Lecture 4 Topics

Friday, January 30, 2026 (Week 1, lecture 4) – Chapter 3.

1. Some stars and constellations

2. Kepler's Laws

Problem Set #2 on ExpertTA due Friday, February 6 by 9:00 am.

Constellations

- **Constellation:** Named grouping of stars that often represents a mythological character/creature.
- Various groupings have been proposed by ancient civilizations.
  → Examples: Chinese, Egyptian, Greek, etc.

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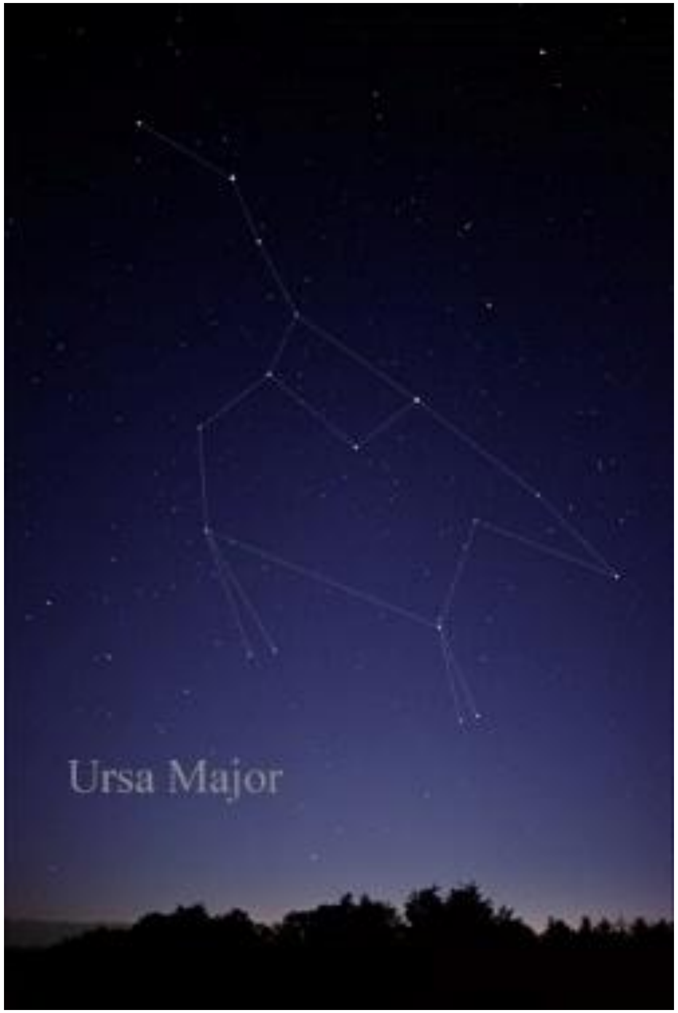
Easy-to-use constellation & star finder: https://stellarium-web.org/

Ursa Major, Big Dipper, Polaris



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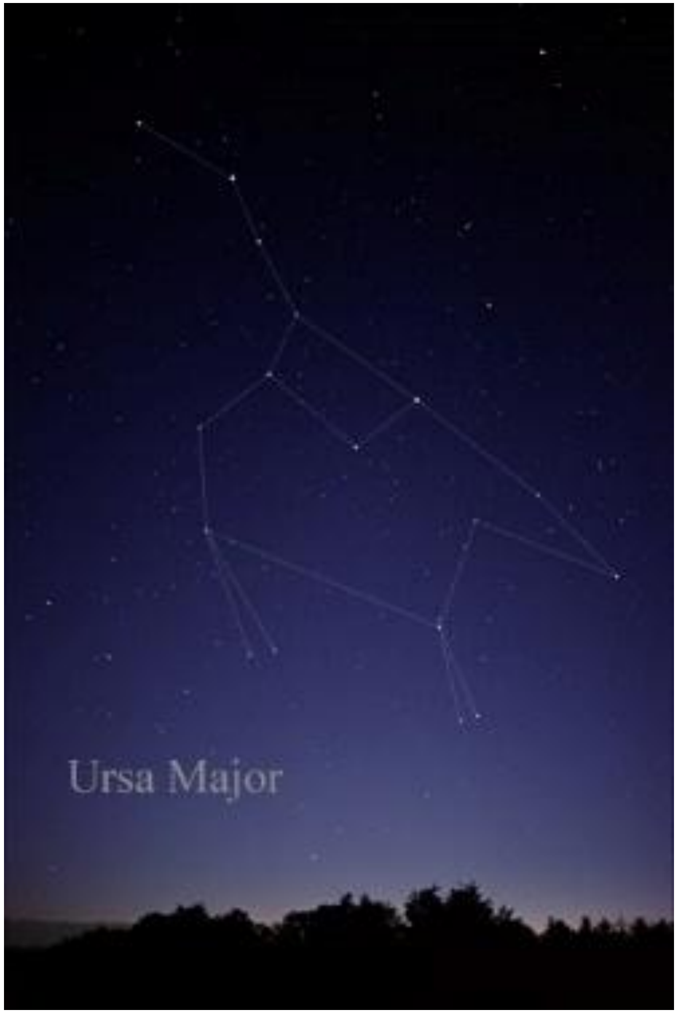
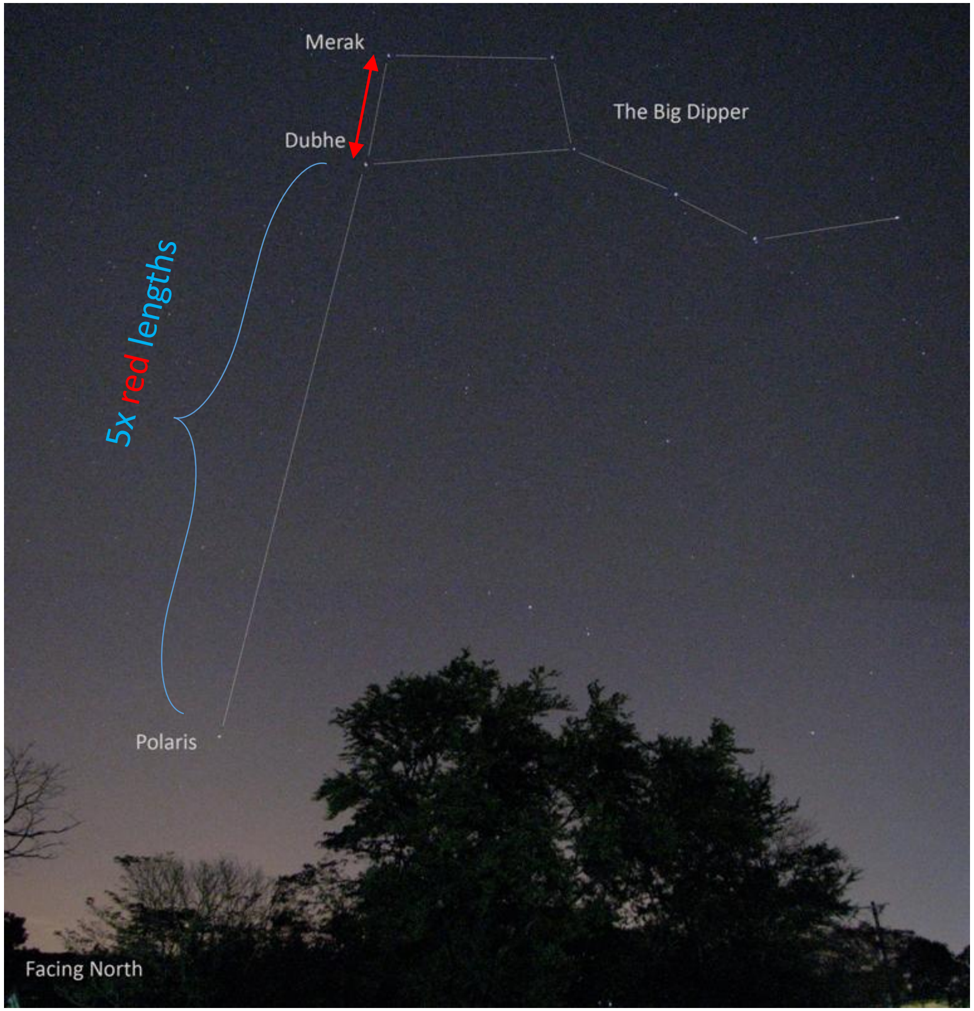


By Till Credner - Own work: AlltheSky.com, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=20042019



Source: https://thenightskyinfocus.files.wordpress.com/2012/02/polaris21.jpg

Ursa Major, Big Dipper, Polaris

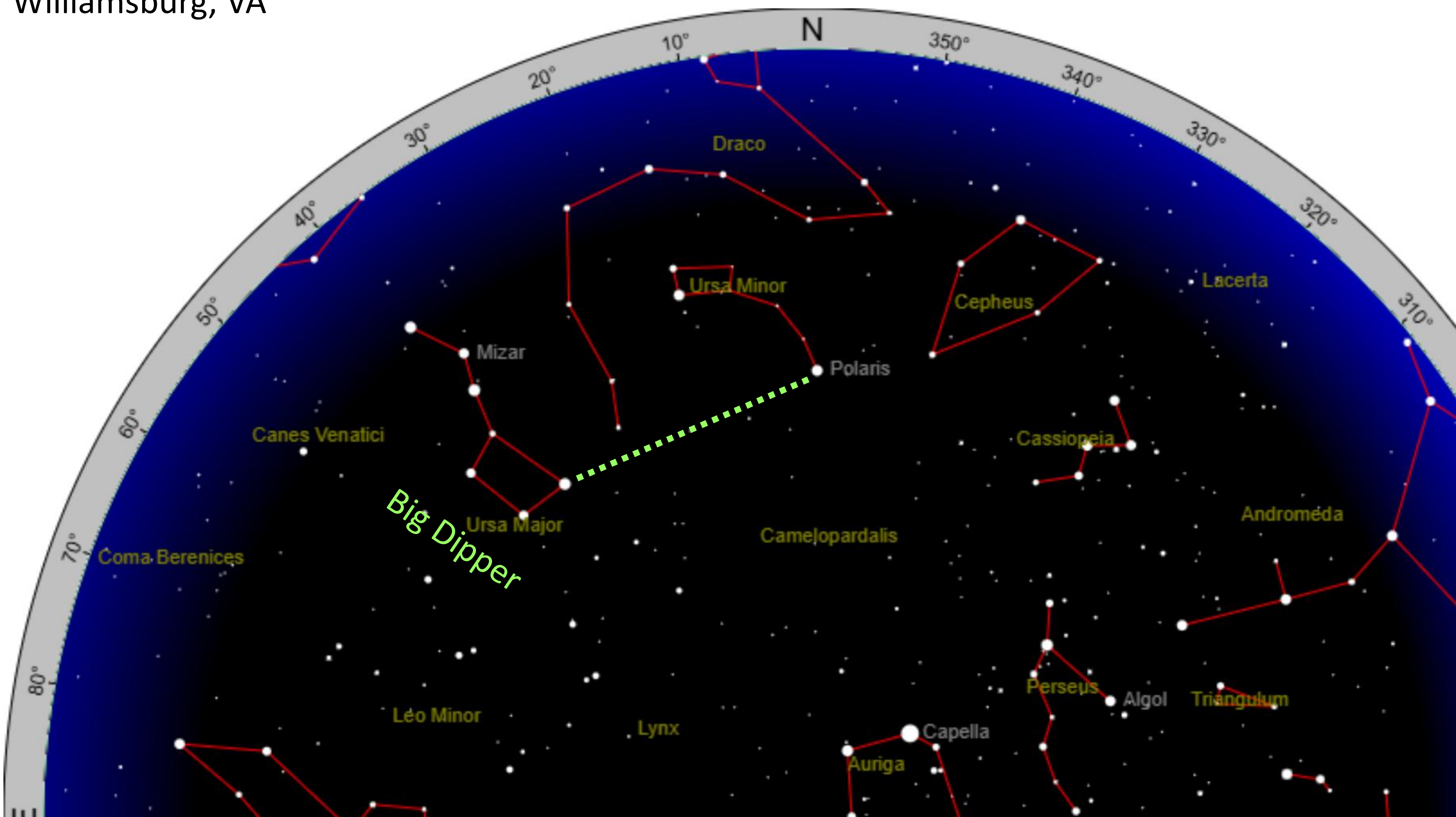
The celestial sphere always “rotates” around the star **Polaris**.

[Source: https://epod.usra.edu/blog/2013/05/earths-rotation-and-polaris.html]

Cassiopeia & Andromeda

Star chart
9:45 pm January 31, 2025
Williamsburg, VA

Source:
https://openstaxcollege.org/l/30heavensabove



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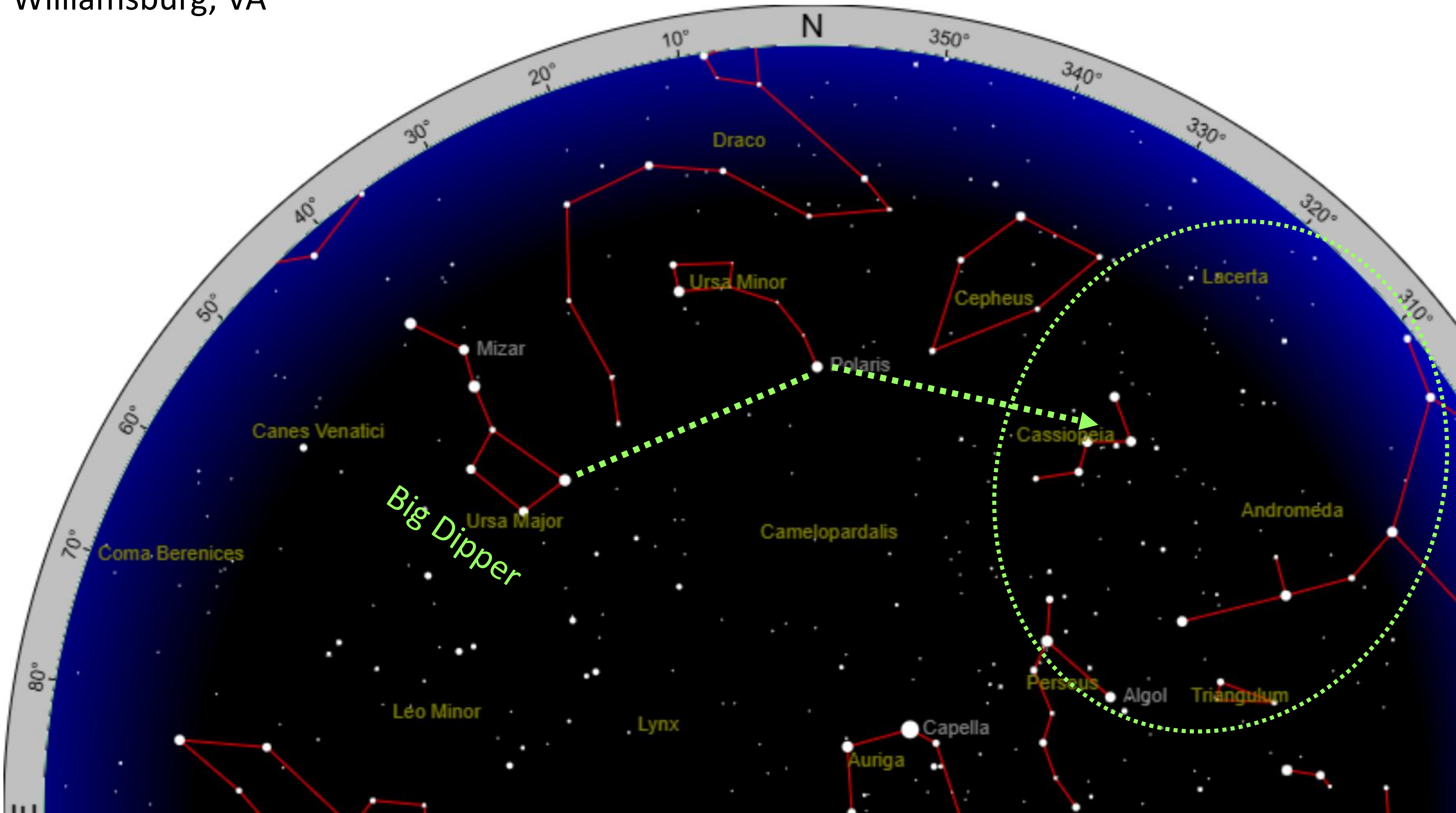

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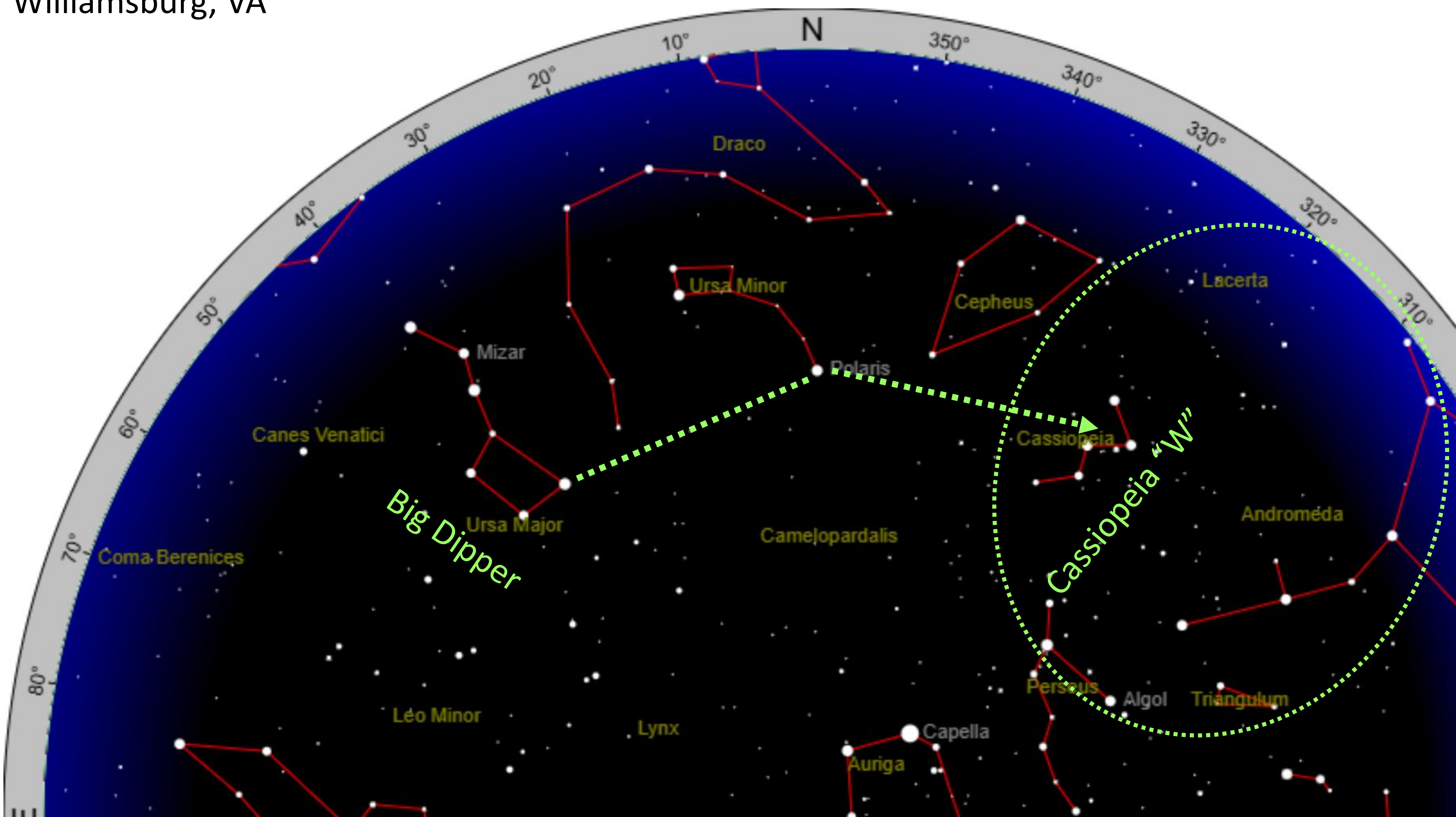

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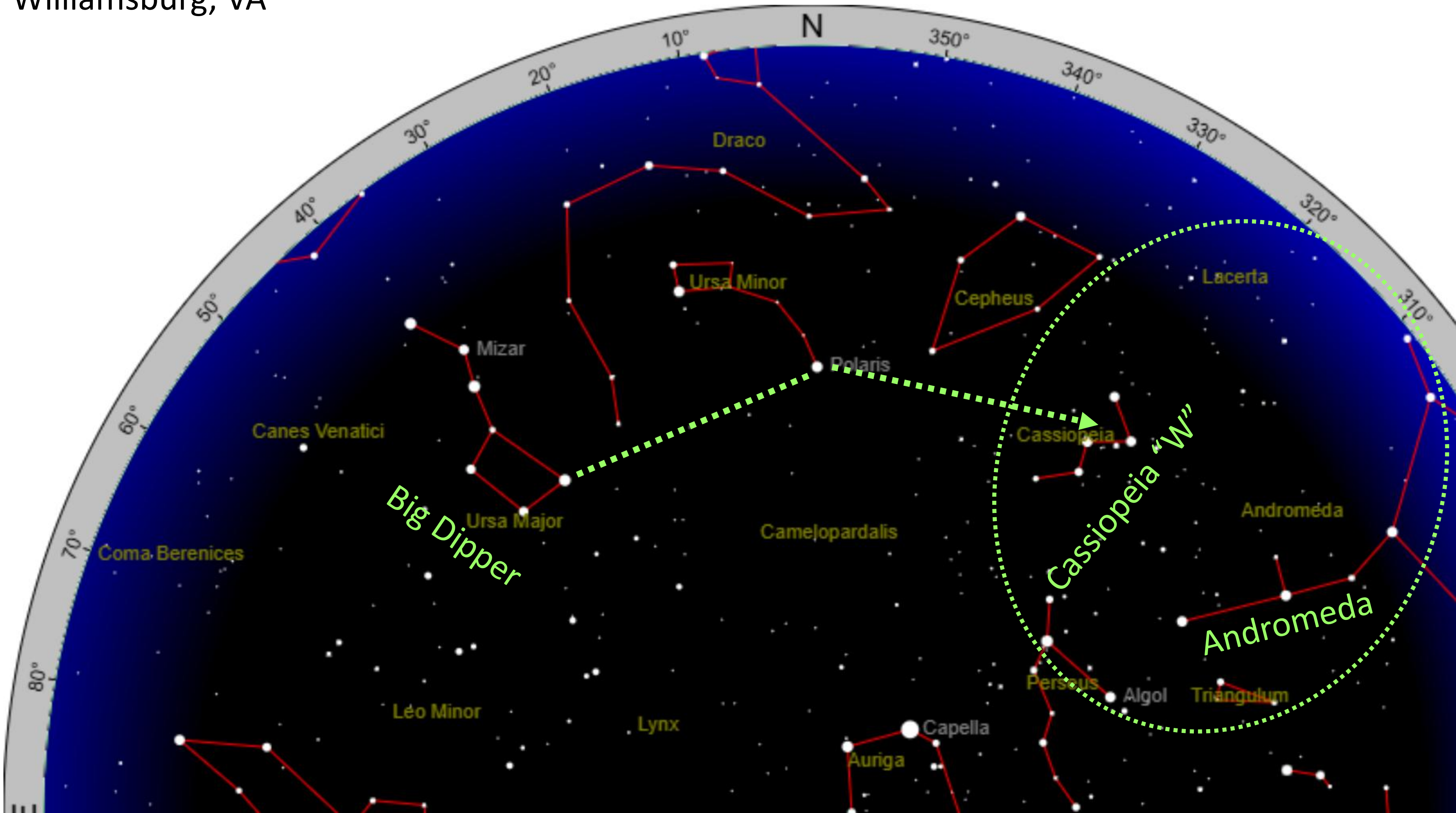

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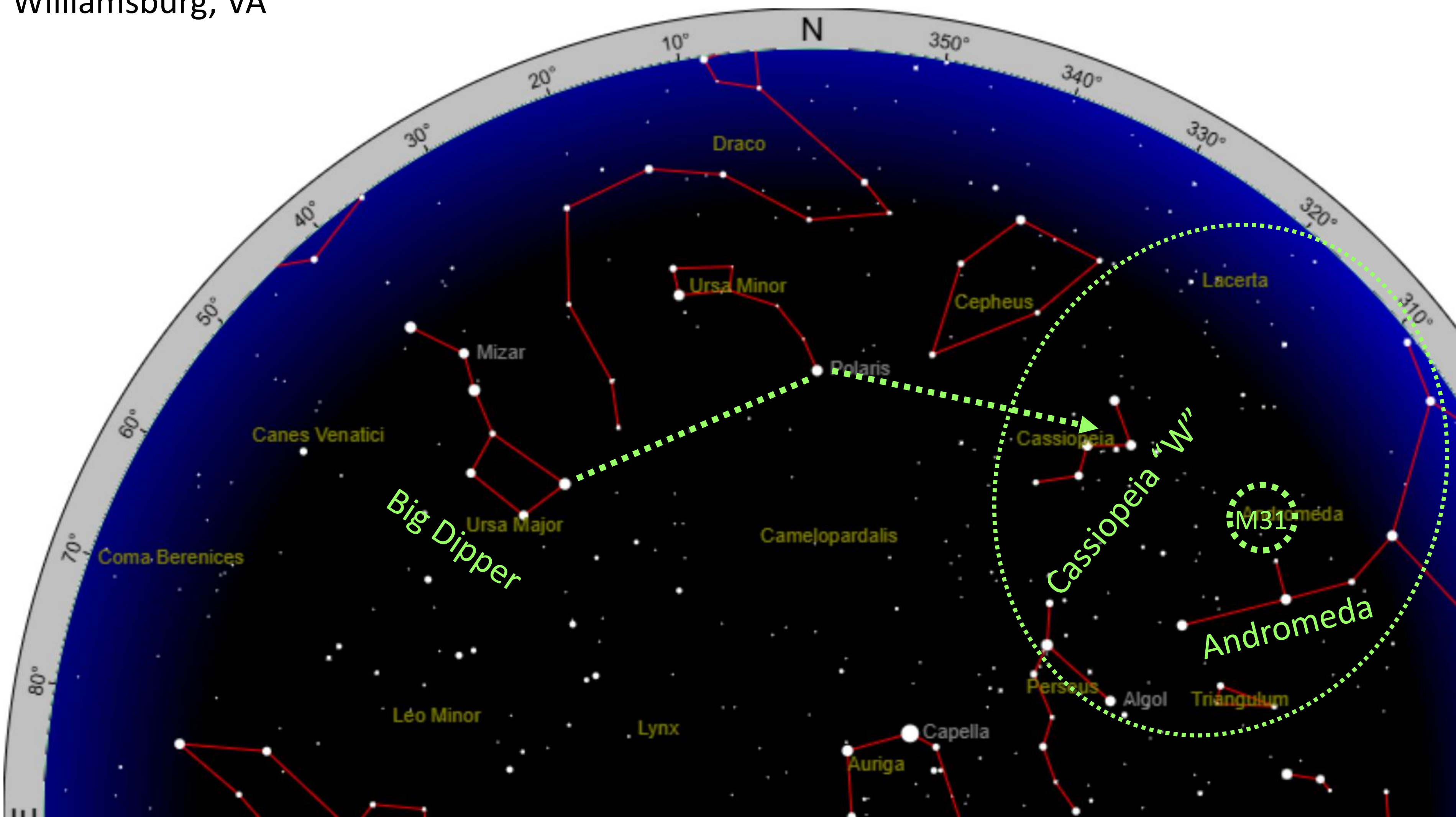

M31: Andromeda Galaxy

[Source: Facebook/Ted Van]

M31: Andromeda Galaxy

- Nearest large galaxy
- Distance: 2.5 Mly
- Diameter: 220 kly
- Size in sky: ~ 5°
- ~ 1 trillion stars

[OpenStax: Adam Evans]

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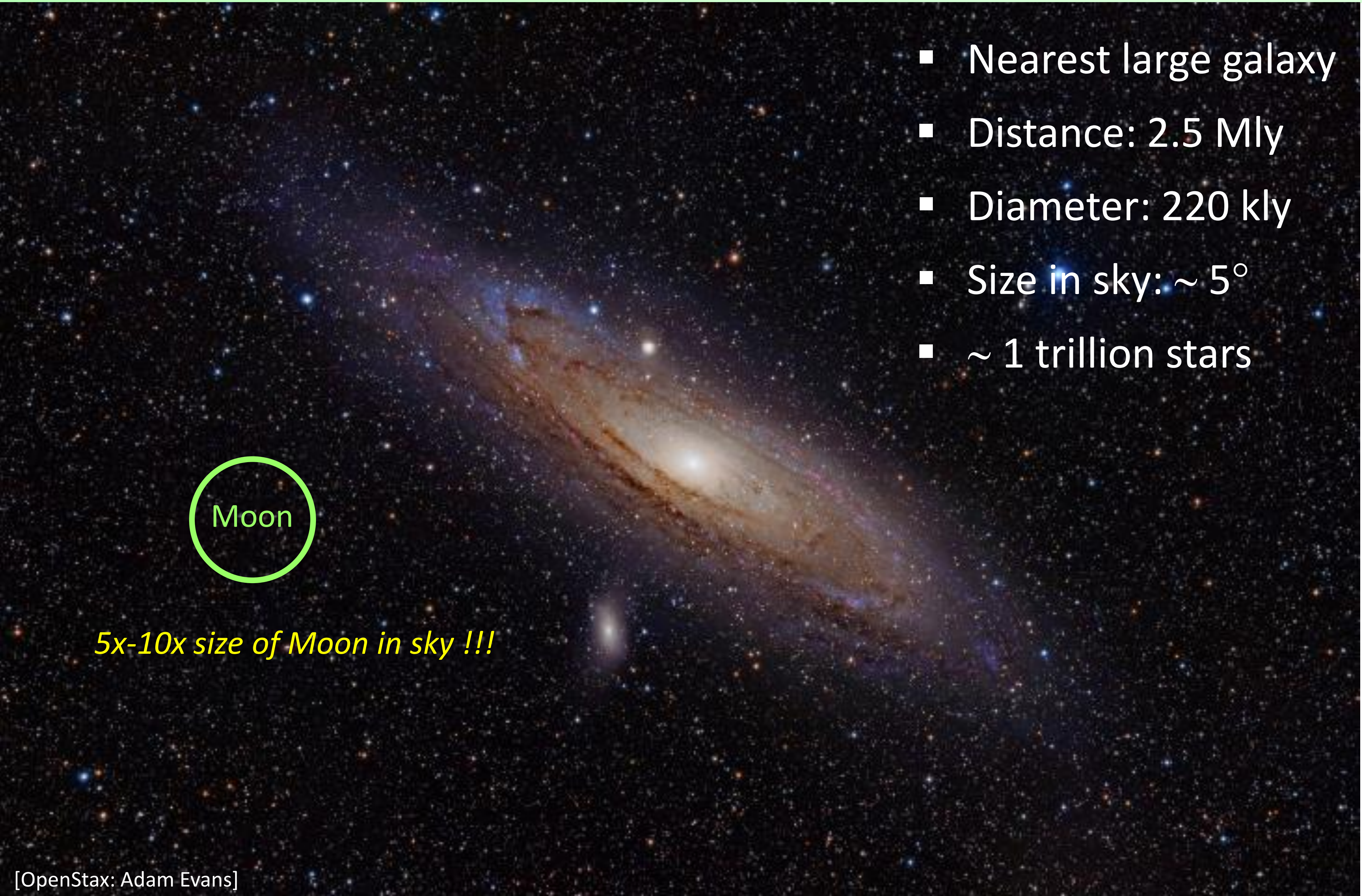

[OpenStax: Adam Evans]

Orion

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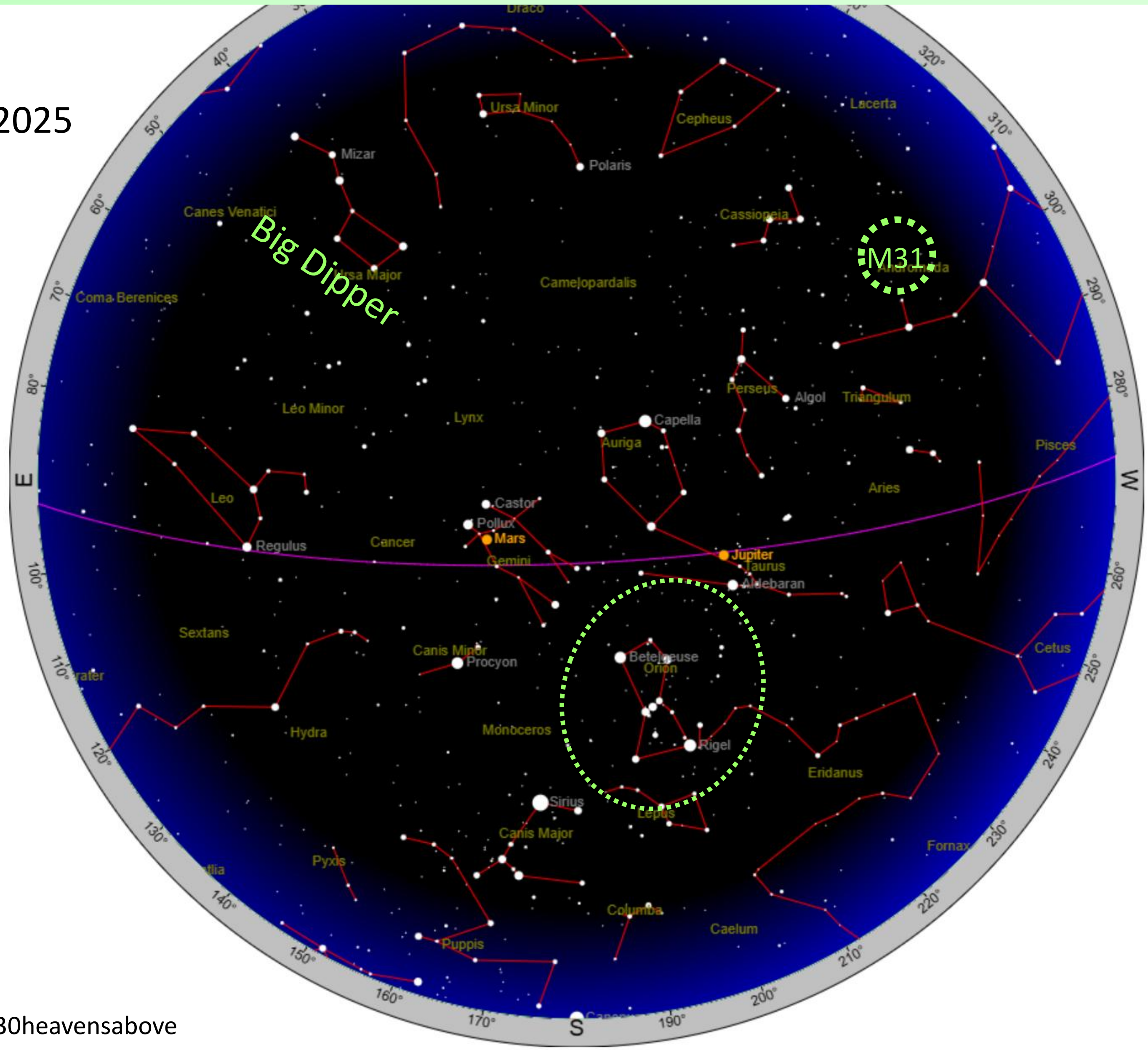

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Orion

By Till Credner - Own work: AlltheSky.com, CC BY-SA 3.0,
https://commons.wikimedia.org/w/index.php?curid=20041769

Orion

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

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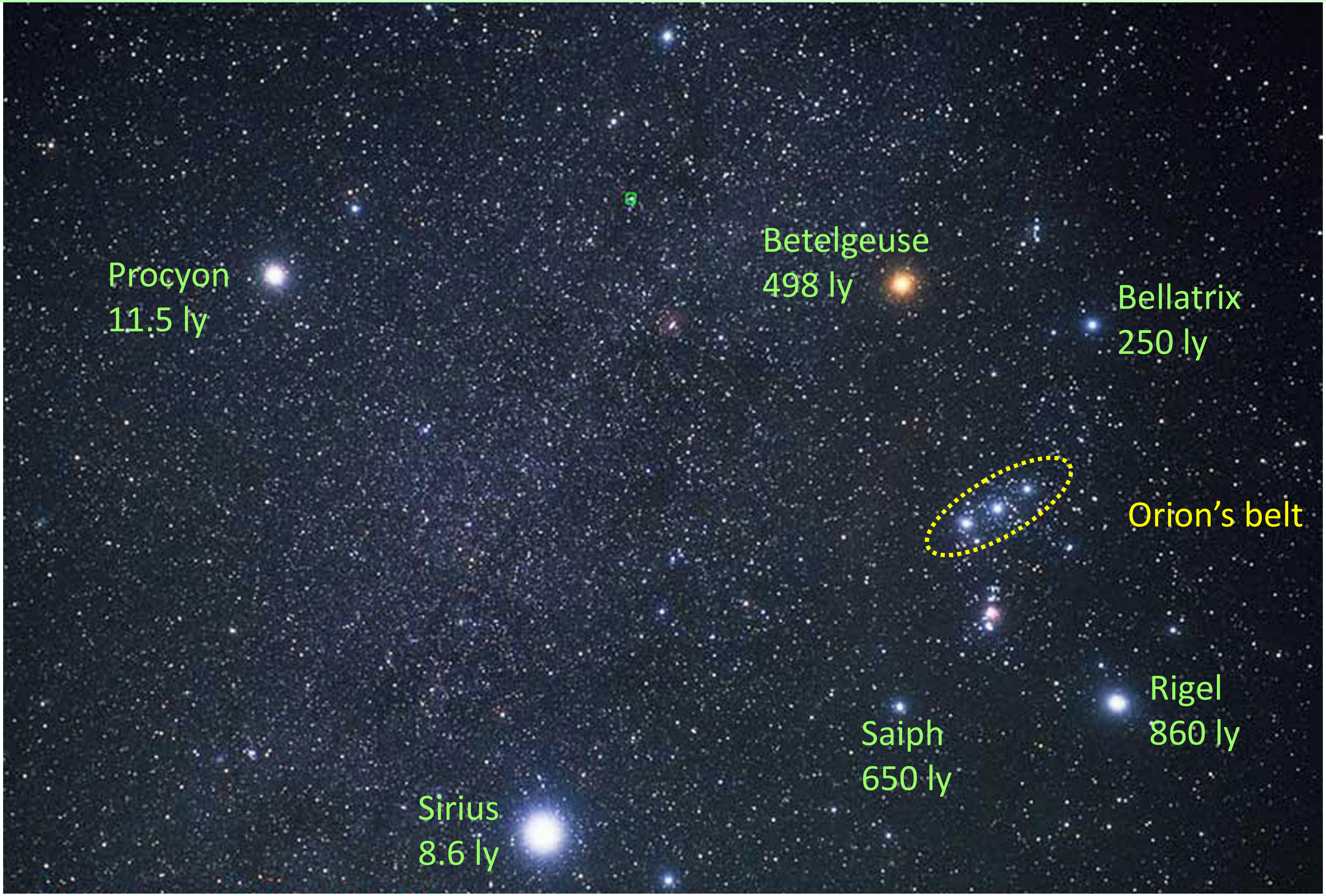

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Orion & Barnard's Loop

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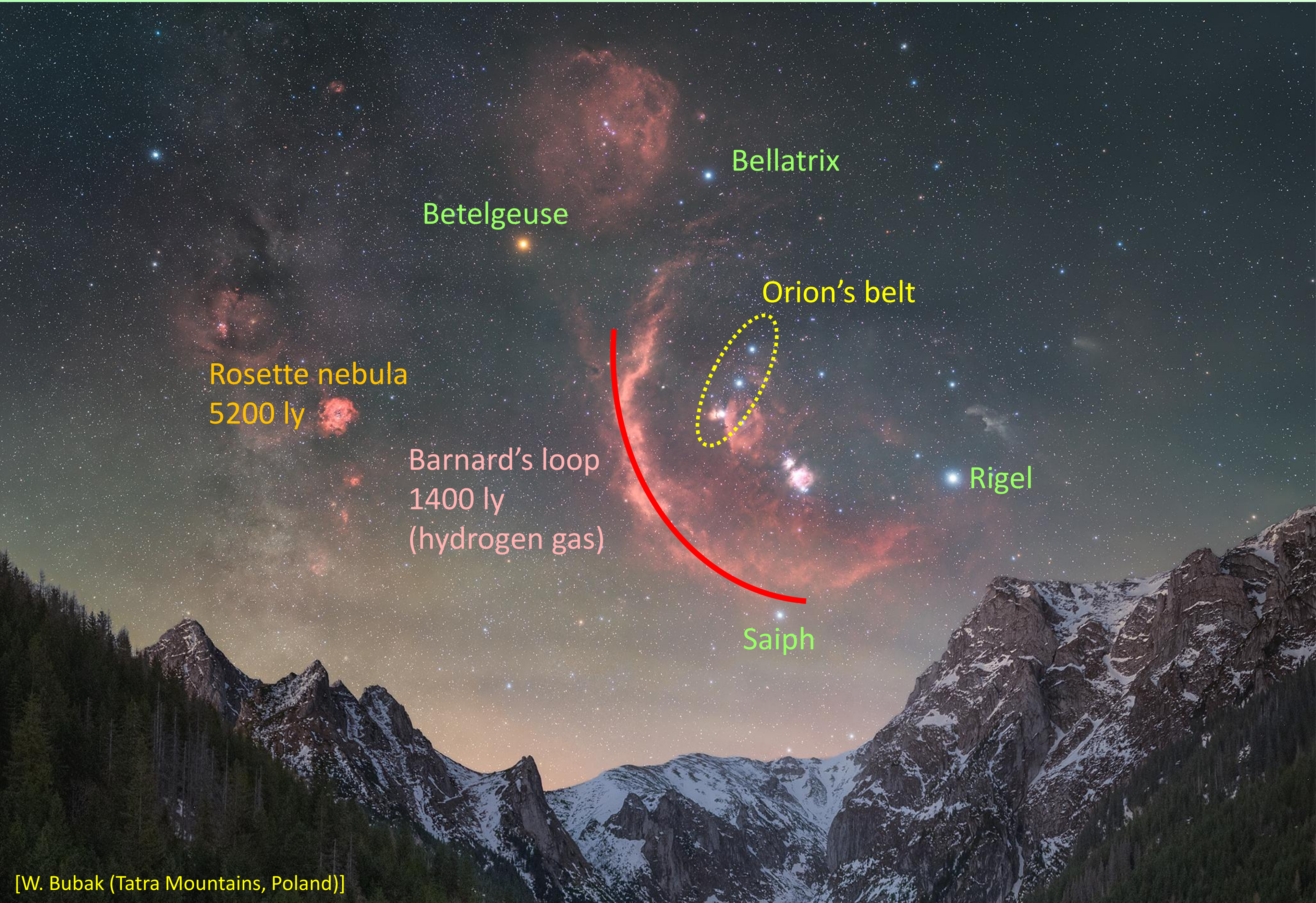
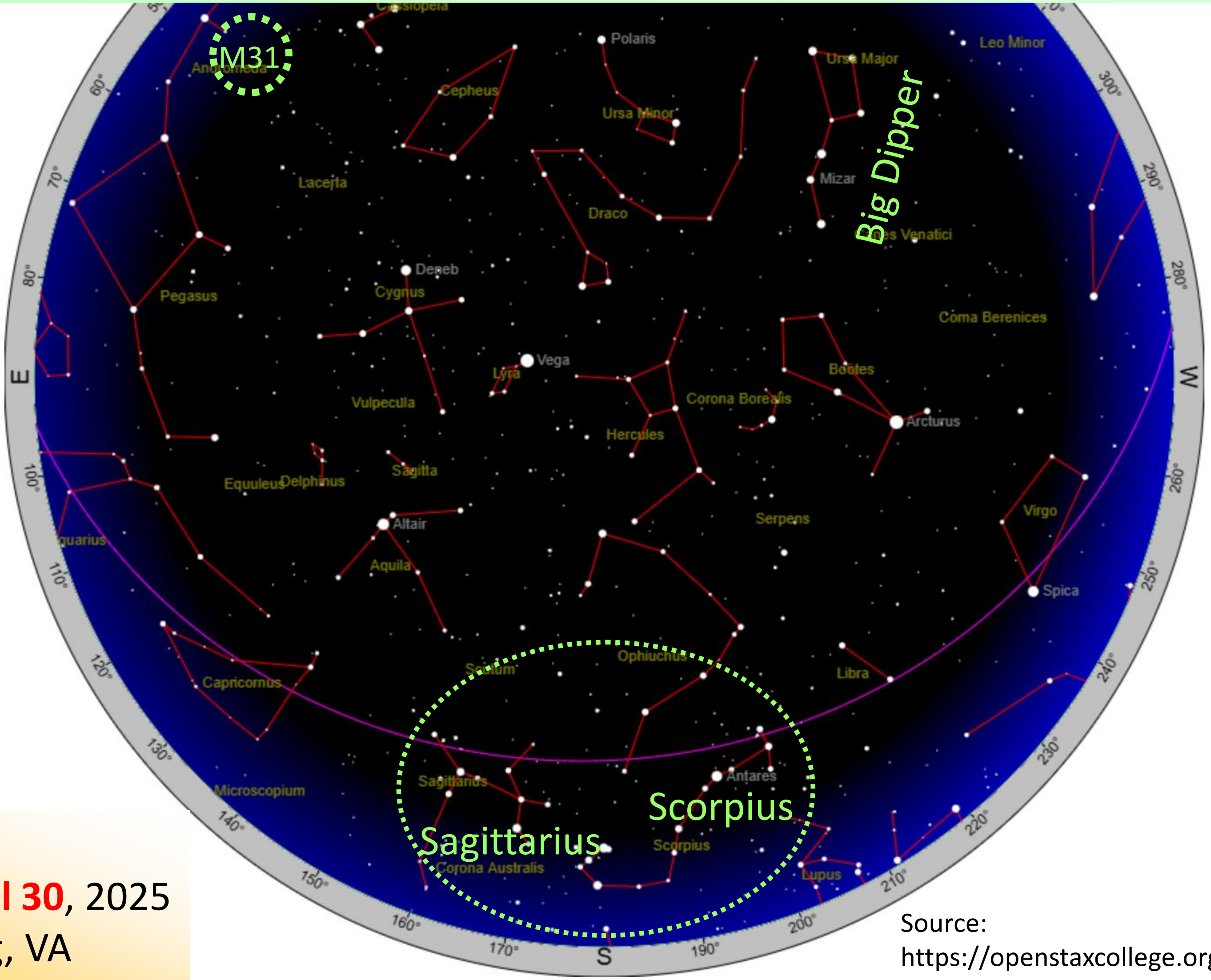


[W. Bubak (Tatra Mountains, Poland)]

Center of the Milky Way Galaxy

Sagittarius & Scorpius



<u>Star chart</u>
4:00 am **April 30**, 2025
Williamsburg, VA

Source:
https://openstaxcollege.org/l/30heavensabove

Sagittarius "Teapot"

[NASA, ESA/Hubble: Terrence Dickinson]

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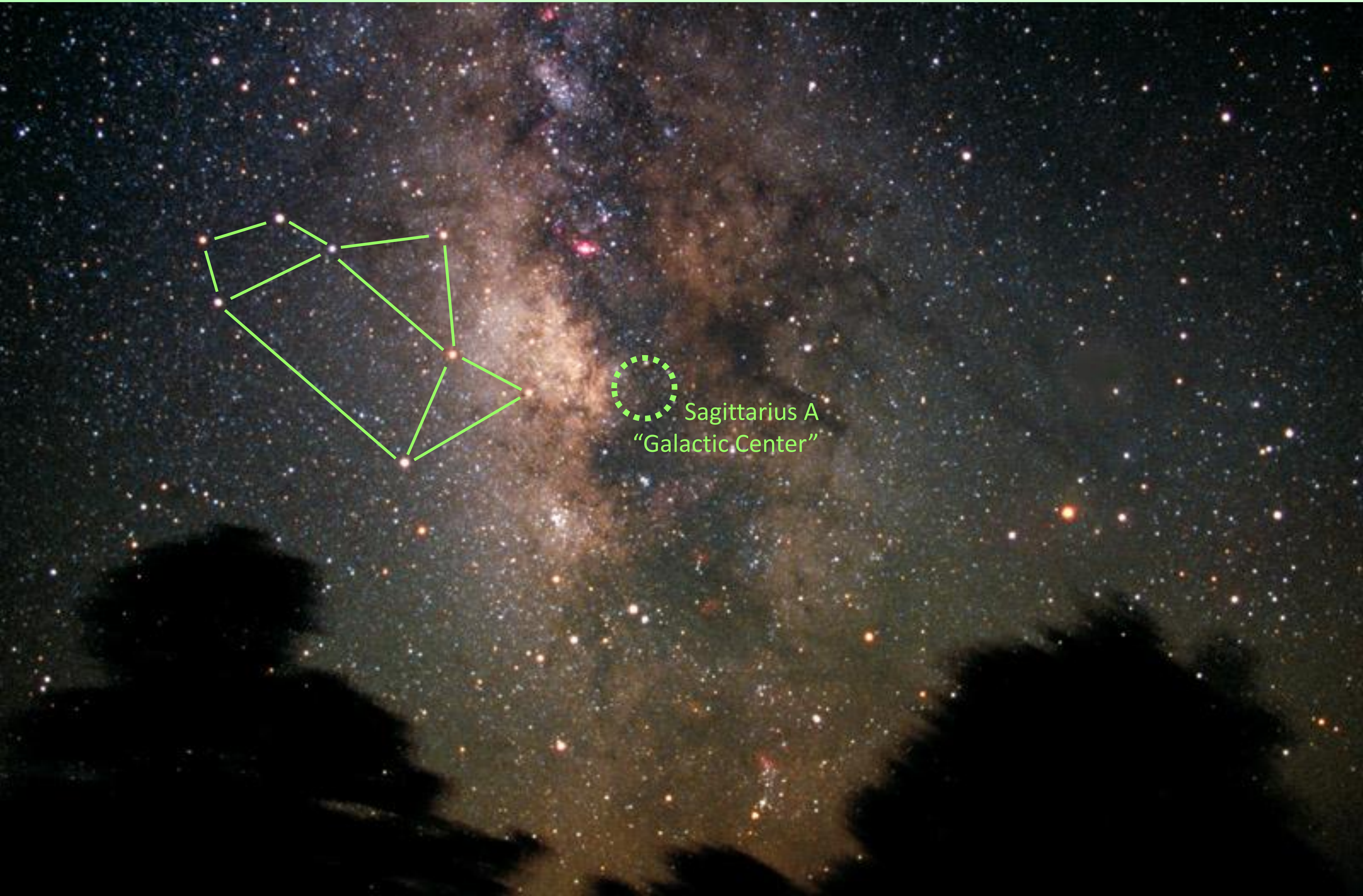

Southern Hemisphere

Crux & "Southern Cross" (asterism)

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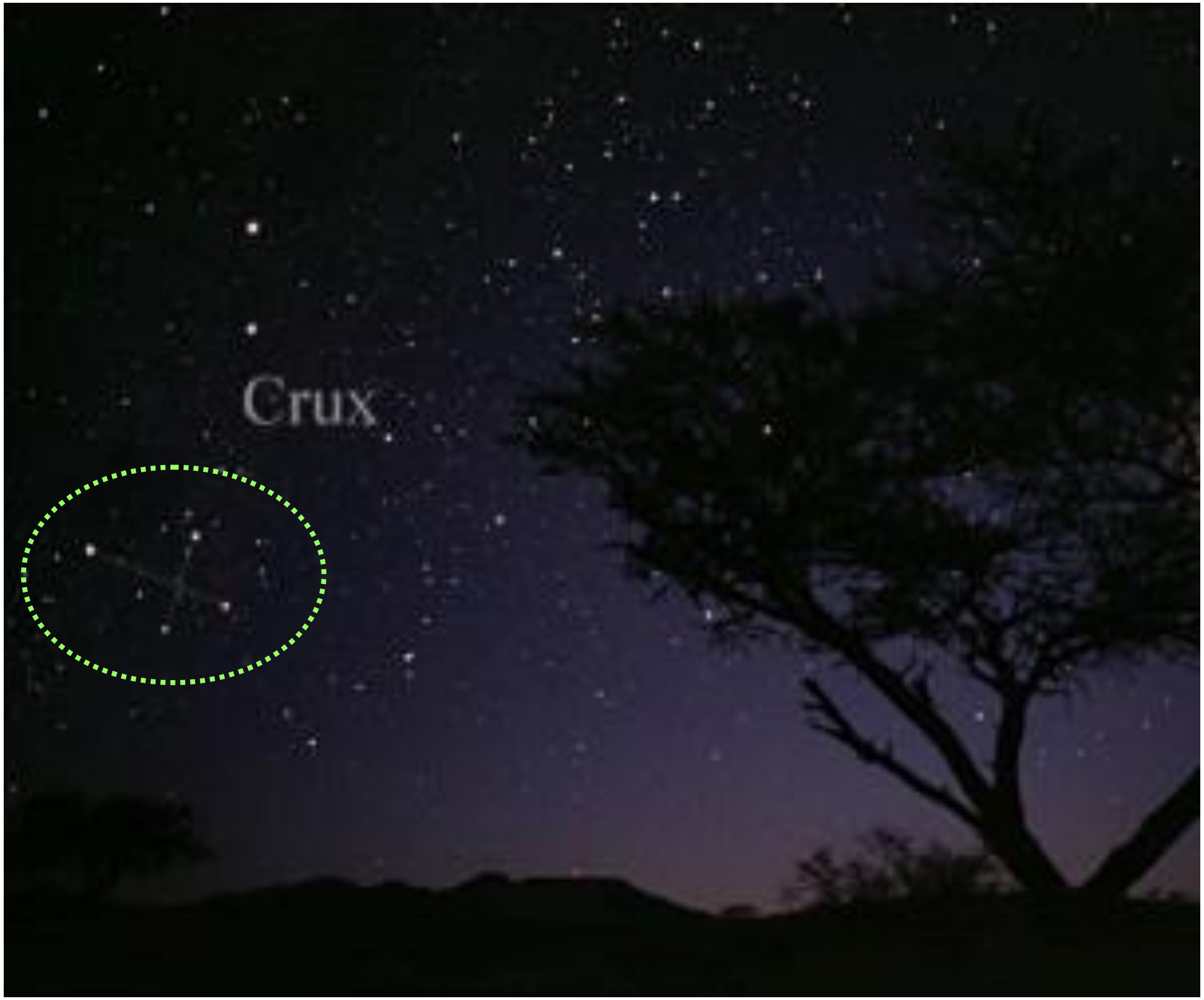

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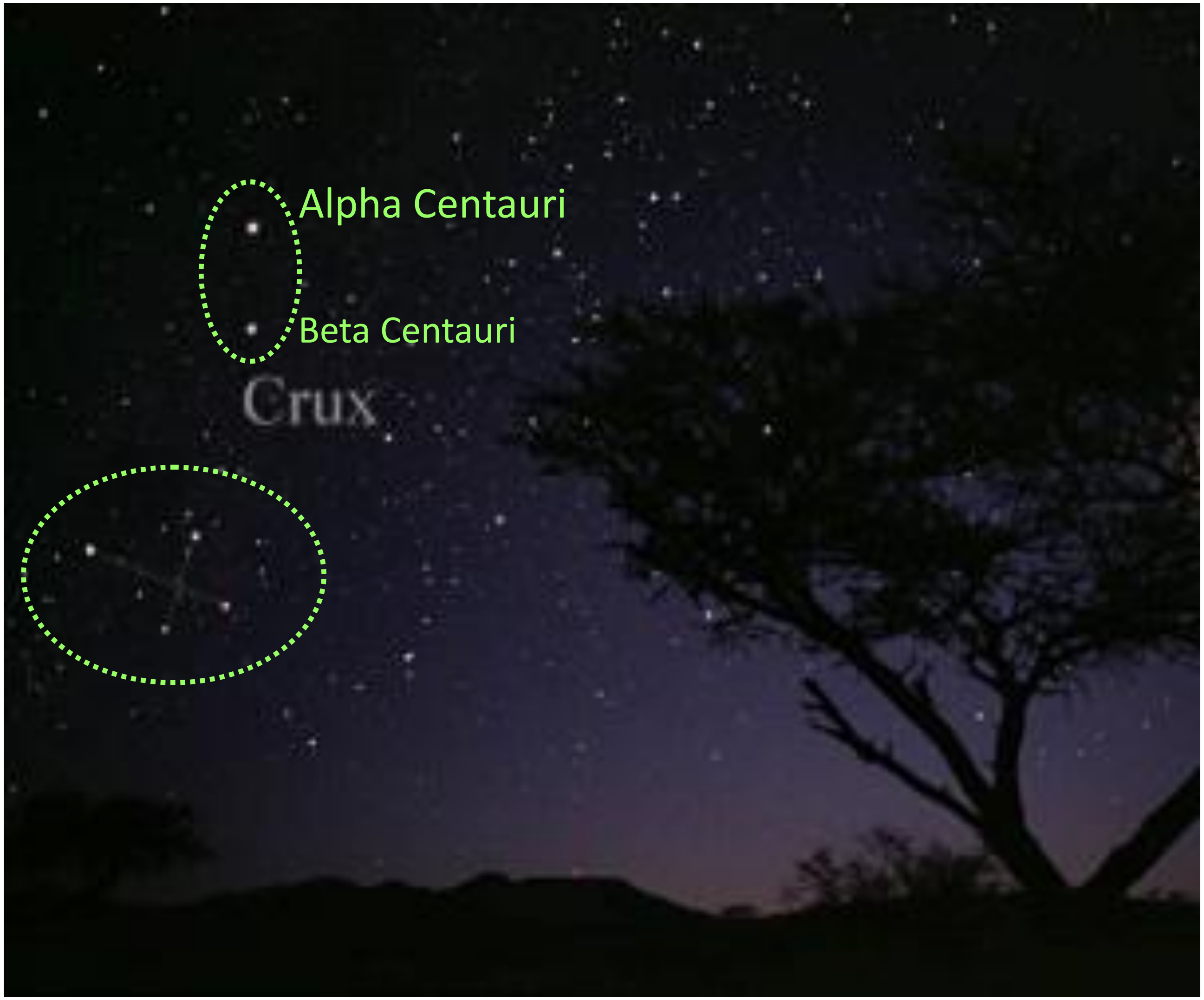


Kepler's Laws

of Planetary Motion

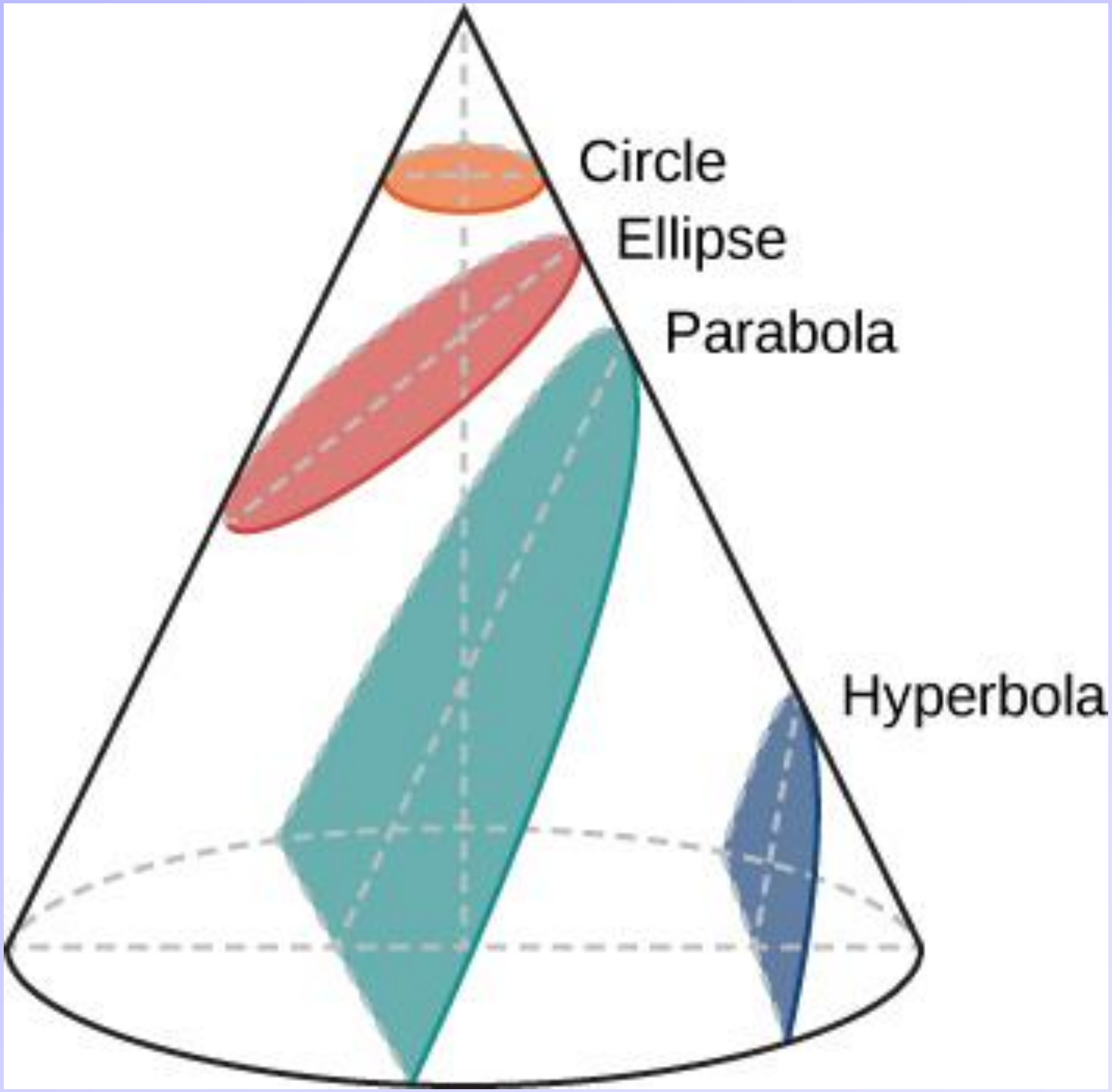
1st Law: The orbits of all planets are **ellipses**.

2nd Law: Law of **equal areas**.

3rd Law: $(\text{orbital period})^2 = (\text{semimajor axis})^3$

[**fine print:** the "=" depends on units used]

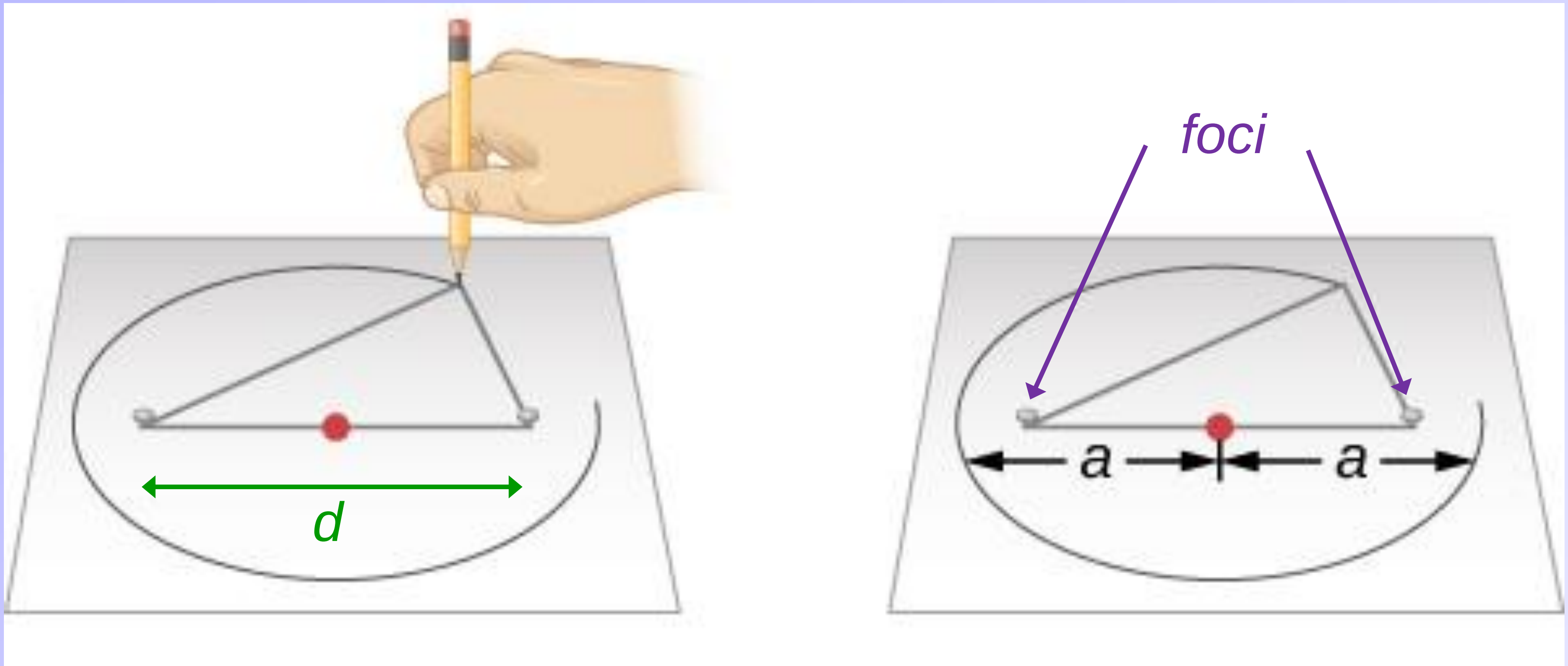
Kepler's 1st Law – Conic Sections



The **circle**, **ellipse**, **parabola**, and **hyperbola** are all formed by the intersection of a plane with a cone.

Note: Unbound orbits can be parabolic or hyperbolic.

Kepler's 1st Law -- Ellipses

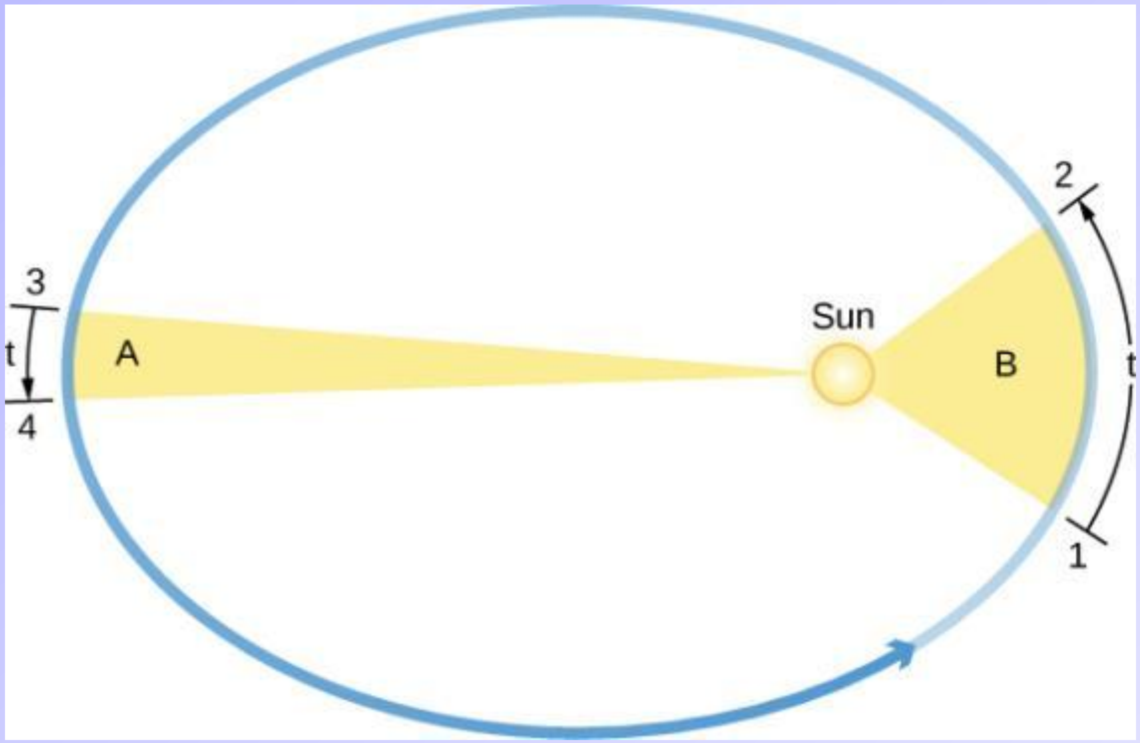


- Sun sits at one of the foci.
- Other focus is empty.

a = semimajor axis

Eccentricity $= \varepsilon = \dfrac{d}{2a}$

Kepler’s 2nd Law



The Law of Equal Areas. The orbital speed of a planet traveling around the Sun varies such that in equal intervals of time *t*, a line between the Sun and a planet sweeps out equal areas (area A = area B).

PollEv Quiz: PollEv.com/sethaubin

Kepler's 3rd Law

T = orbital period in units of Earth years

a = semimajor axis in AU

$$T^2 = a^3$$

Kepler's 3rd Law

Example: Martian Orbit

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Given T_{Mars} = 1.88 yr,

what is the average distance of **Mars** from the **Sun** ?

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$$\Rightarrow \quad a = (1.88)^{2/3} \simeq 1.52 \text{ AU}$$

On average, Mars is $a = 1.52$ AU from the Sun.