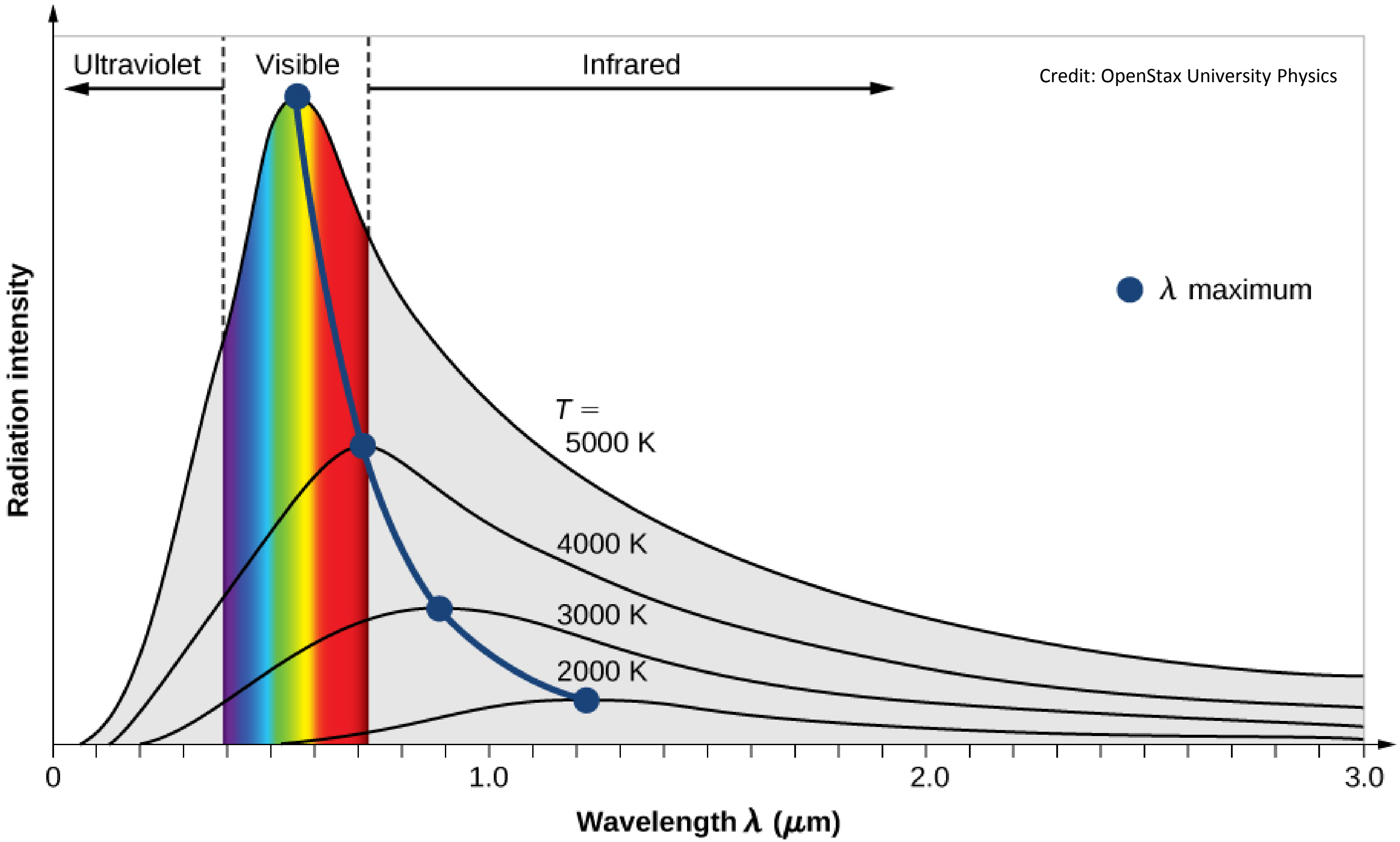
Star Color = Temperature



Question: Why aren’t there green stars ?

Star Color = Temperature



Question: Why aren't there green stars ?

Answer: The "greenest" you can get is when the peak emission is green (T~5000-6000 K), but since you have comparable amounts of blue and red light, the star looks white-ish.

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Star Color	Approximate Temperature	Example
Blue	25,000 K	Spica
White	10,000 K	Vega
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Orange	4000 K	Aldebaran

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Star color follows roughly from Wien's law for peak wavelength: $\boxed{\lambda_{max,\, nm} = \frac{2.9 \times 10^6}{T}}$

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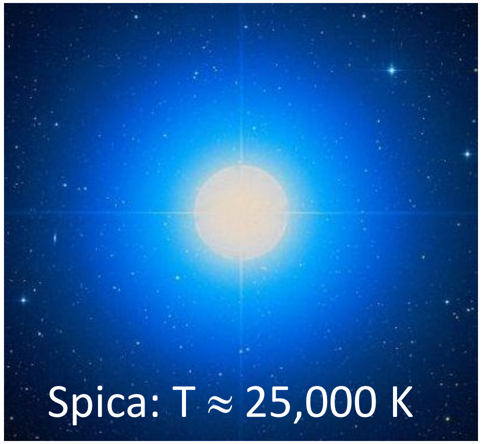
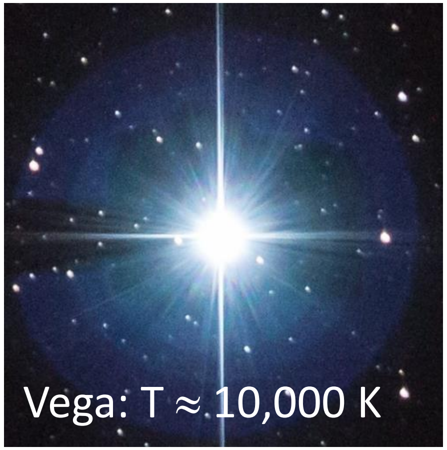
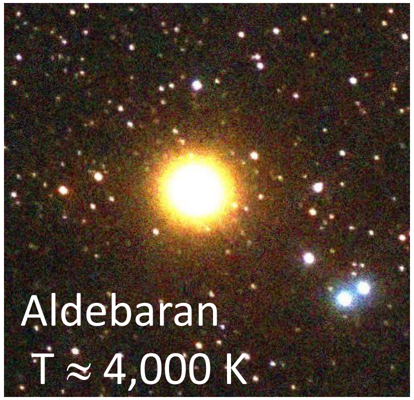


[astronomytrek.com/star-facts-spica]



[Wikipedia: Stephen Rahn]

[Wikipedia: Skatebiker]



[Wikipedia: Giuseppe Donatiello]

Star Spectral Classes

Historical error: Spectroscopic studies of stars in the late 1800's led astronomers to believe that stars were constituted of vastly different elements.

→ Stars were classified by their spectral type: O, B, A, F, G, K, M.

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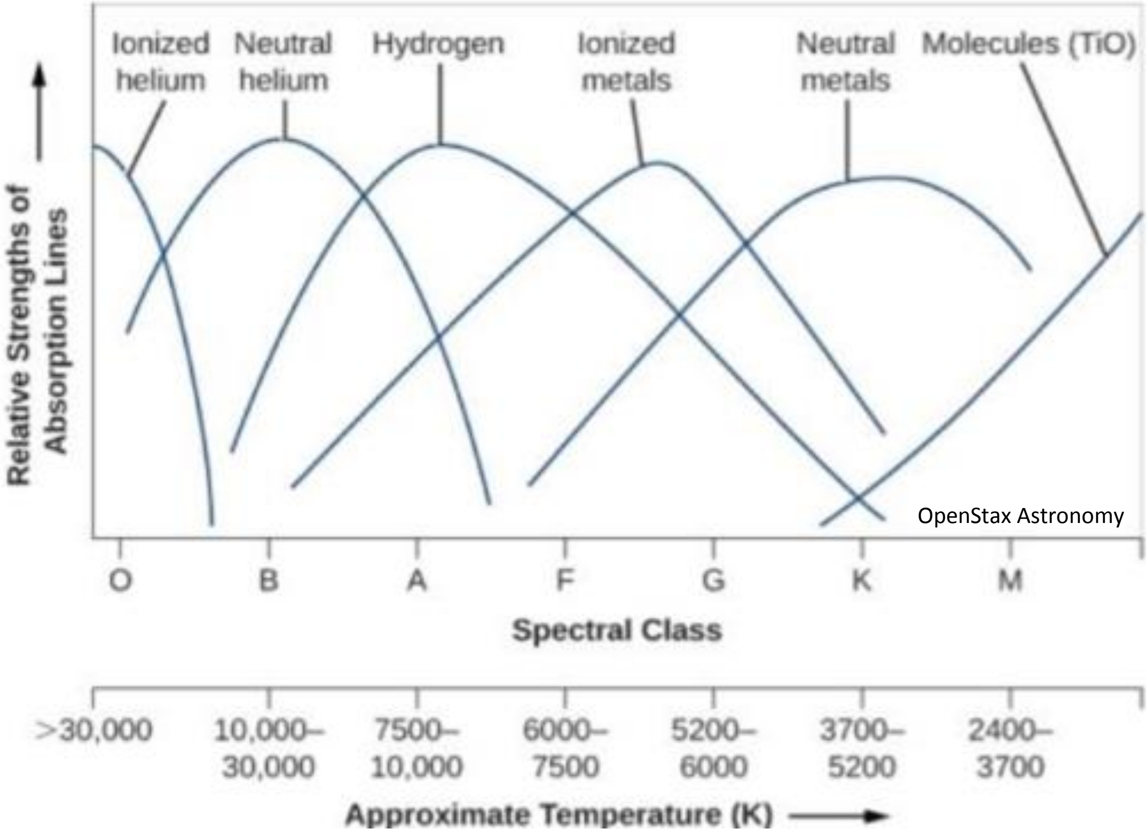
Cecilia Payne-Gaposchkin
(1900-1979)

Reality: All stars are mostly made of <u>hydrogen</u> and <u>helium</u>.

- Spectral differences are due to the **temperatures** of the stars.
- Discovered by Cecilia Payne-Gaposchkin (1925, PhD Harvard).



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- The surface area of a star is related to its radius, i.e. size:

$$\boxed{Surface\ Area = 4\pi R^2}$$

A large star is more luminous