Today's Topics

Wednesday, March 4, 2026 (Week 6, lecture 17) – Chapters 17, 18.

A. Observing the stars: brightness

B. Star color

C. Luminosity

D. Stellar statistics

E. Luminosity vs mass

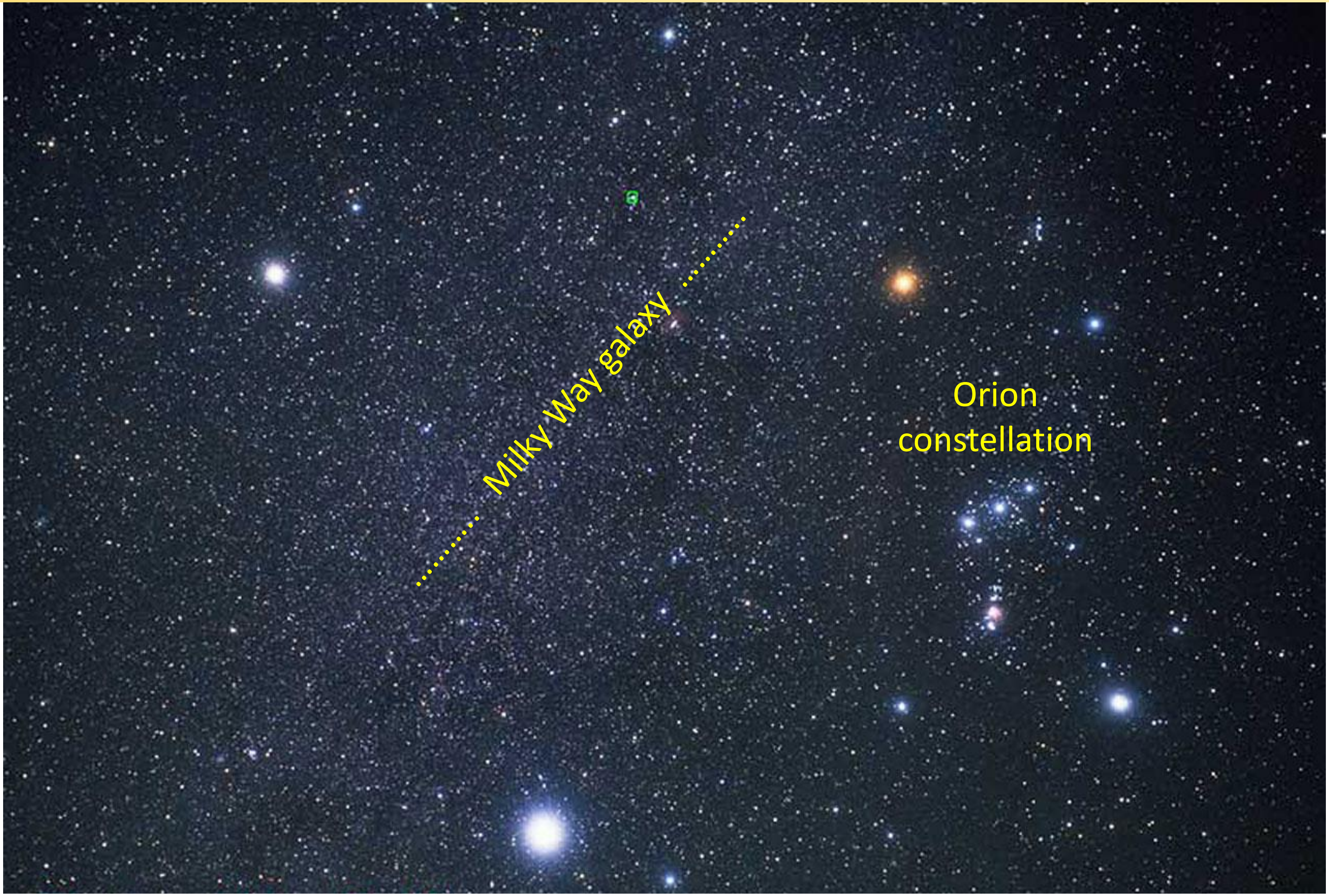
Reminder: Problem Set #5 part 1 is due on ExpertTA on Friday, March 6, by 9:00 am.

Problem Set #5 part 2 is due in class on Friday, March 6 (hardcopy).

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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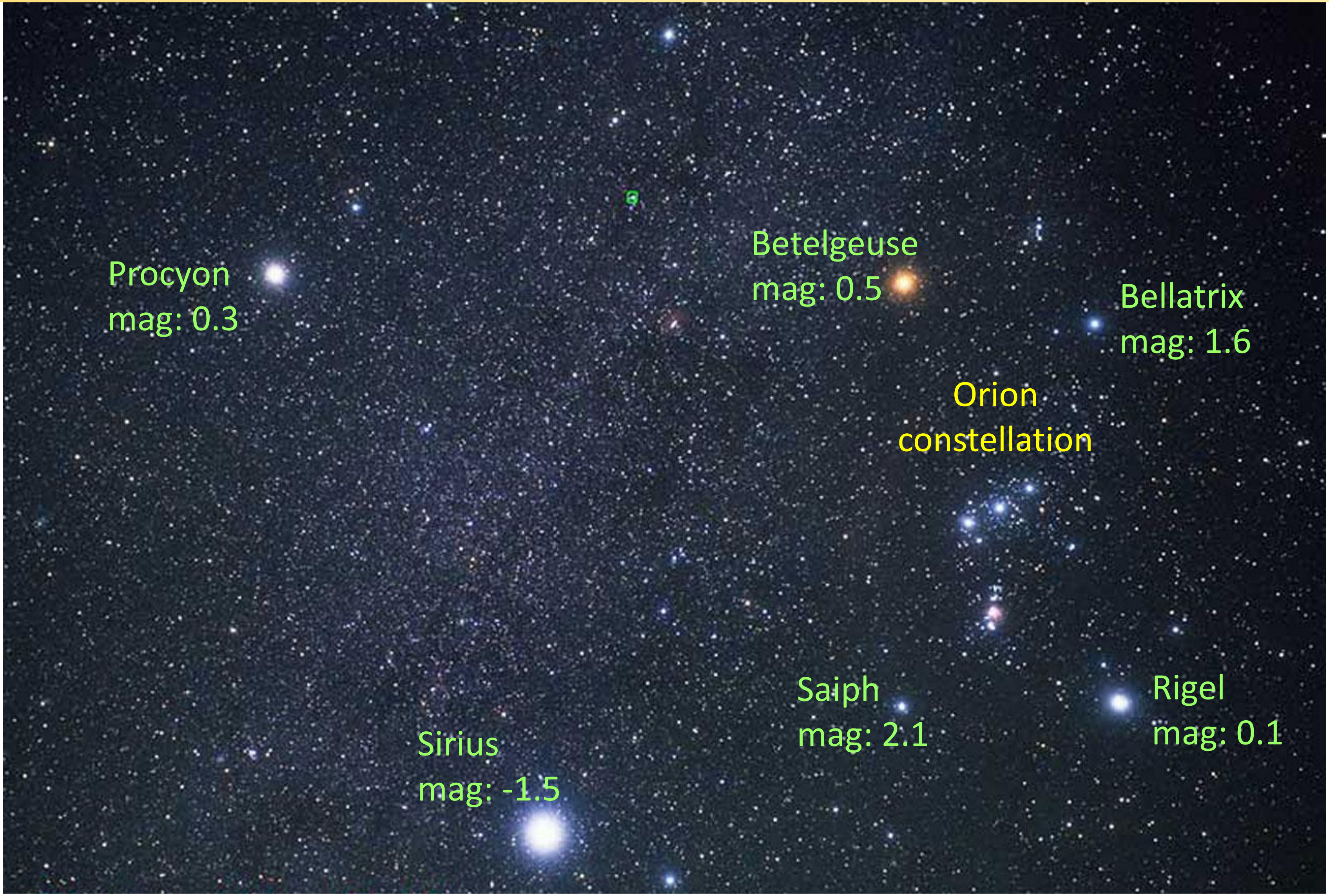

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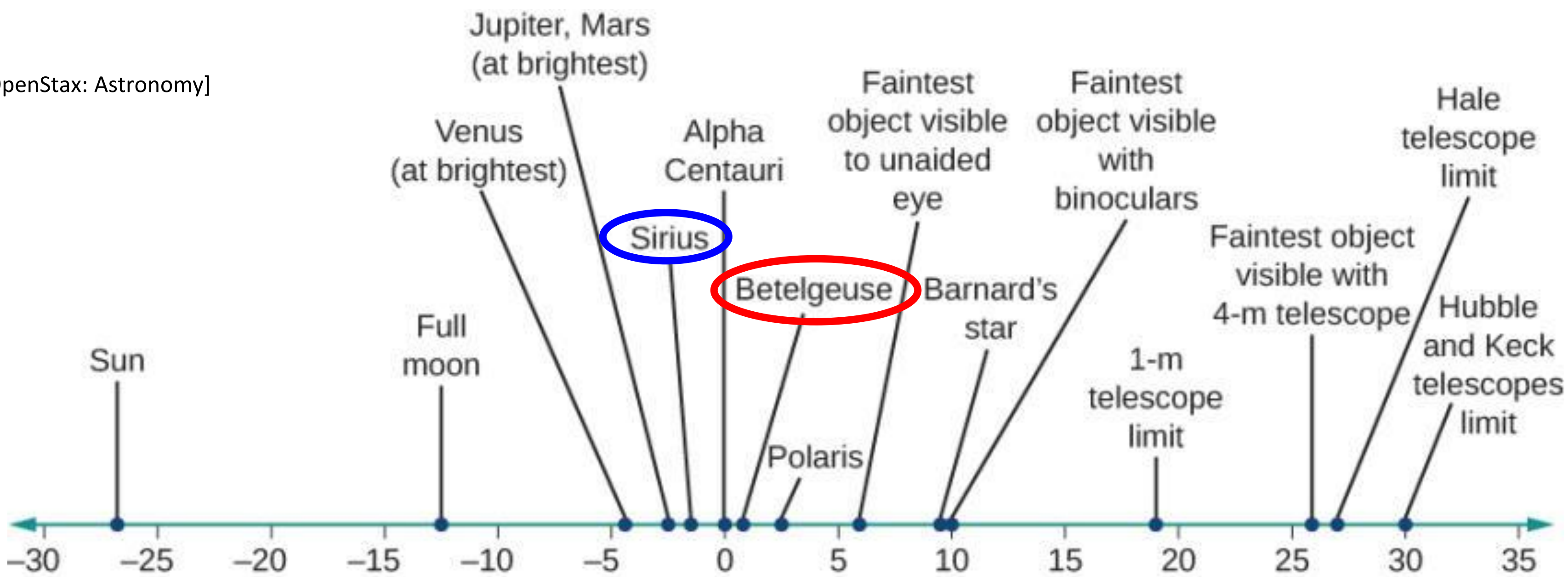
Apparent Magnitude

Logarithmic brightness scale

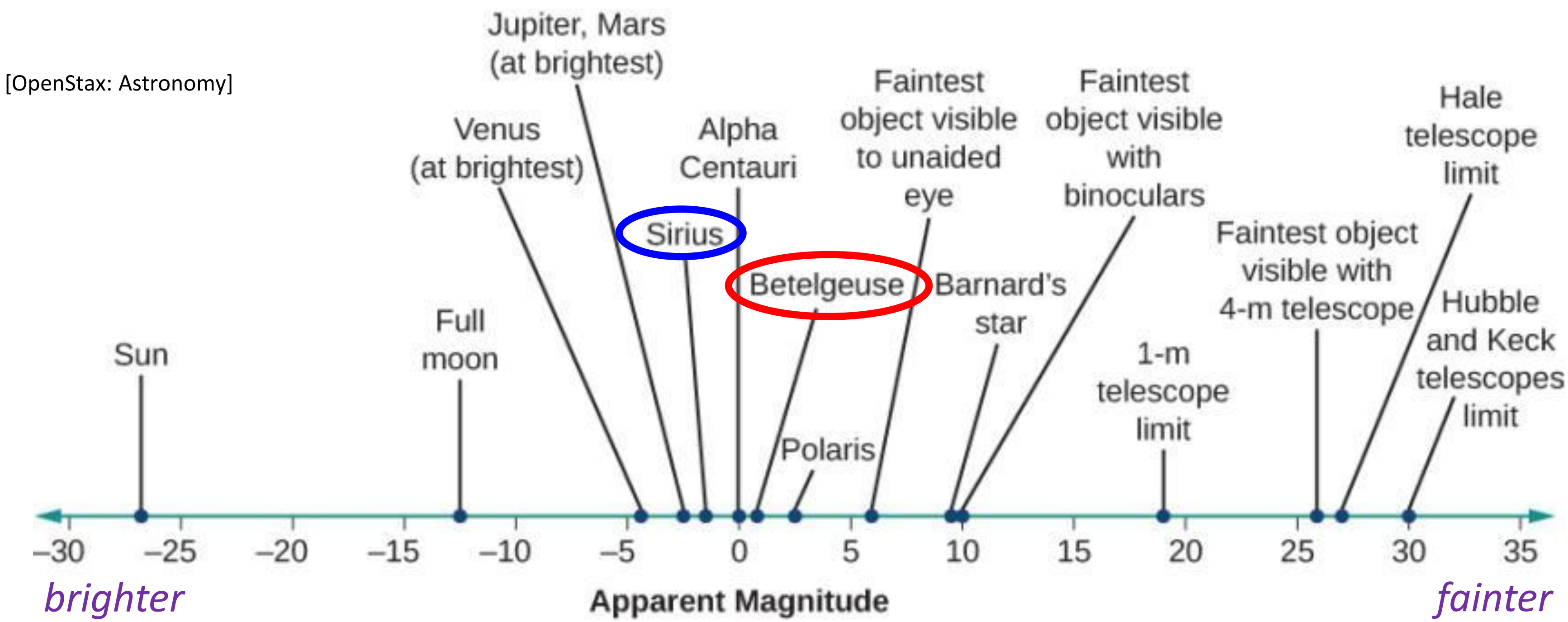
[OpenStax: Astronomy]



brighter *fainter*

Apparent Magnitude

Logarithmic brightness scale



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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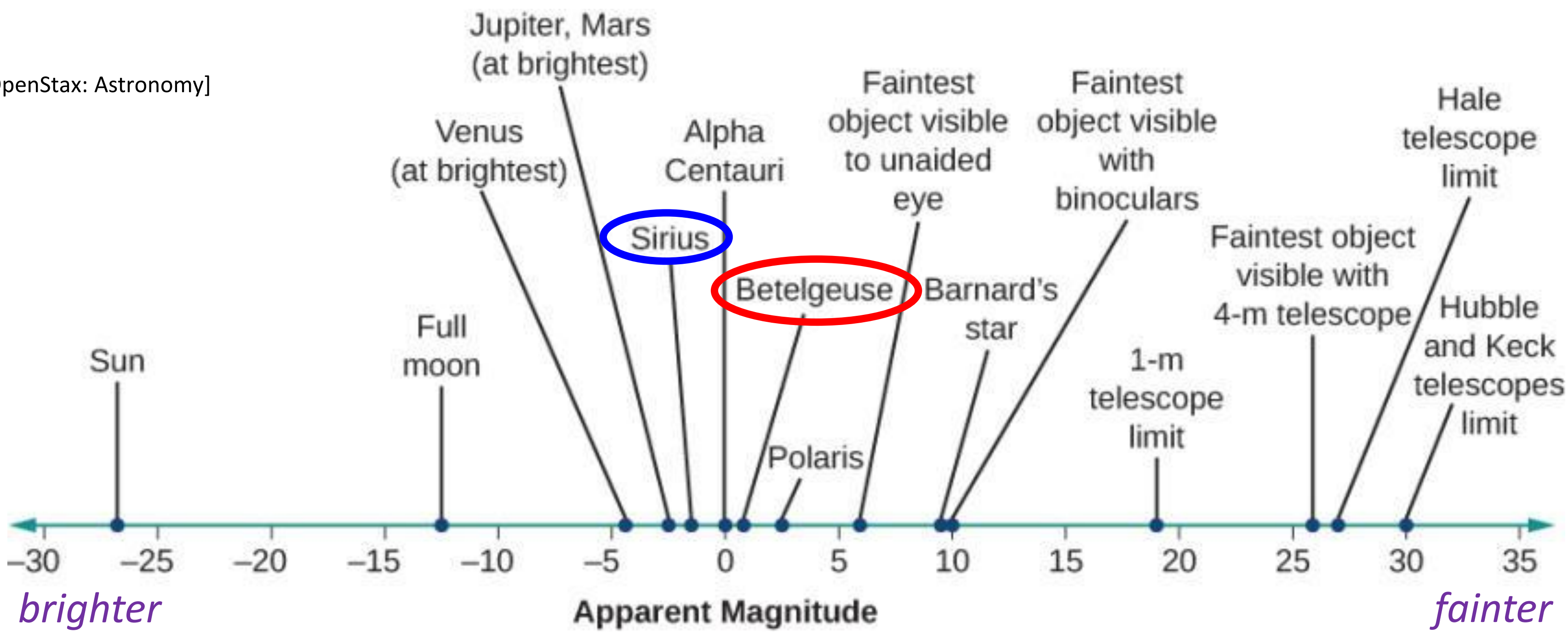

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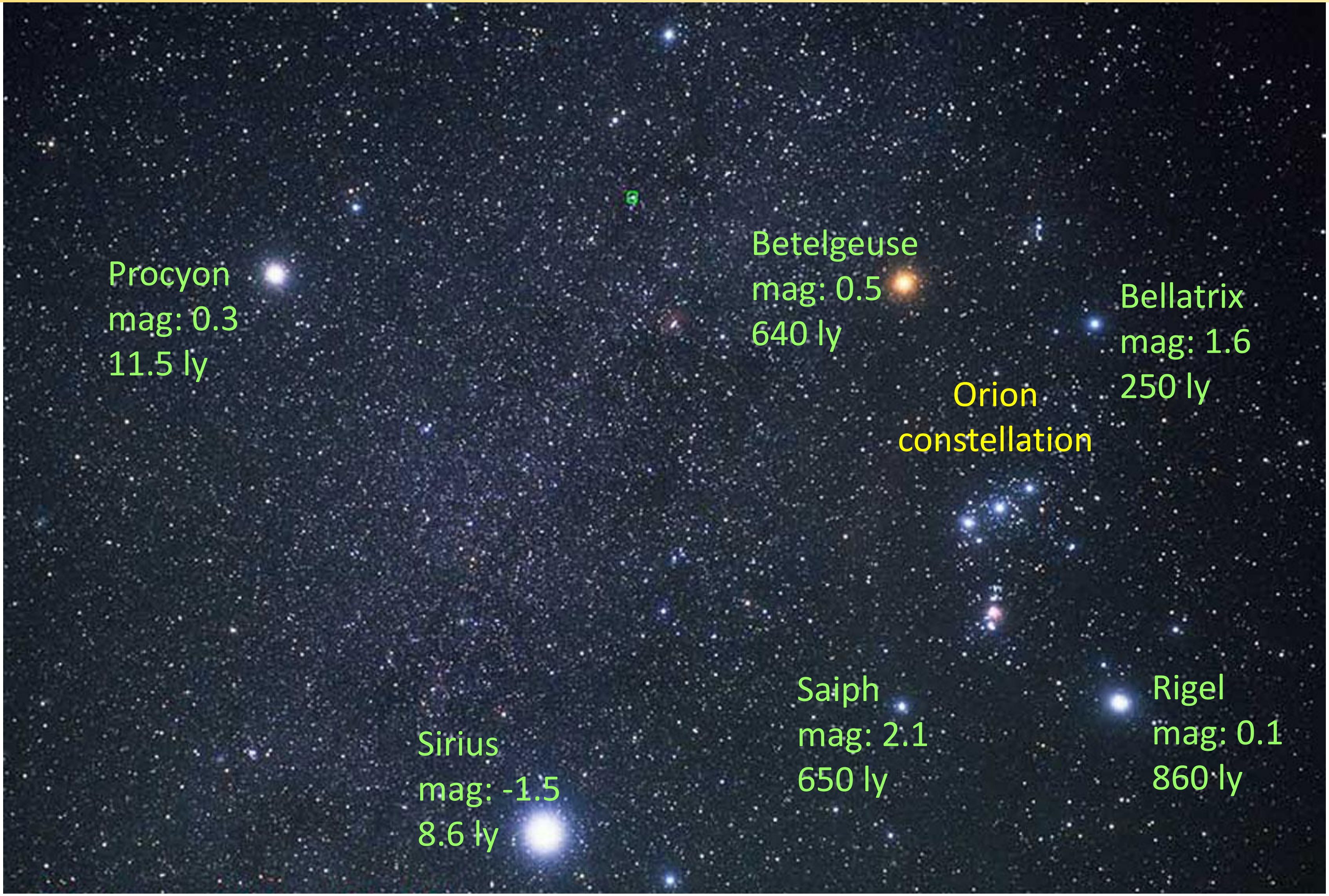
Human eyes are **logarithmic** detectors of brightness, so they measure **magnitude**.

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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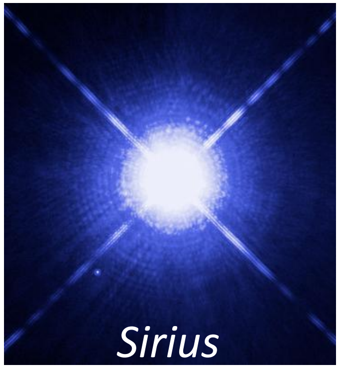
Apparent Brightness vs Luminosity

Luminosity *(definition)*

Total **power** output of a star.

energy per second



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

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

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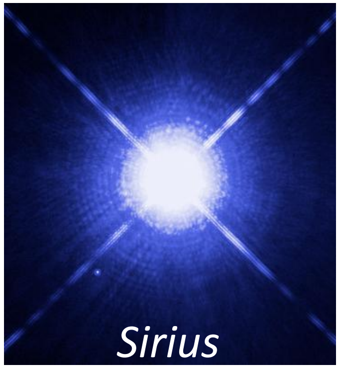

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Distance of Star: The farther away a star is, the dimmer it will appear.

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

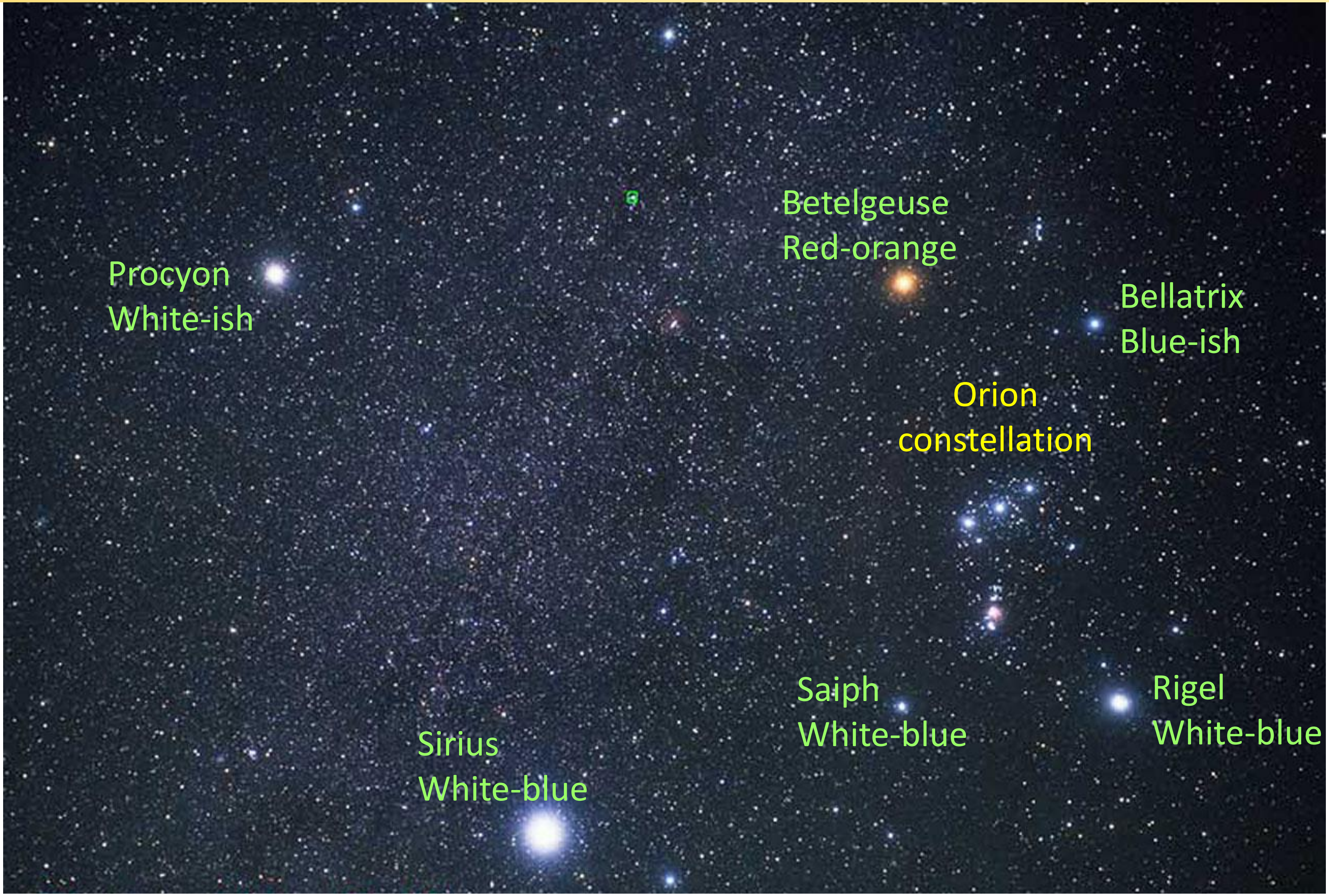
Dim Stars

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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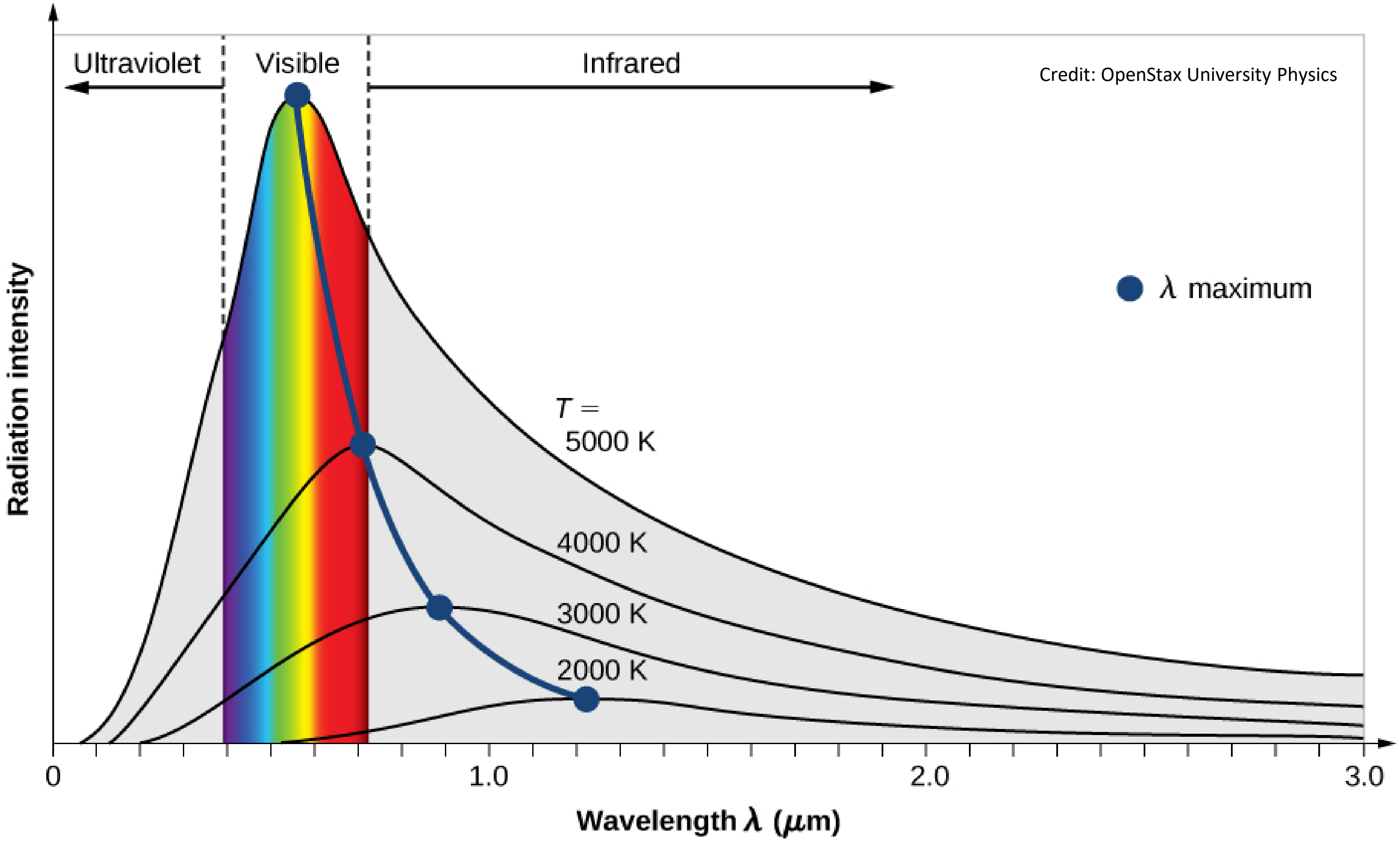
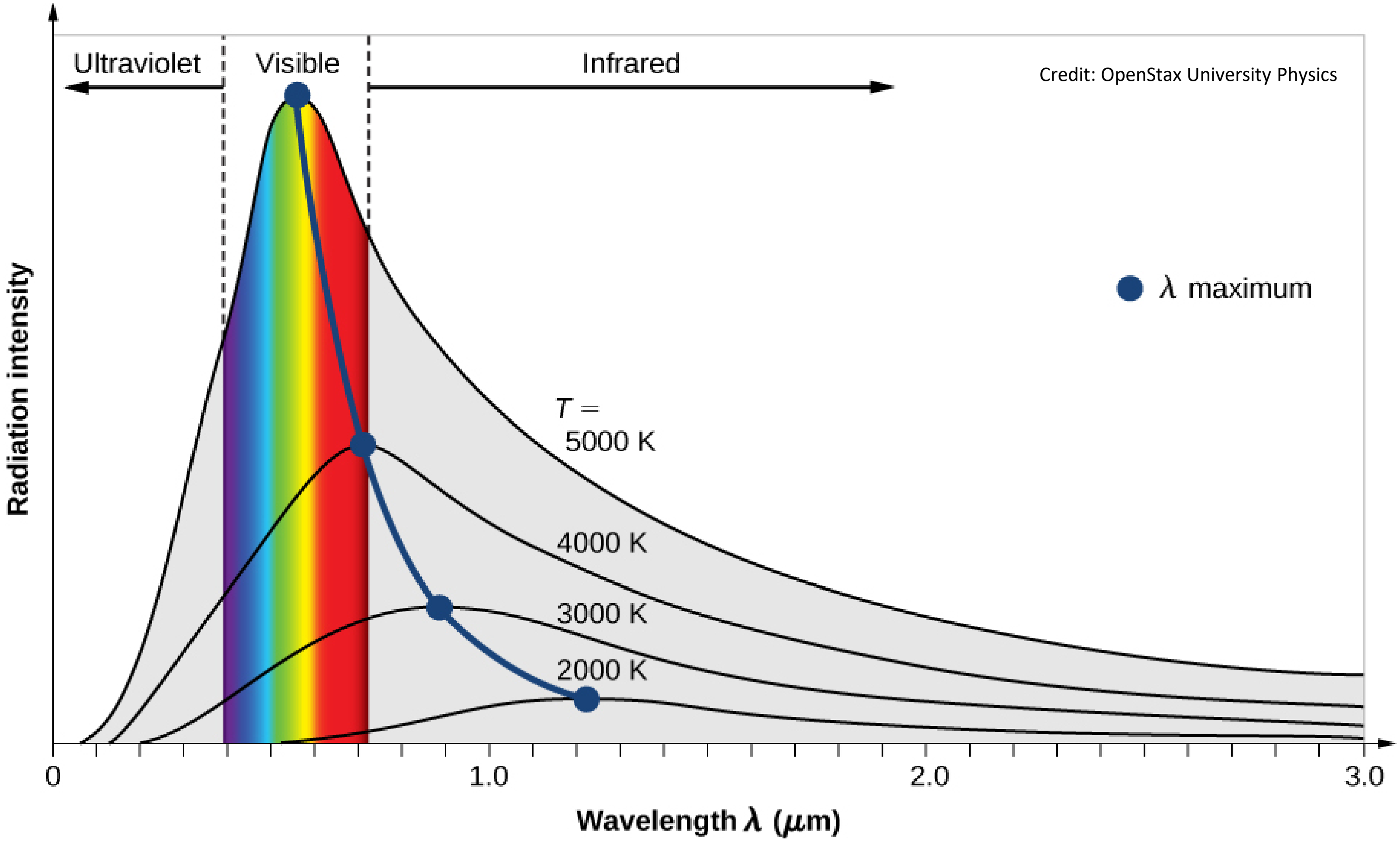
Star Color = Temperature



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.

Star Color = Temperature

Star Color	Approximate Temperature	Example
Blue	25,000 K	Spica
White	10,000 K	Vega
Yellow	6000 K	Sun
Orange	4000 K	Aldebaran

[OpenStax: Astronomy]

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Star light is blackbody radiation

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

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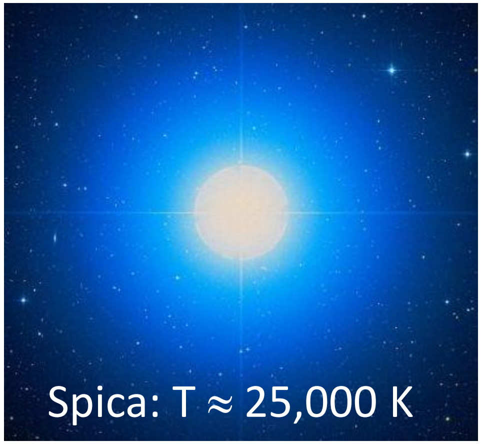
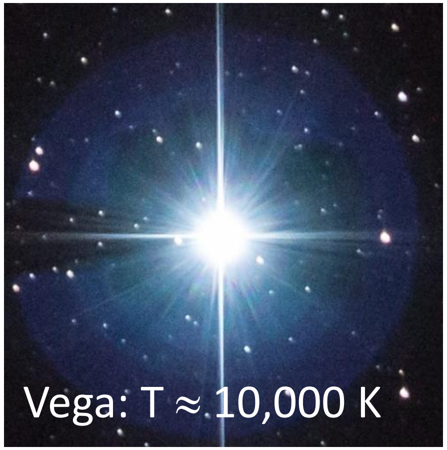
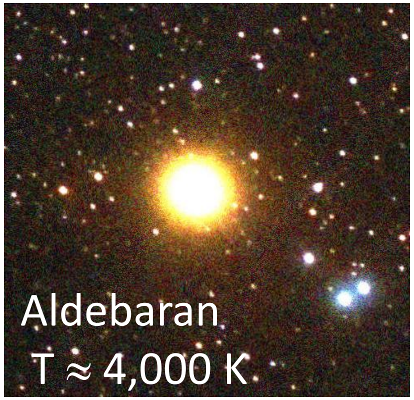


[astronomytrek.com/star-facts-spica]



[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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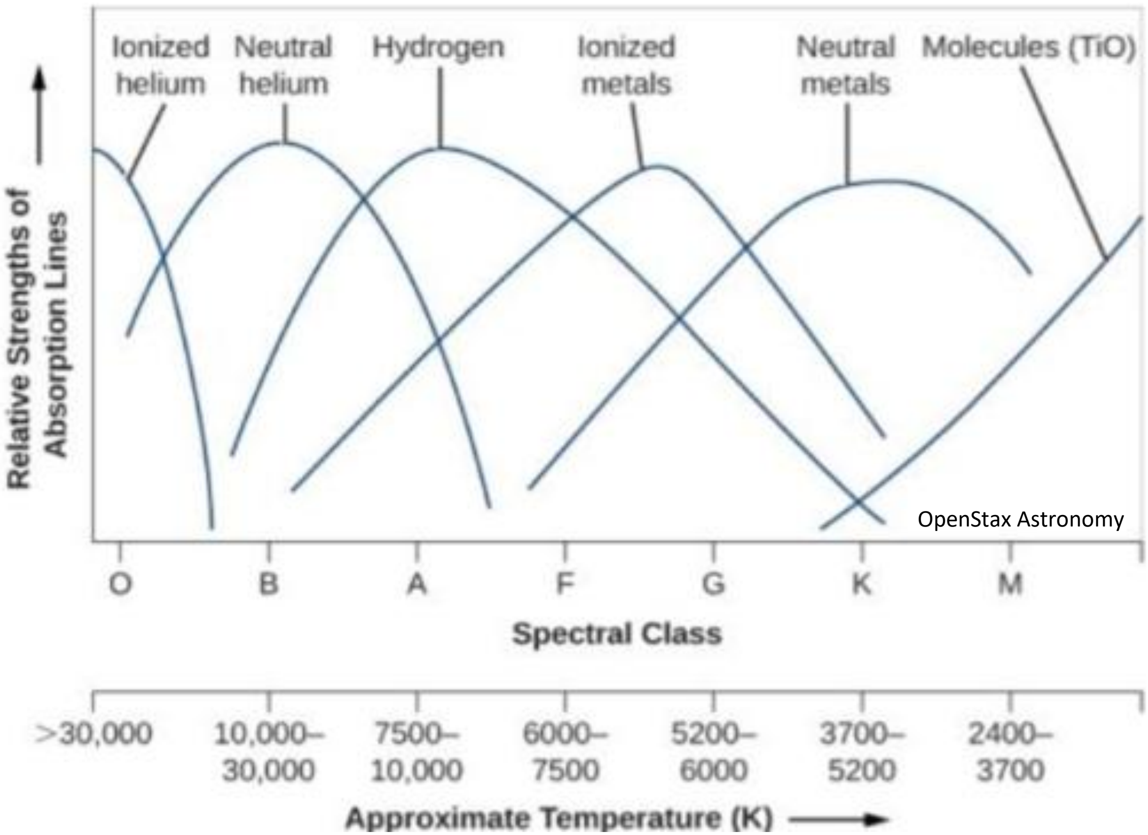
Cecilia Payne-Gaposchkin
(1900-1979)

Reality: All stars are mostly made of hydrogen and helium.

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



Luminosity = Output Power

Stellar luminosity is given by

$$Luminosity = Output\ Power = Intensity\ \times Surface\ Area$$

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→ A hot star is more luminous

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→ A hot star is more luminous

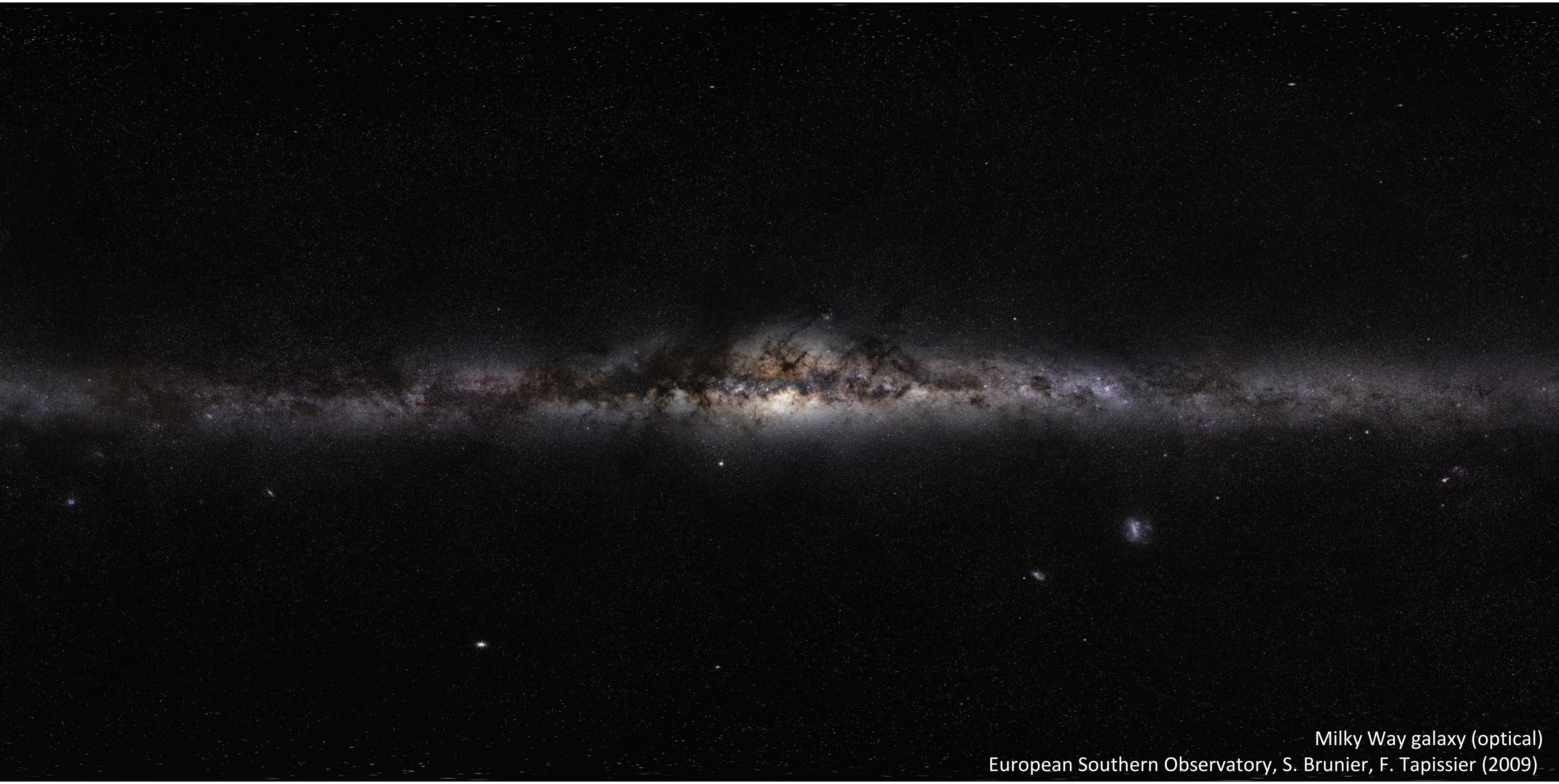
- The surface area of a star is related to its radius, i.e. size:

$$Surface\ Area = 4\pi R^2$$

→ A large star is more luminous

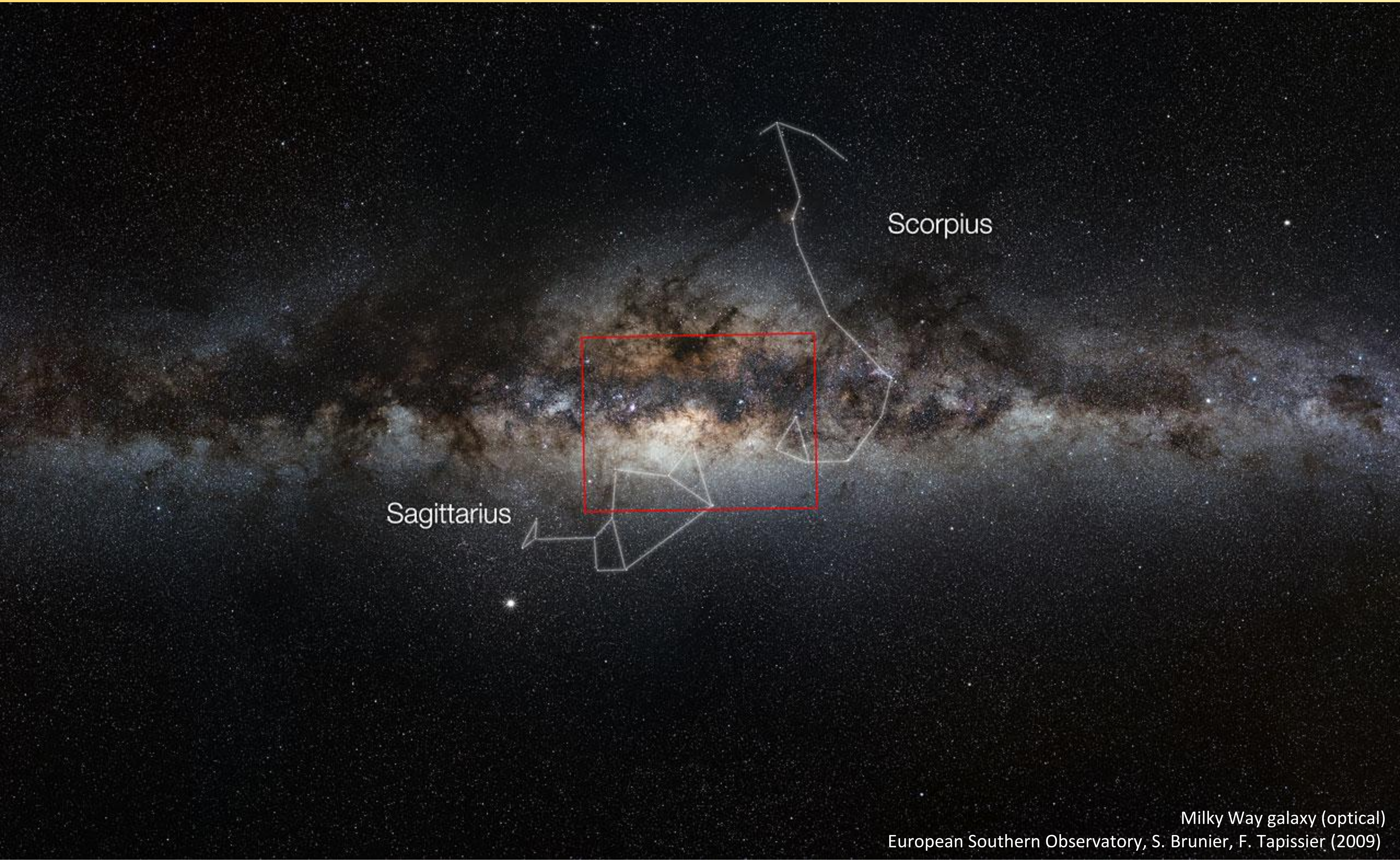
Stellar Census → Stellar Statistics

Our Milky Way galaxy has 100-400 billion stars → a statistical analysis of stars is feasible.



Milky Way galaxy: 360° view.

Stellar Census → Stellar Statistics

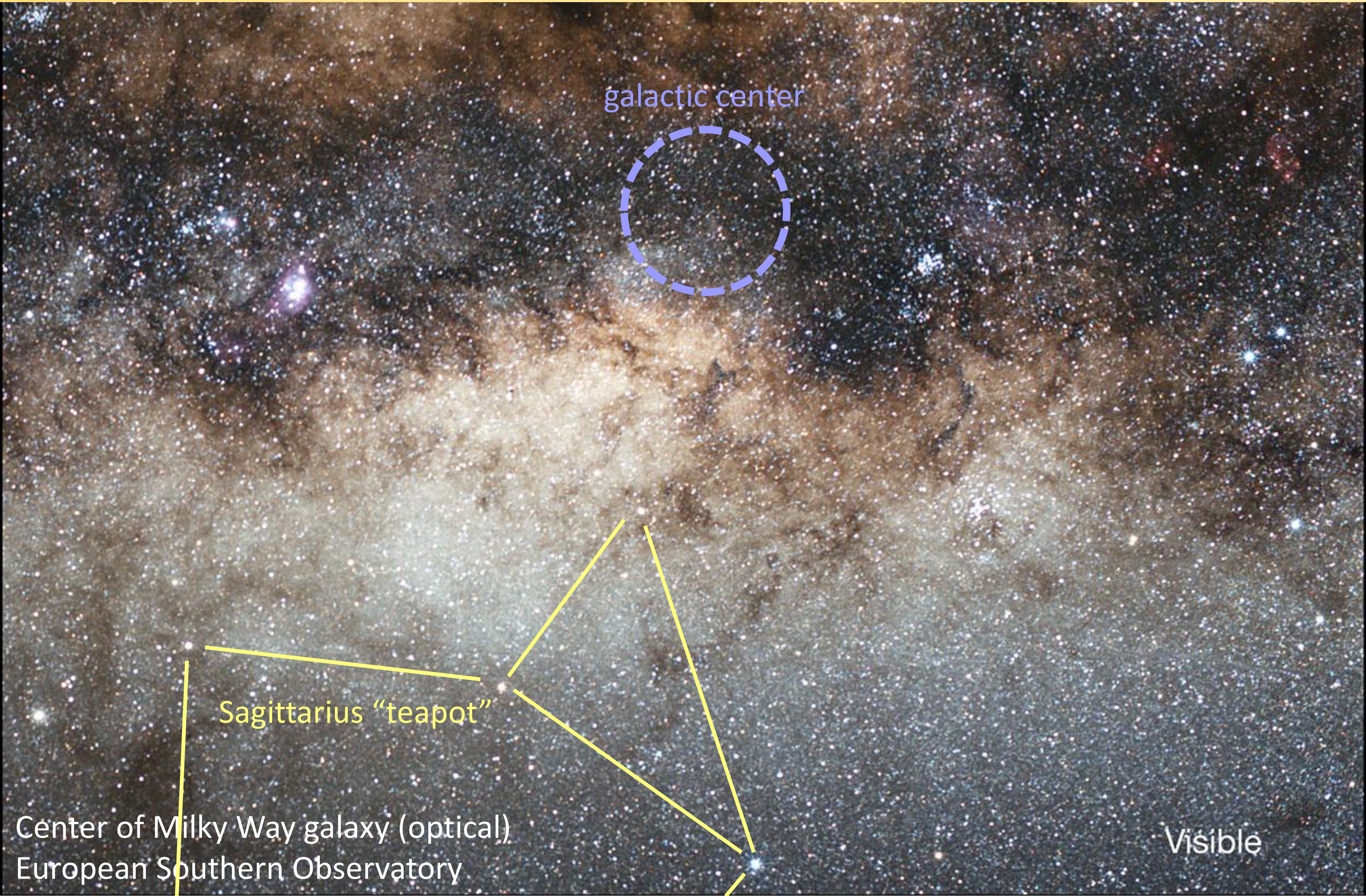


Milky Way galaxy (optical)
European Southern Observatory, S. Brunier, F. Tapissier (2009)

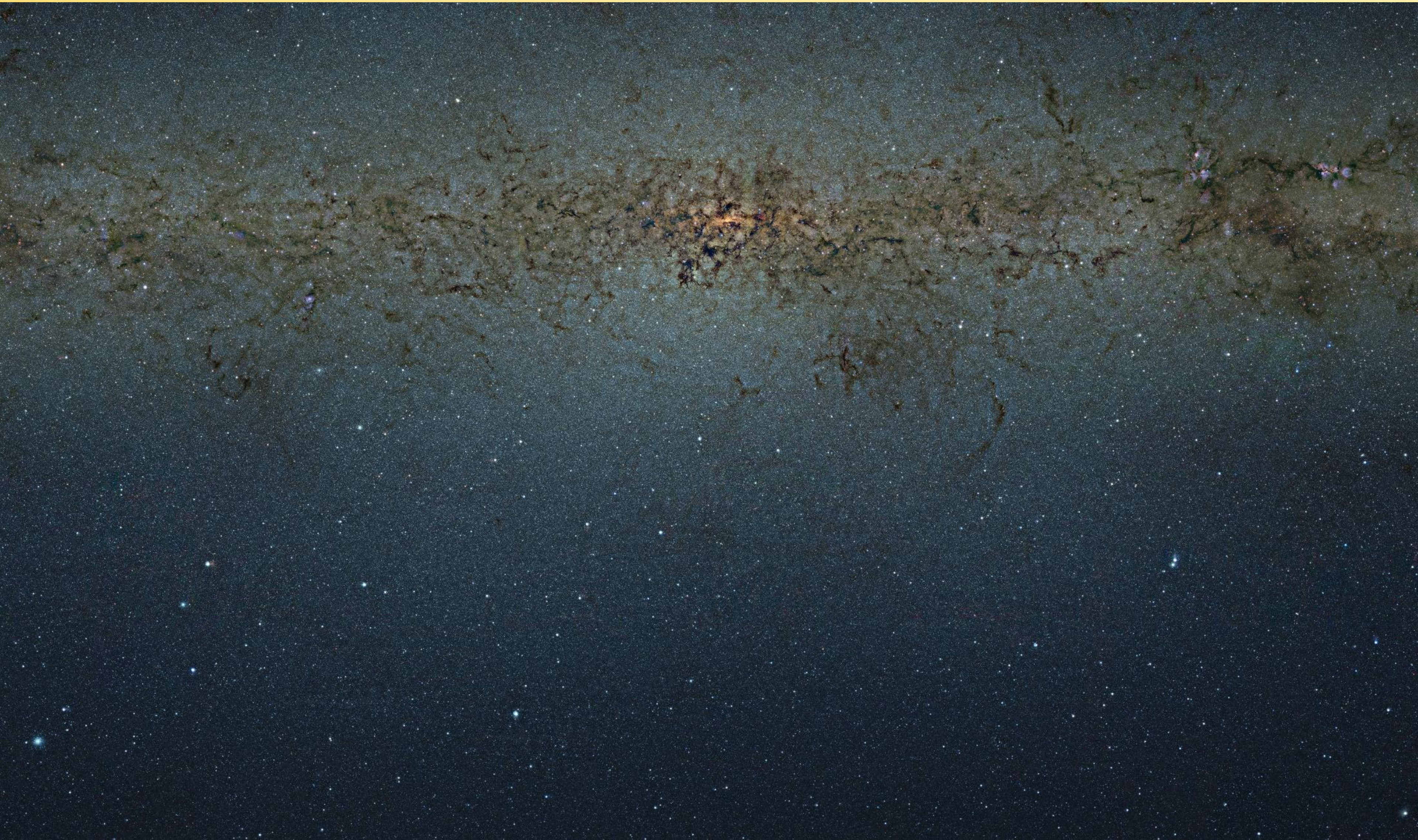
Stellar Census → Stellar Statistics

Center of Milky Way galaxy (optical)
European Southern Observatory

Stellar Census → Stellar Statistics



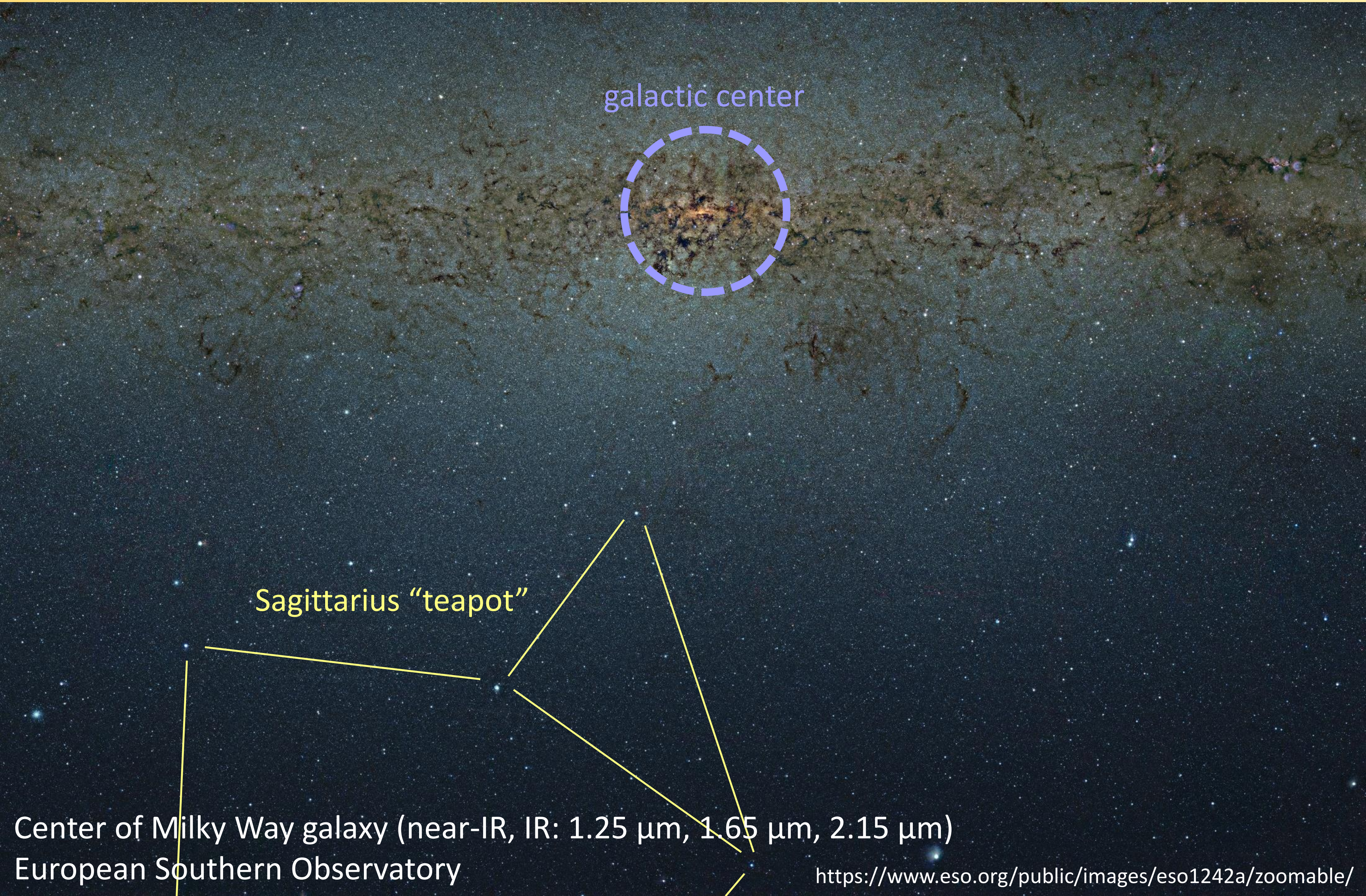
Stellar Census → Stellar Statistics



Center of Milky Way galaxy (near-IR, IR: 1.25 µm, 1.65 µm, 2.15 µm)
European Southern Observatory

https://www.eso.org/public/images/eso1242a/zoomable/

Stellar Census → Stellar Statistics



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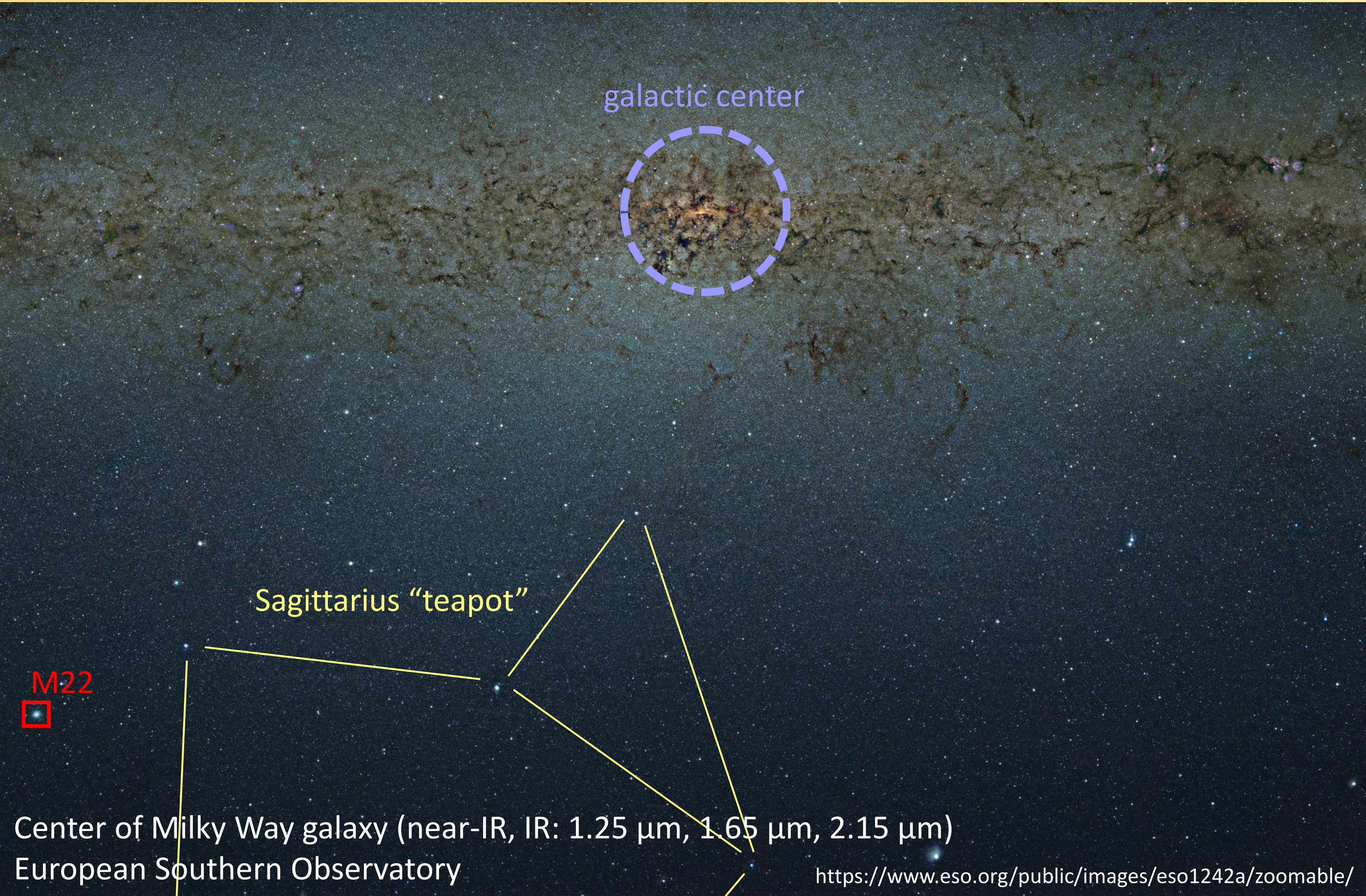

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Stellar Census → Stellar Statistics

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M22 globular cluster, Milky Way galaxy

PollEv Quiz: PollEv.com/sethaubin

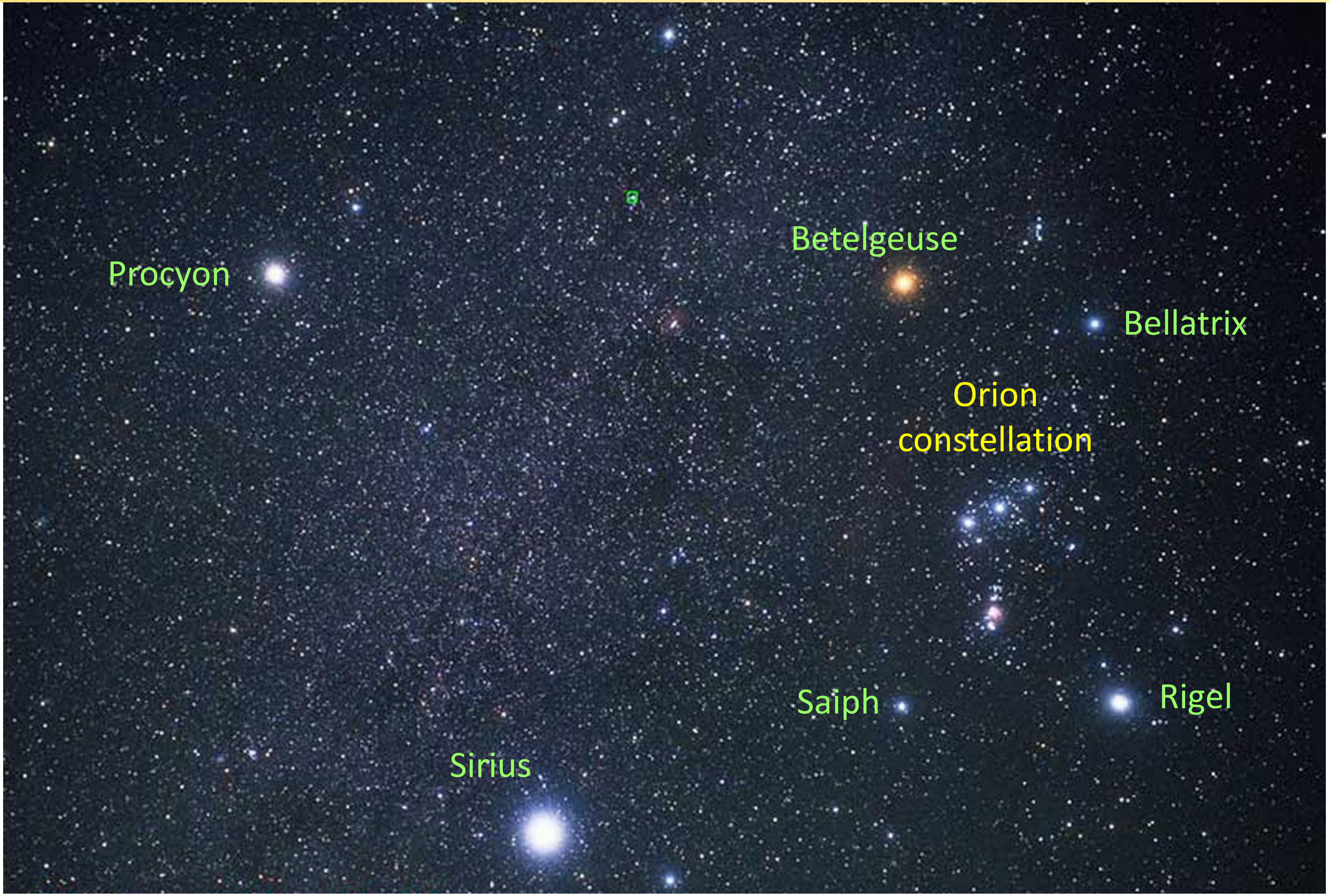
Mass-Luminosity Relation

- Luminosity can be determined by the brightness of star (as seen from Earth) and its distance.

  → *Reminder: distance can be measured by* ***parallax.***

- How do you determine the mass of a star?

About Half of "Stars" are Binary/Trinary Stars



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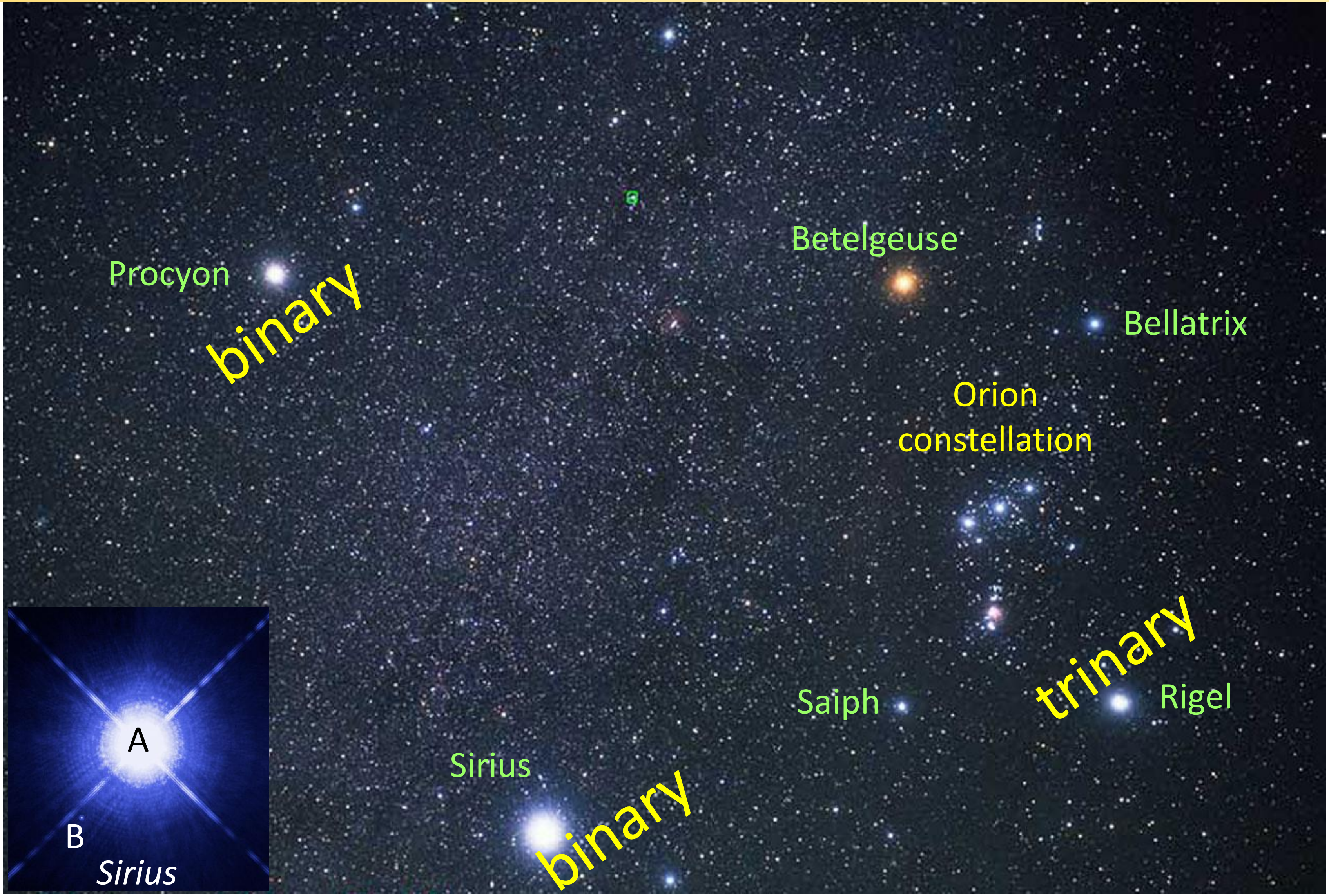

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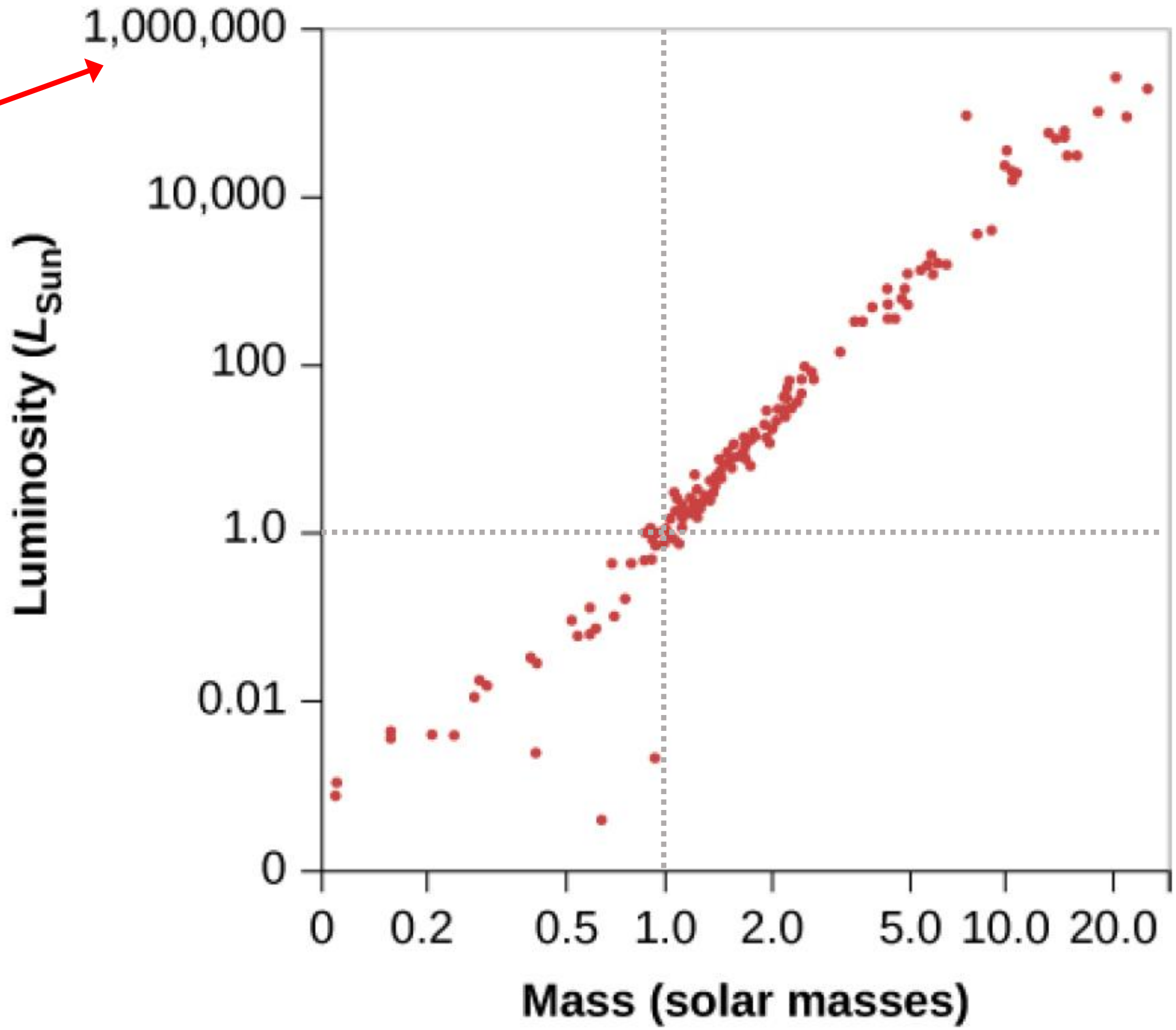
How to Determine Stellar Mass ?

- Use binary star systems.
- Use Kepler's 3rd law (Newton's version) to determine M1 + M2.
- Use observation of center-of-mass to obtain M1/M2.
  (or use Doppler velocimetry)

Mass-Luminosity Relation

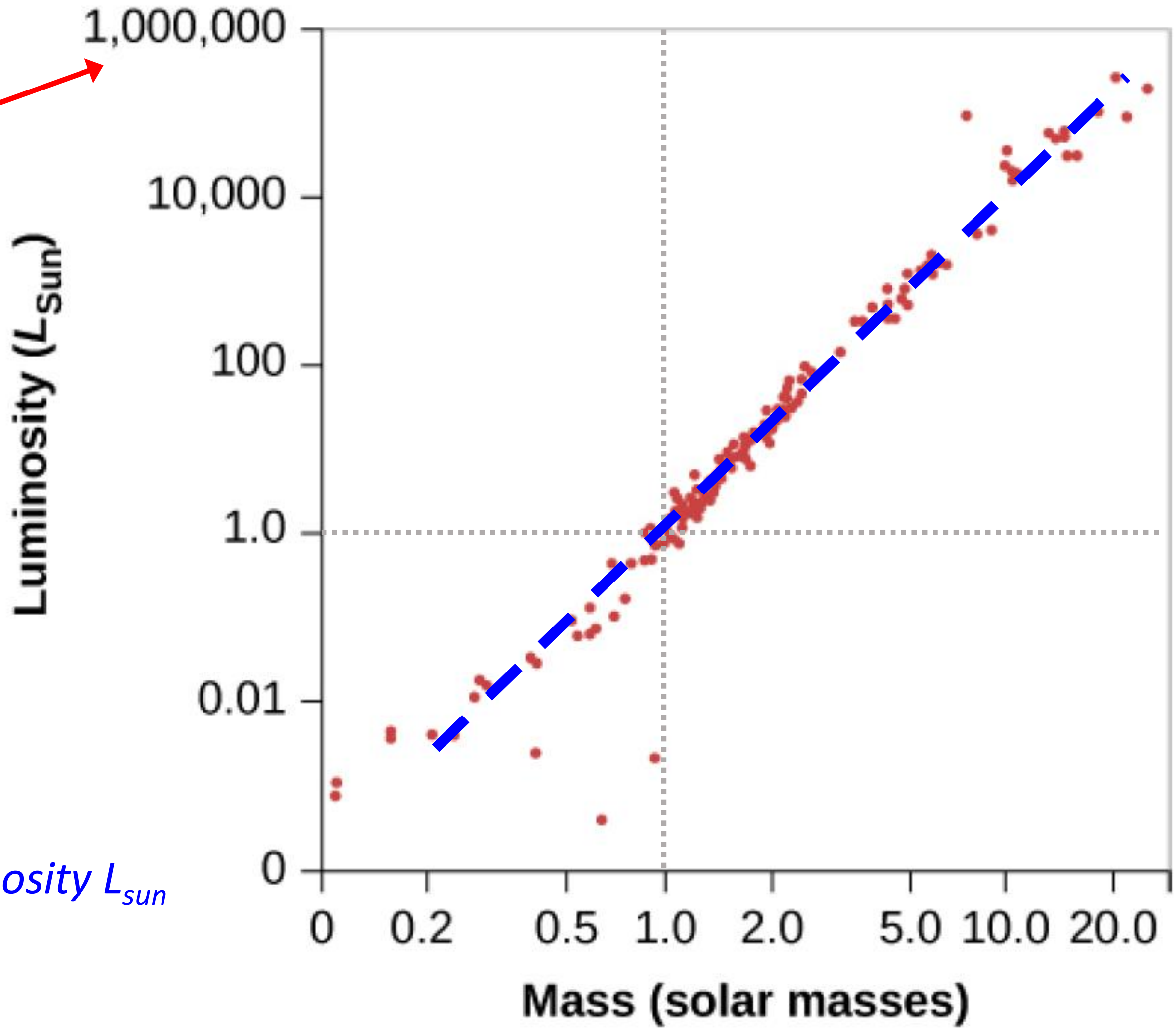
logarithmic scale



Main sequence stars (not white dwarfs or red giants)

logarithmic scale

Mass-Luminosity Relation



logarithmic scale

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Main sequence stars (not white dwarfs or red giants)

Units: Solar Luminosity L_{sun}

$$Luminosity \sim Mass^{3.9}$$

Units: Solar Mass M_{sun}