Reminders

I. Problem Set #1 due on Friday.

II. You should be reading Chapter 3

(and finished Chapters 1-2)

Lecture 4 Topics

Wednesday, August 26, 2020 (Week 1, lecture 4) – Chapters 3.

1. Some stars and constellations

2. Kepler's Laws

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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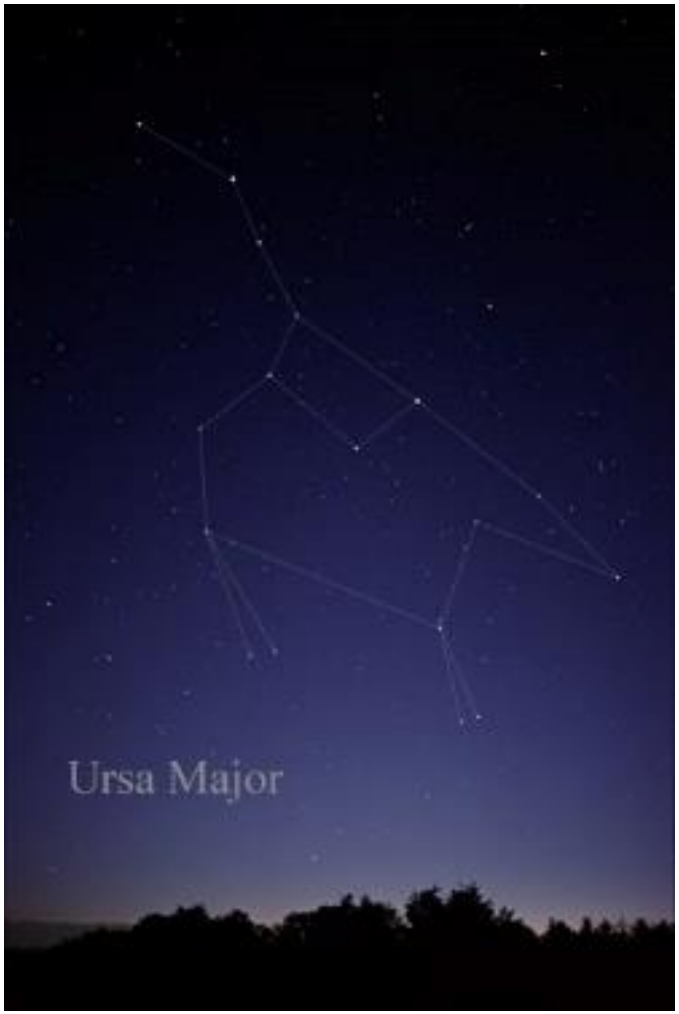
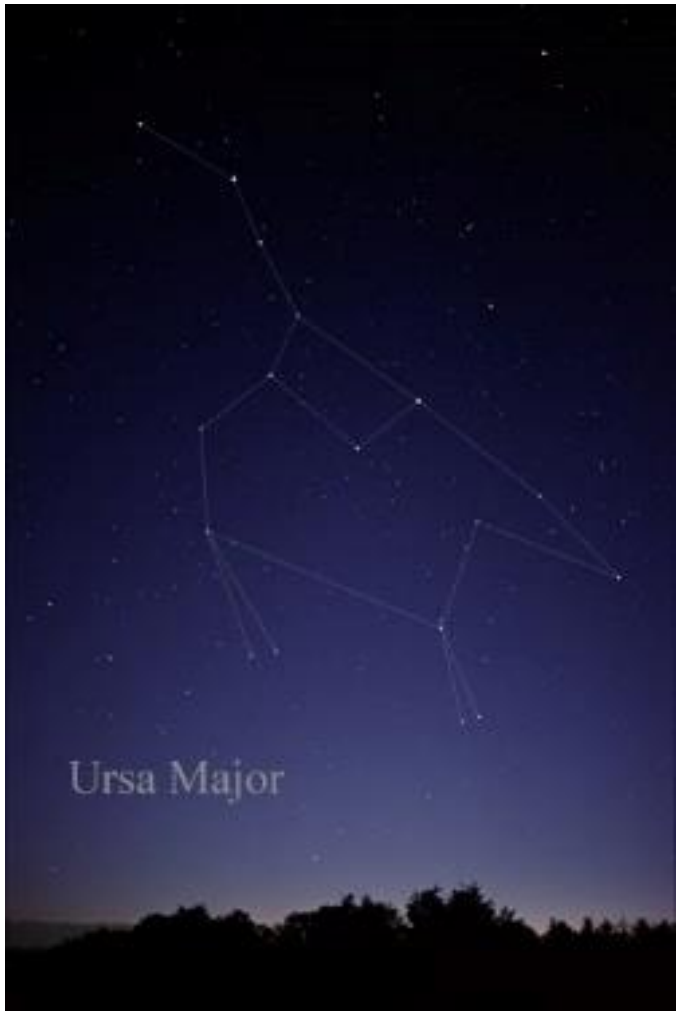
- **Asterism:** Easily recognized part of a constellation.

  → Example: The **"Big Dipper"** is an asterism within Ursa Major.

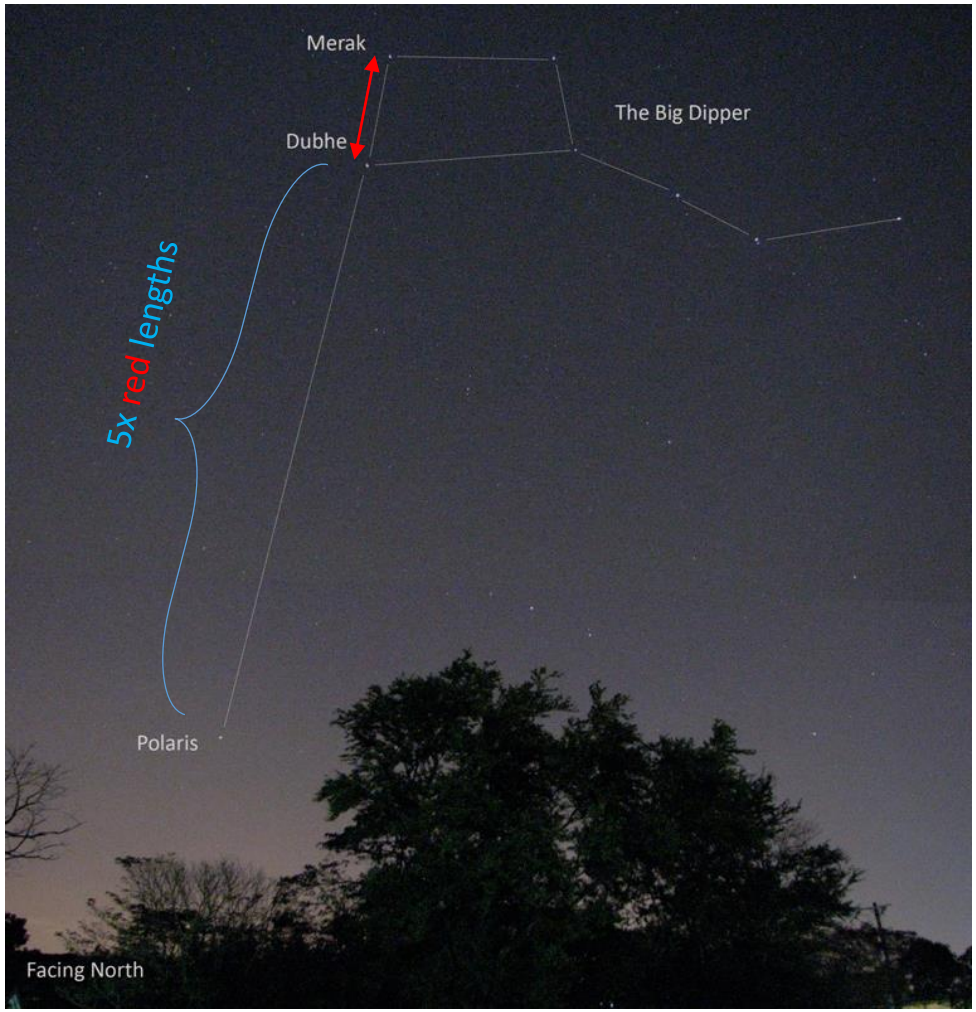
Ursa Major, Big Dipper, Polaris



Ursa Major, Big Dipper, Polaris



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

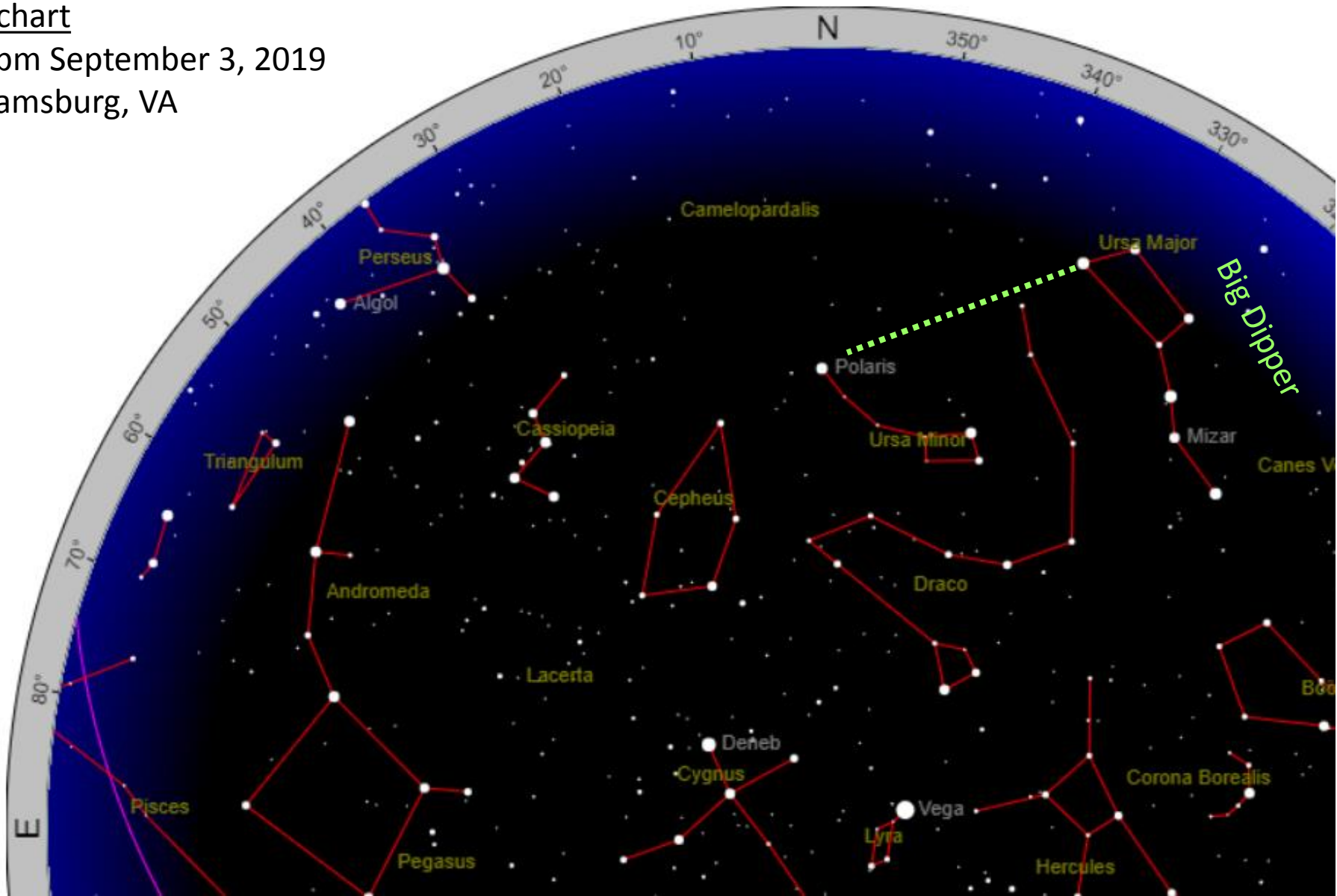
Ursa Major, Big Dipper, Polaris

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
9:30pm September 3, 2019
Williamsburg, VA



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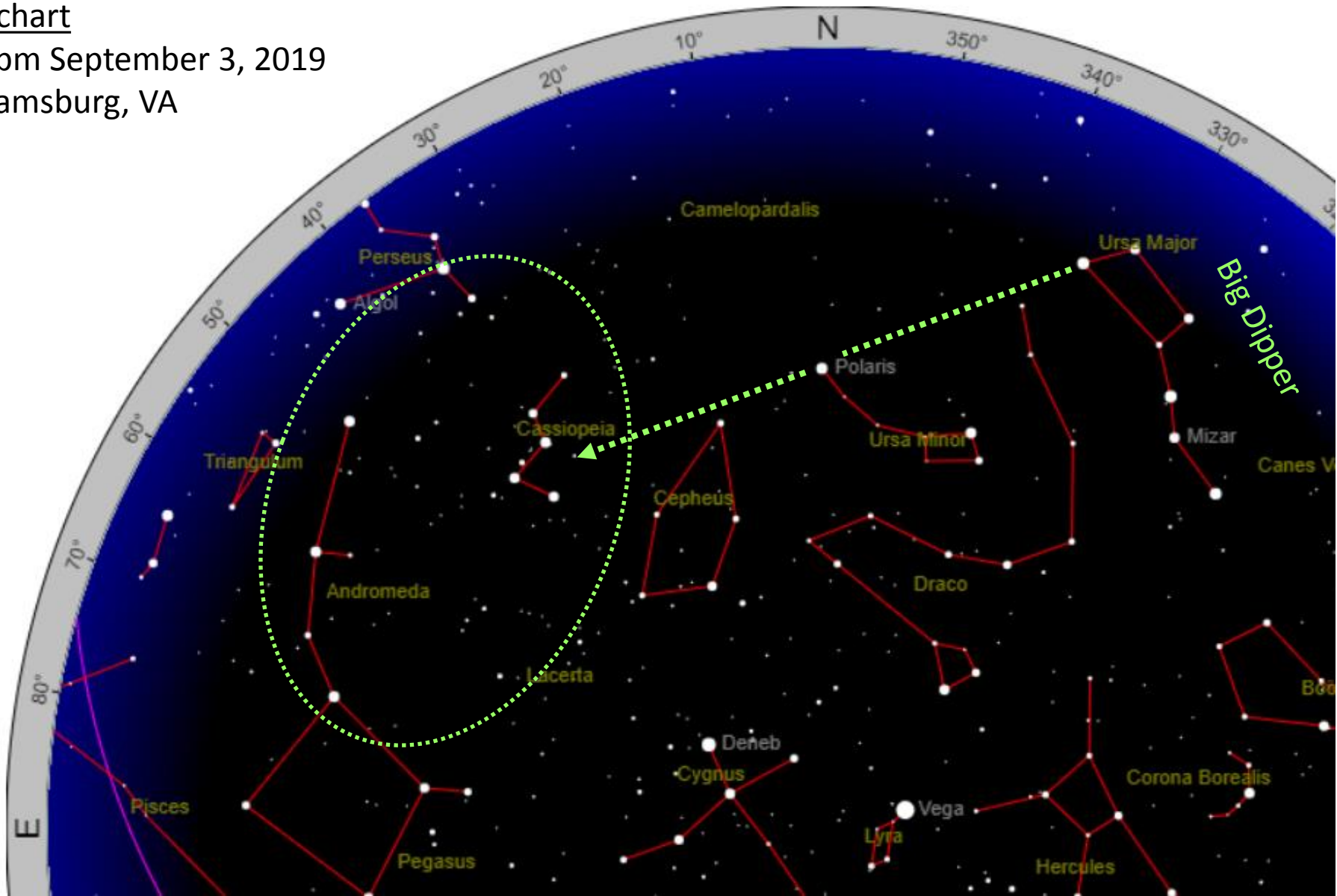

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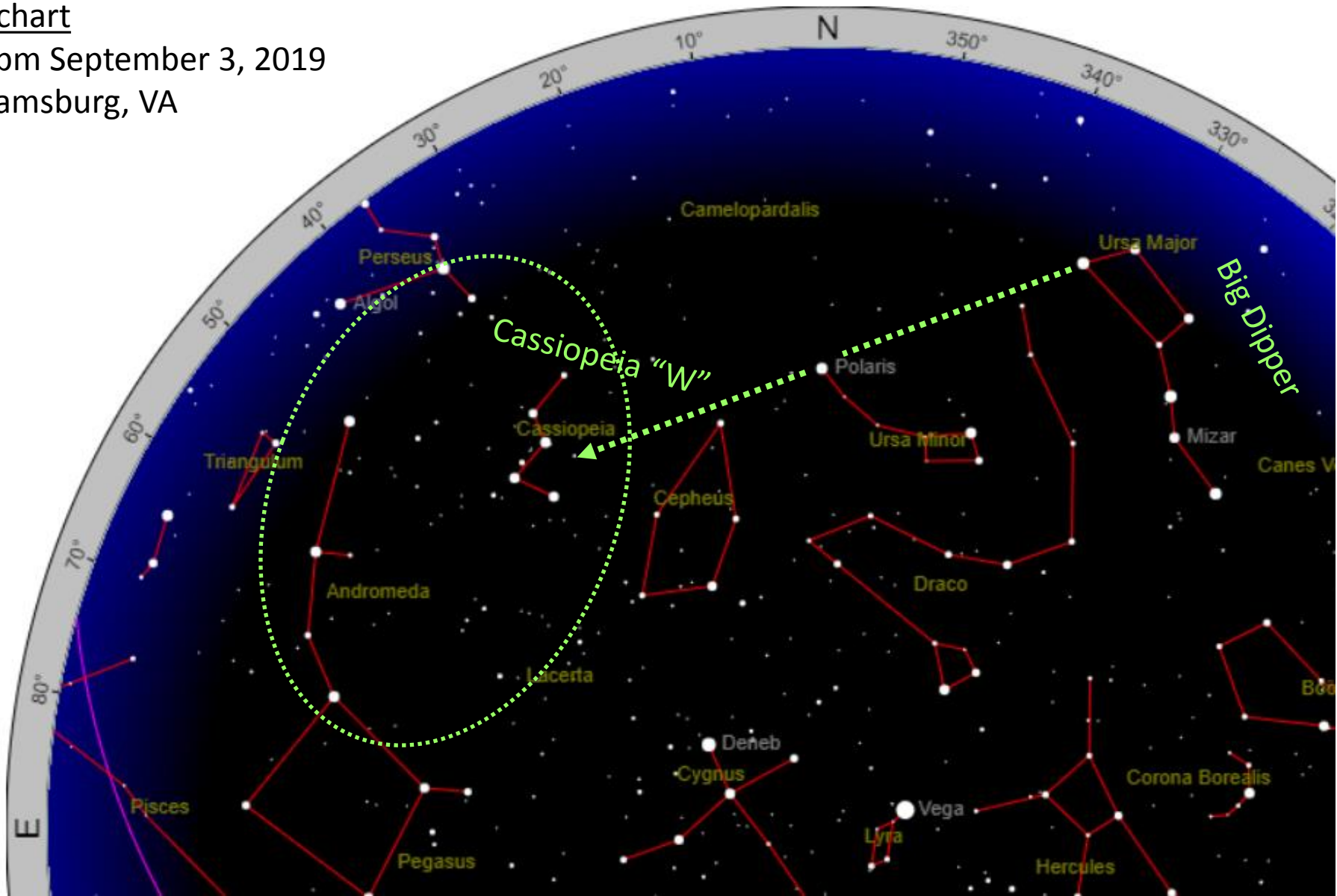

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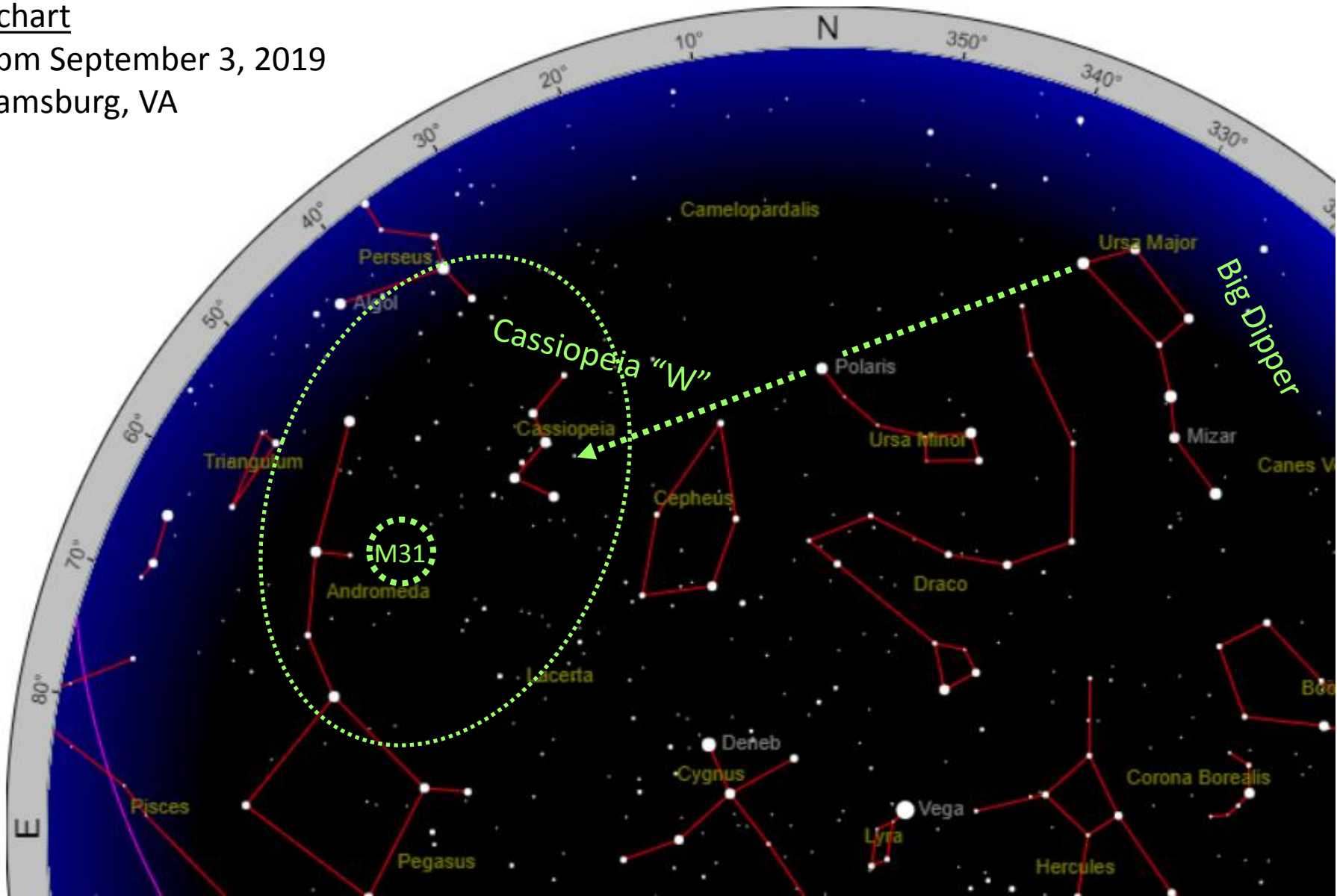

M31: Andromeda Galaxy

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

[OpenStax: Adam Evans]

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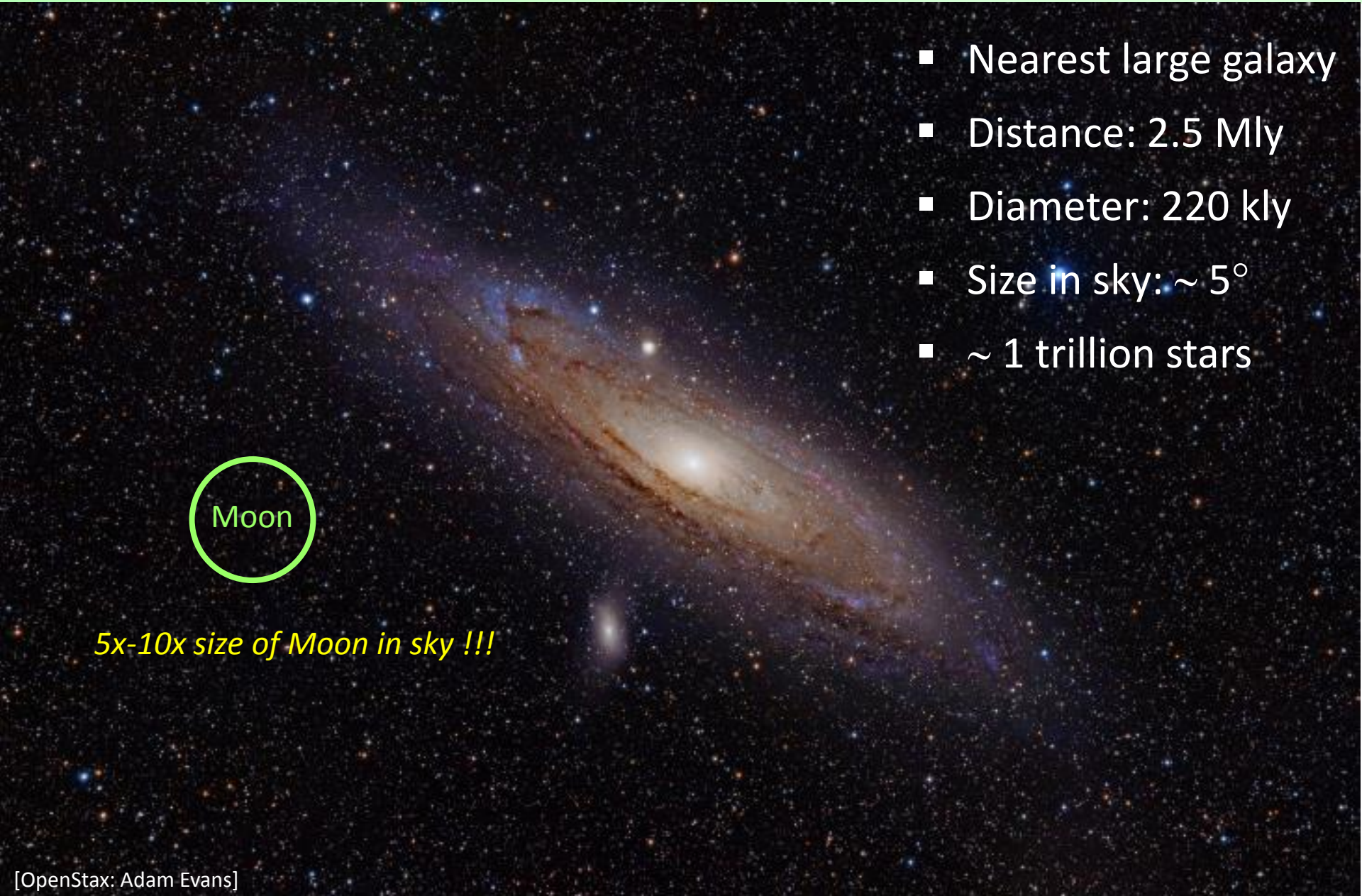

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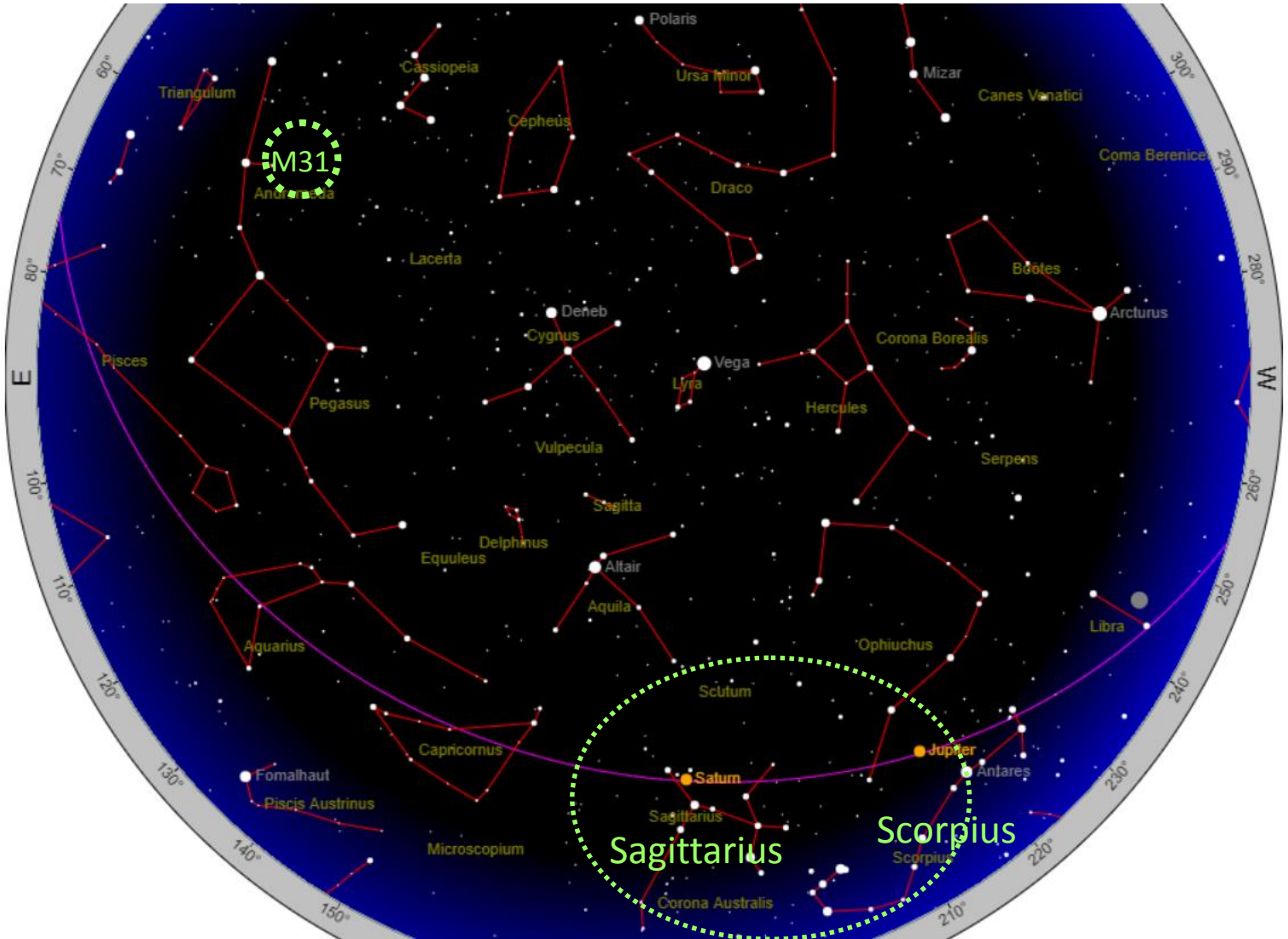
Moon

5x-10x size of Moon in sky !!!

[OpenStax: Adam Evans]

Center of the Milky Way Galaxy

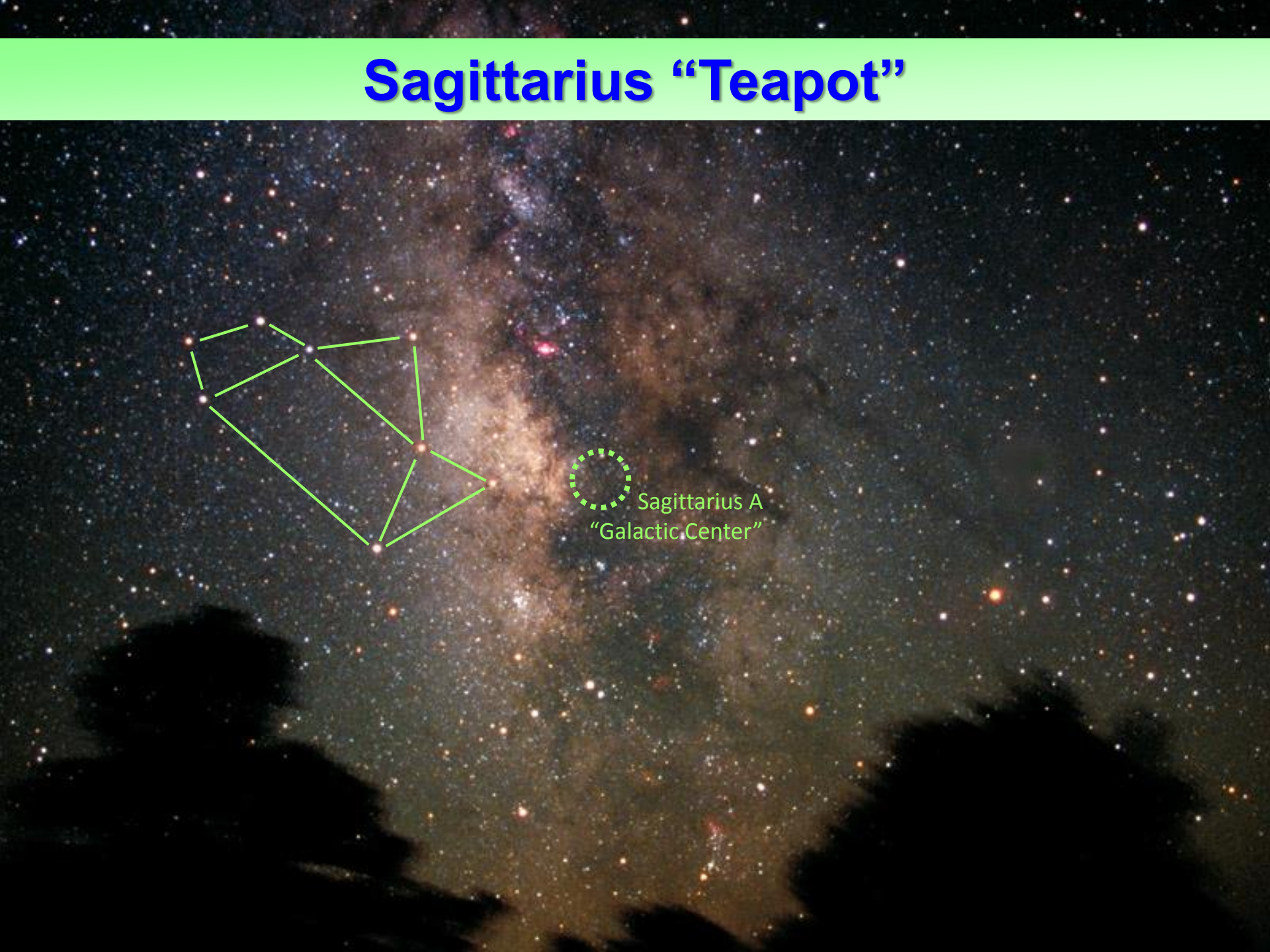
Sagittarius & Scorpius



Sagittarius “Teapot”

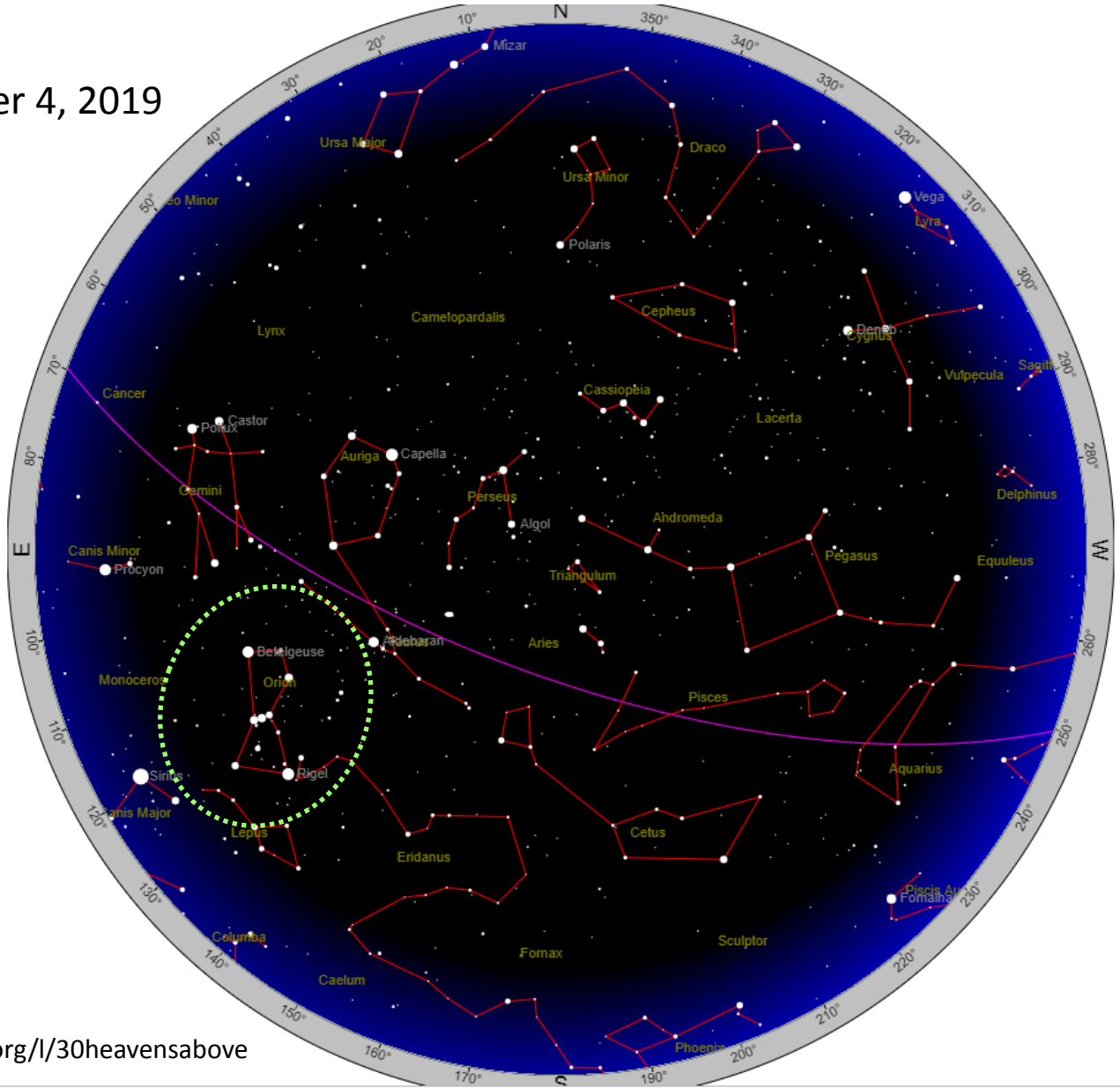
[NASA, ESA/Hubble: Terrence Dickinson]

Sagittarius “Teapot”



Orion

Star chart
4:30am September 4, 2019
Williamsburg, VA



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

Orion

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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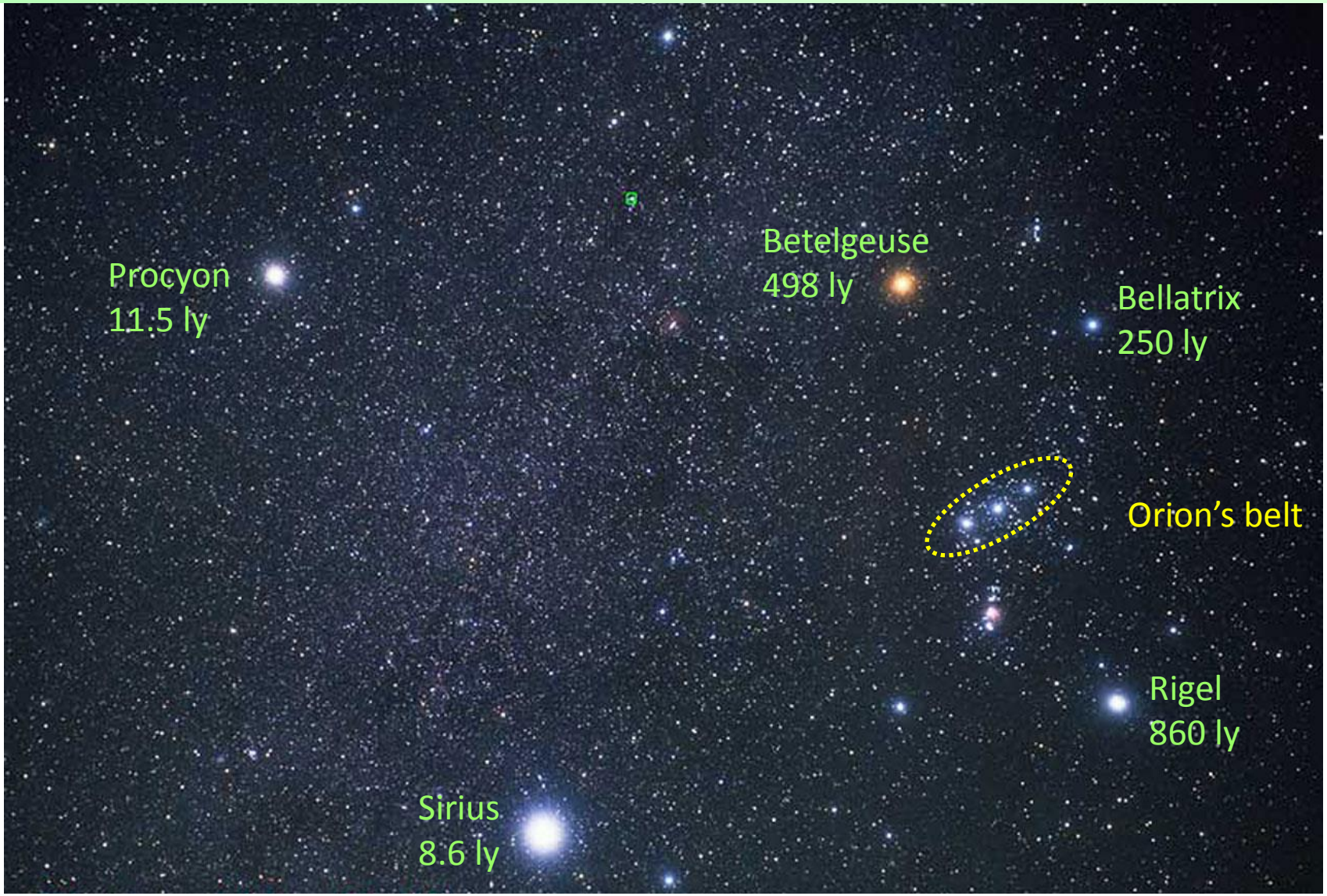

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Southern Hemisphere

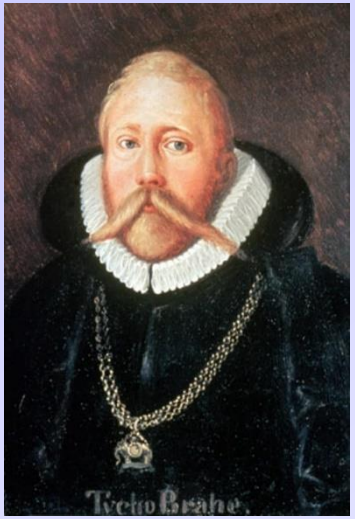
Crux & "Southern Cross" (asterism)

Back to the Solar System

- **Tycho Brahe** (1546-1601) collected extensive precision observational data (pre-telescope) on the motion of the planets.

- **Johannes Kepler** (1571-1630) worked for Tycho Brahe.

- Kepler **analyzed 20+ years of data** to understand the motion of the planets.



Tycho Brahe


Johannes Kepler

Kepler's Laws of Planetary Motion

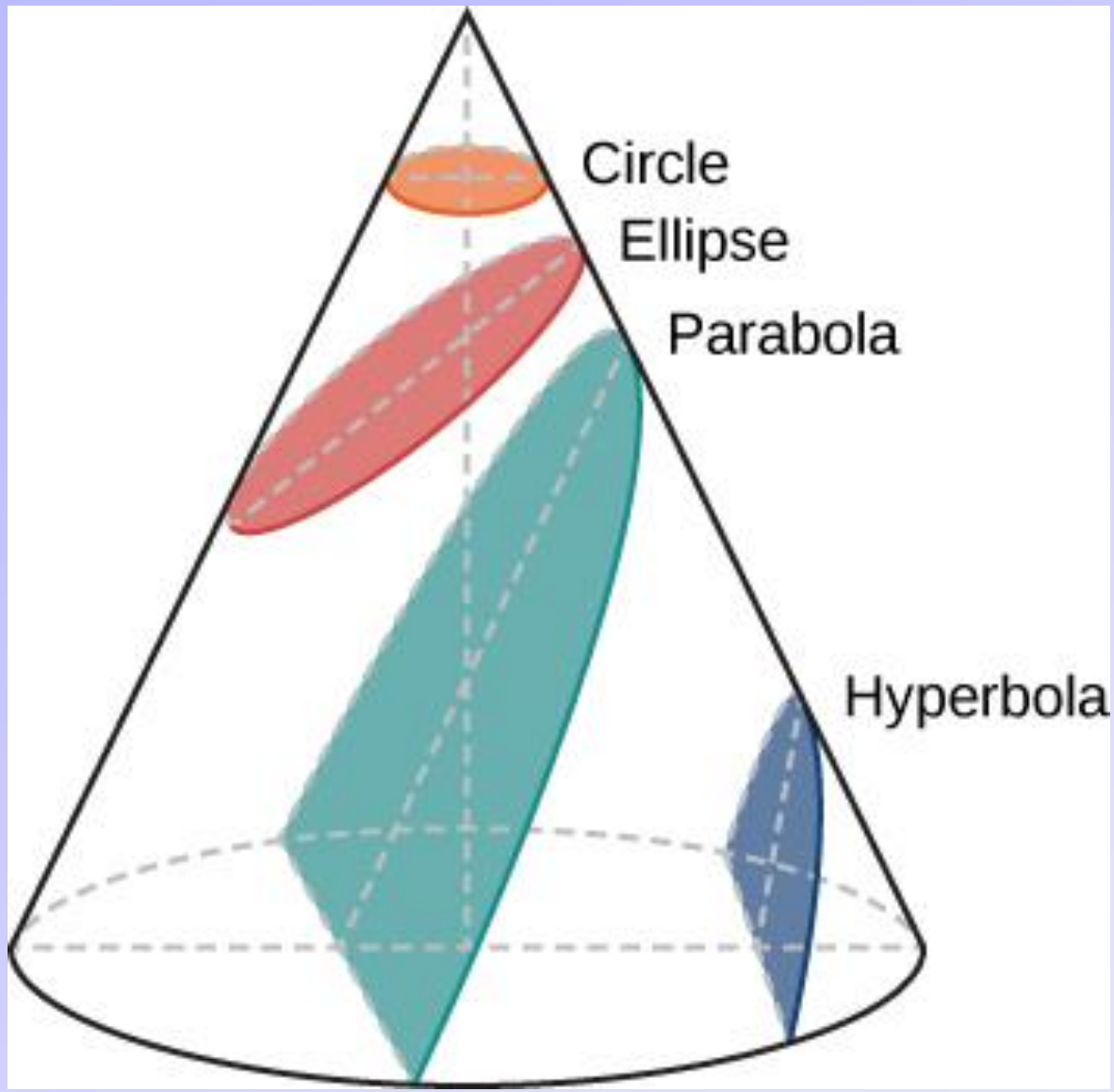
1st Law: The orbits of all planets are **ellipses**.

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

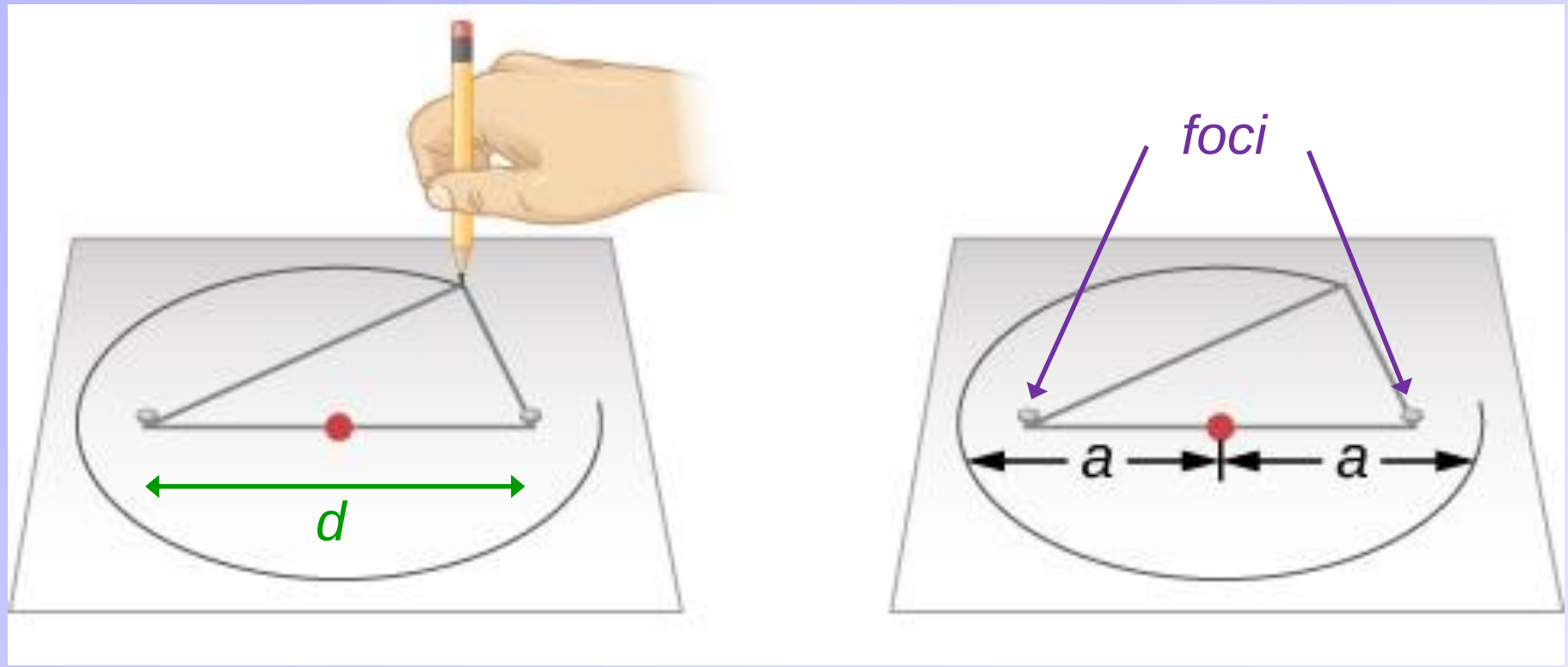


The **circle**, **ellipse**, **parabola**, and **hyperbola** are all formed by the intersection of a plane with a cone.

Note: Unbound orbits can be parabolic or hyperbolic.

Kepler's 1st Law – Ellipses & hyperbolas

Kepler's 1st Law -- Ellipses

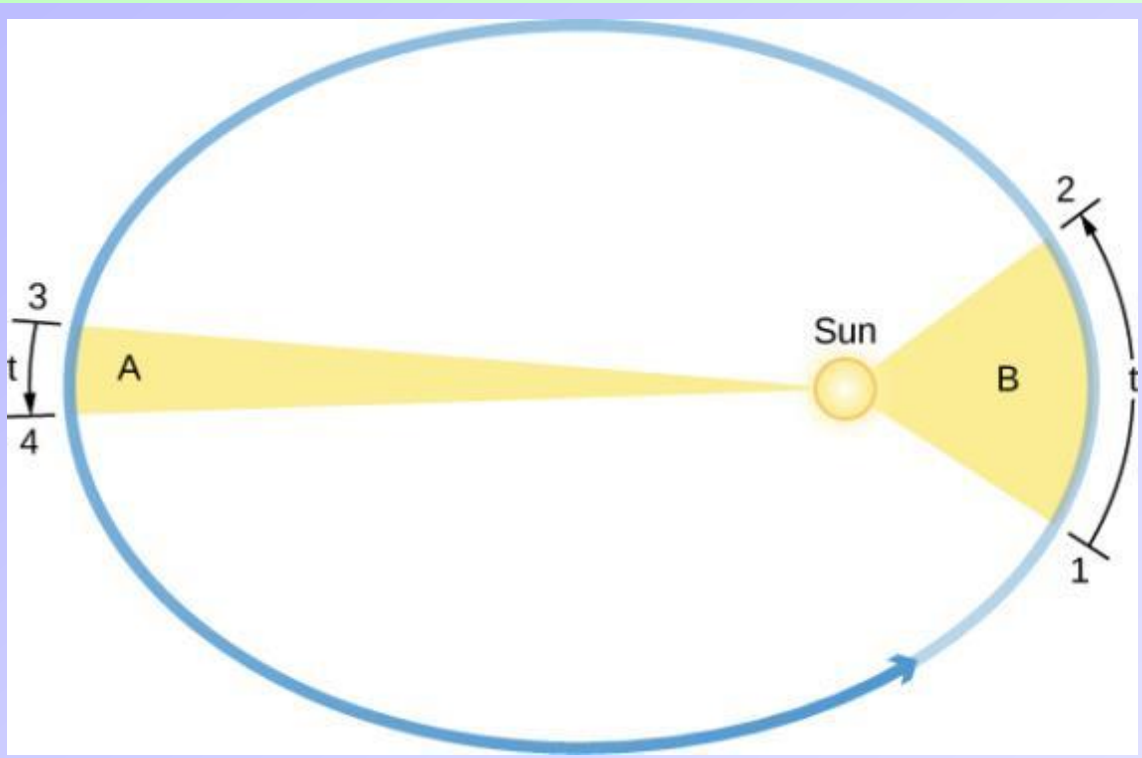


- Sun sits at one of the foci.
- Other focus is empty.

a = semimajor axis

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

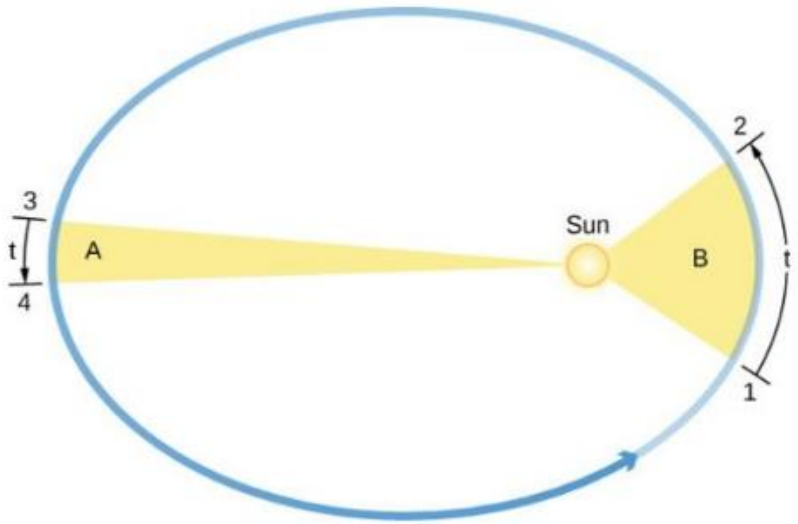
Kepler's 2nd Law



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).

Quiz (use next slide to enter answer)

Where does the planet travel fastest on ellipse?



position A (at aphelion, i.e. farthest from Sun) **A**

position B (at perihelion, i.e. closest to Sun) **B**

Same speed at all positions along ellipse **C**

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.