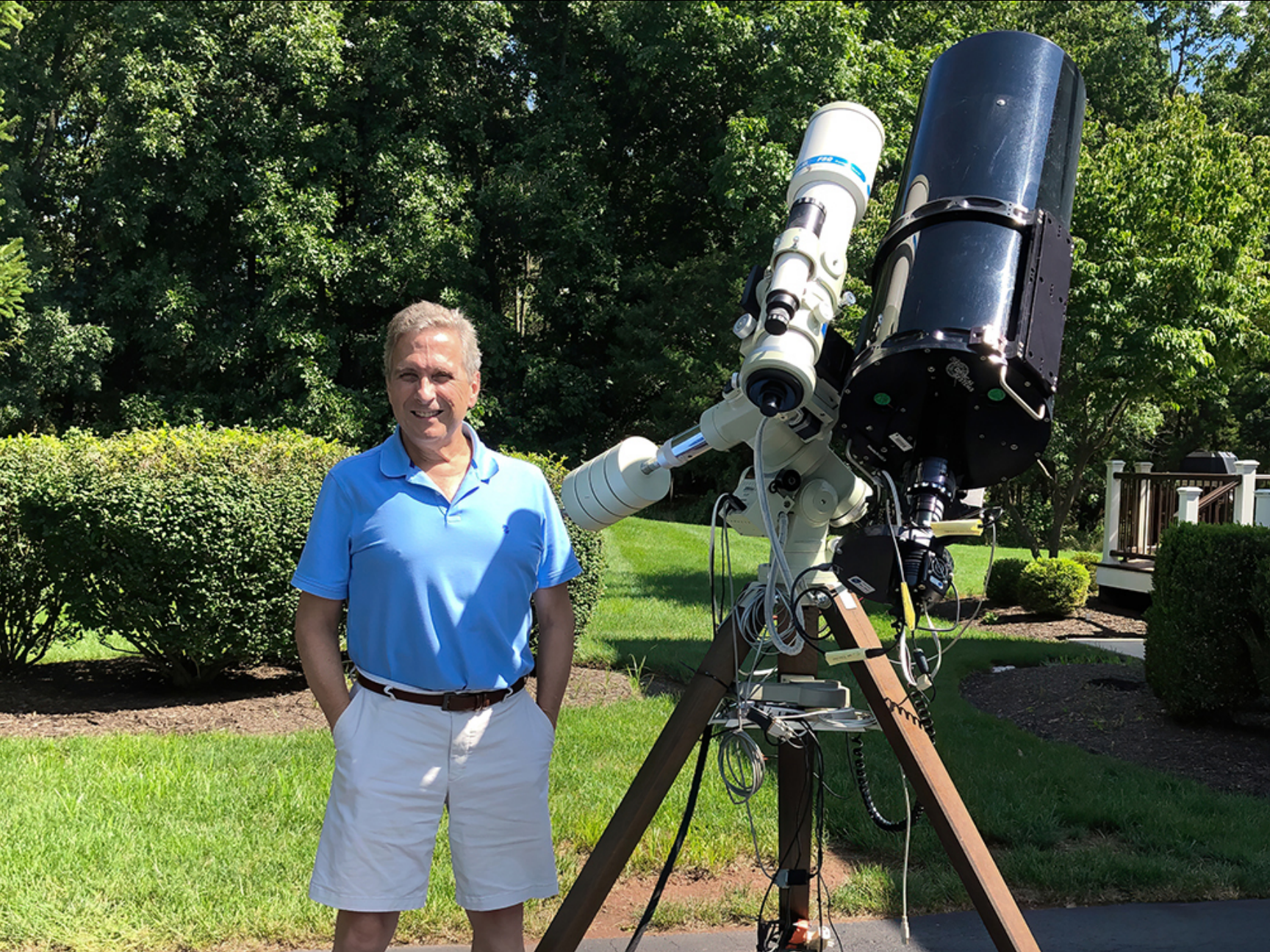


Astronomy...
Things Both Near and Far

Robert Vanderbei

Hopewell Elementary

<http://vanderbei.princeton.edu>



Crescent Moon

4:07pm Nov. 5, 2021



Crescent Moon

4:23pm Dec. 18, 2020



First Quarter Moon

10:56pm Feb 11, 2011



Super Full Moon

June 14, 2022



Last Quarter Moon

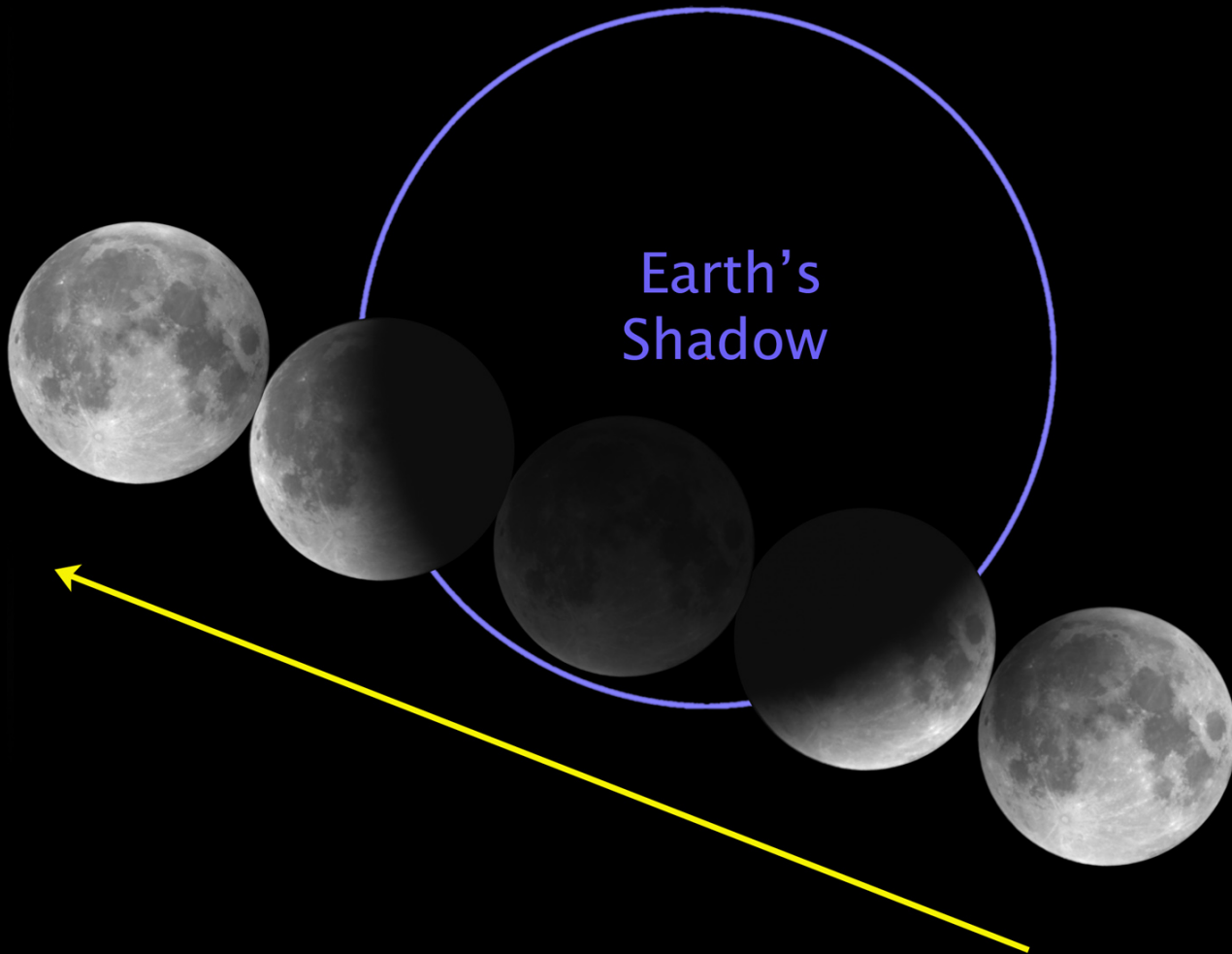
5:41am May 31, 2013



Is The Earth Flat?

A Picture's Worth a Thousand Words...





How Aristarchus measured the size of the Moon.

Lunar Eclipse

November 8, 2022



Lunar Eclipse

November 8, 2022



Lunar Eclipse

November 8, 2022



Lunar Eclipse

November 8, 2022



Moon

1.2 sec



Moon and Mars



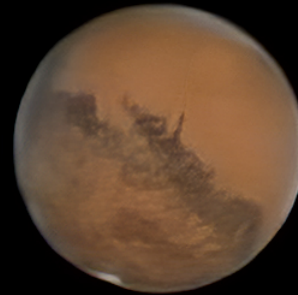
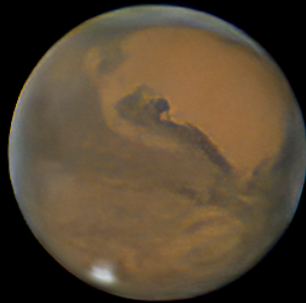
Moon and Mars

1.2 sec and 3.3 min



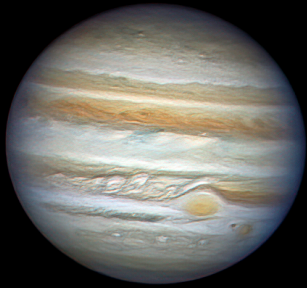
Mars

Oct. 6 and 18, 2020

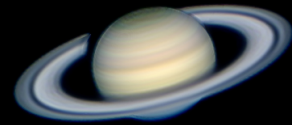


Jupiter and Saturn

32 and 67 min



o



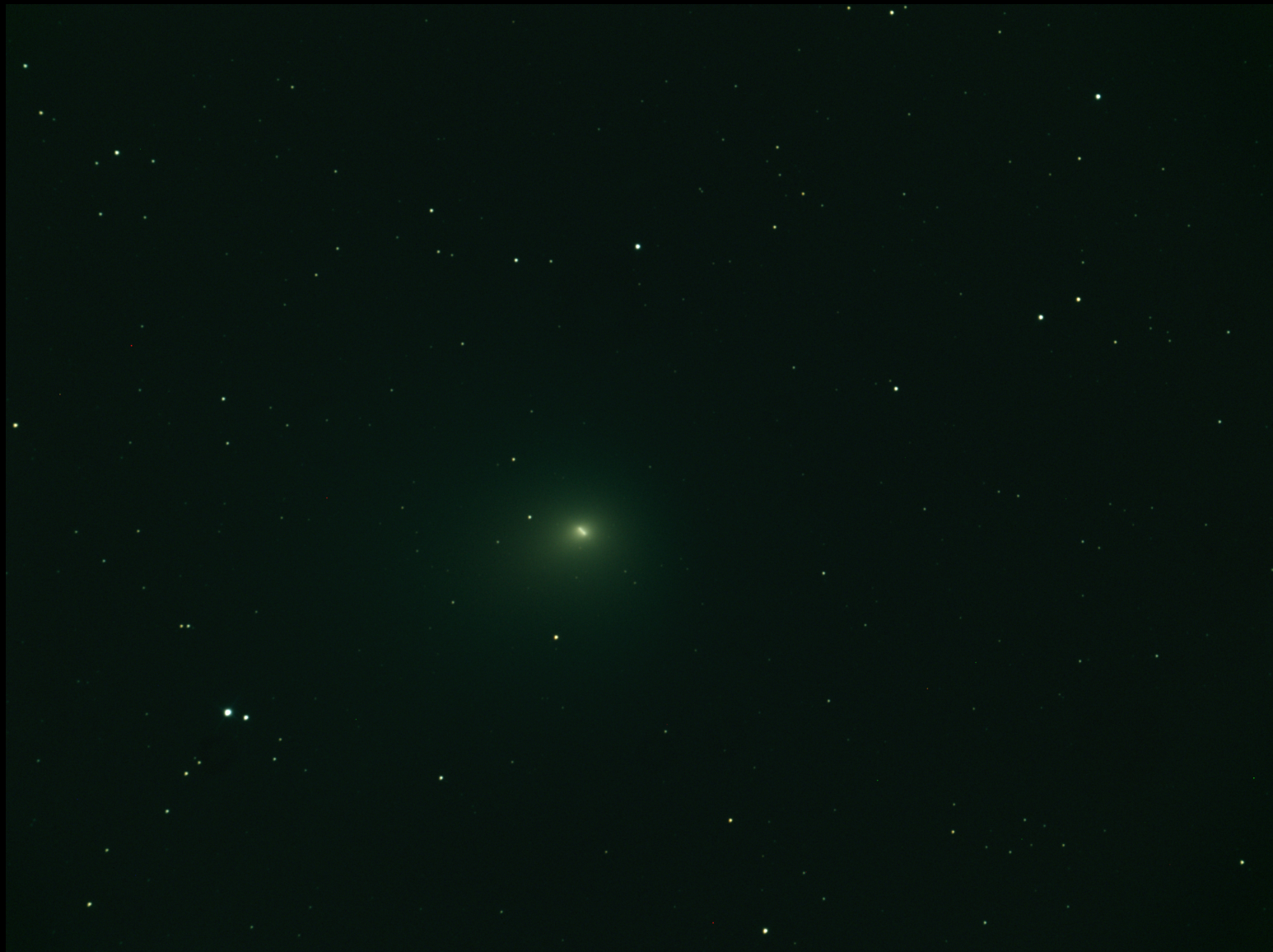
Comet 103P / Double Cluster

1.2 min / 7,460 and 7,640 yrs



The Green Comet (aka ZTF)

Feb. 1, 2023



Looking Out Beyond Our Solar System

Orion Nebula

Star Forming Region

1,344 yrs



Dumbbell Nebula

Dying Star

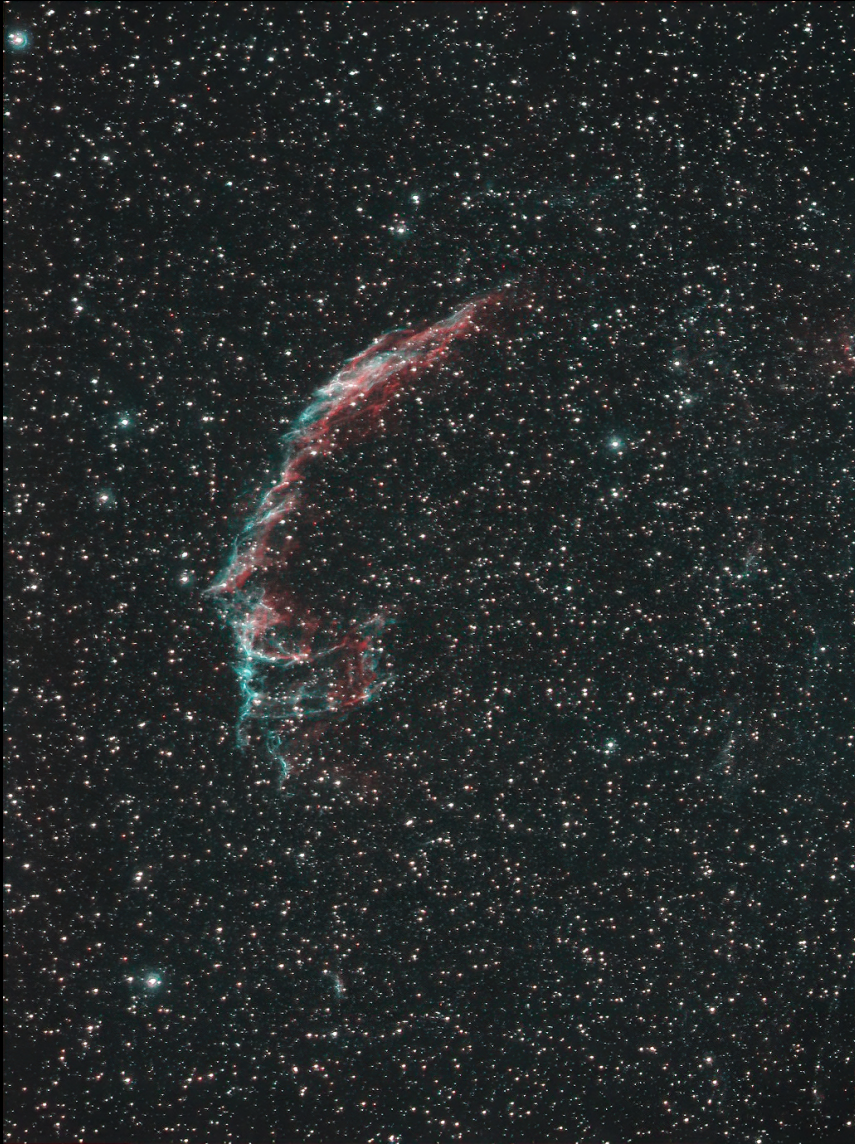
1,360 yrs



Veil Nebula

Supernova Remnant

2,400 yrs

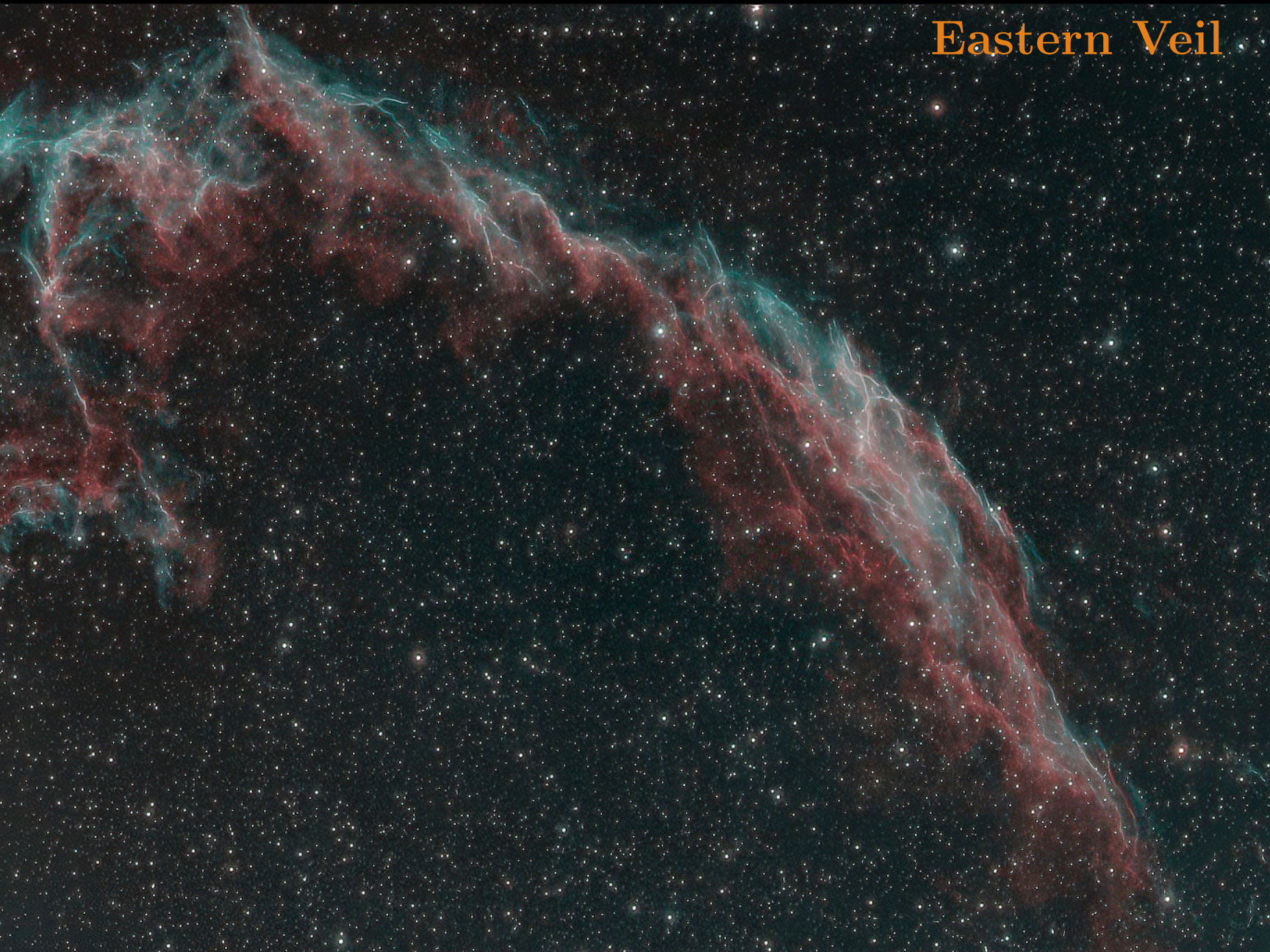


Western Veil

2,400 yrs



Eastern Veil



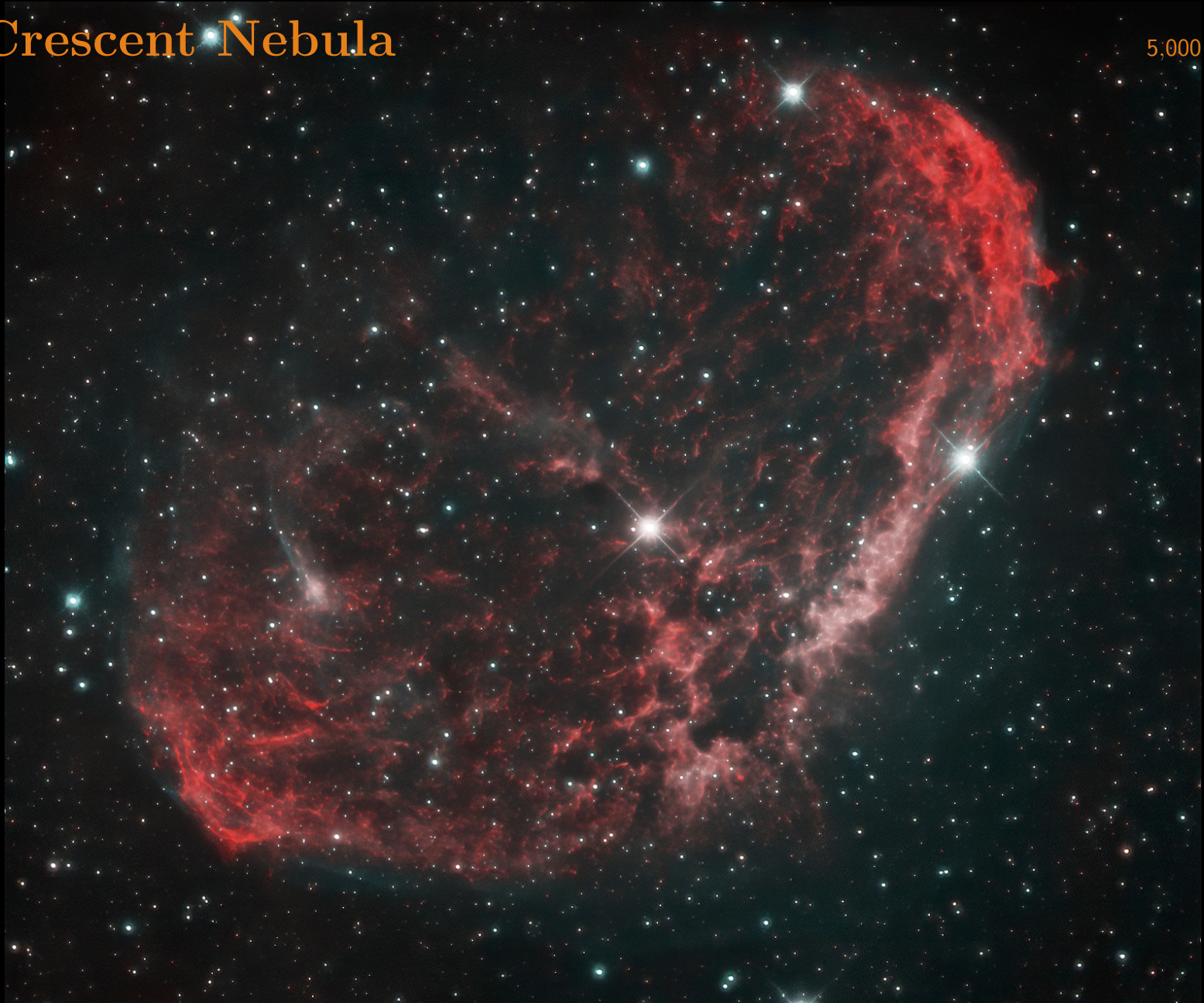
Ring Nebula

2,567 yrs



Crescent Nebula

5,000 yrs



Jellyfish Nebula

5,000 yrs



Rosette Nebula

5,200 yrs



Eagle Nebula

5,700 yrs



Crab Nebula

Mar. 26, 2019

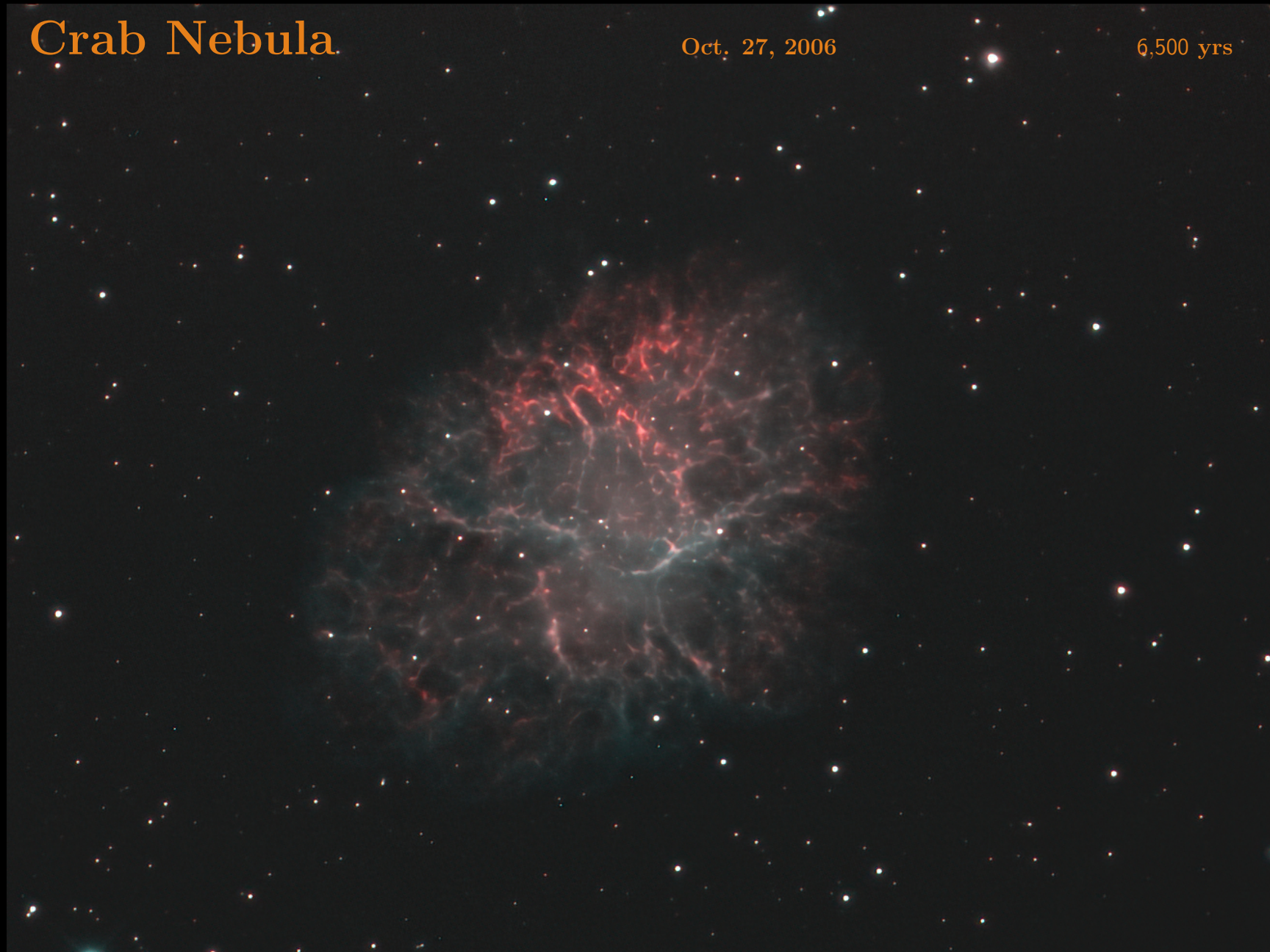
6,500 yrs



Crab Nebula

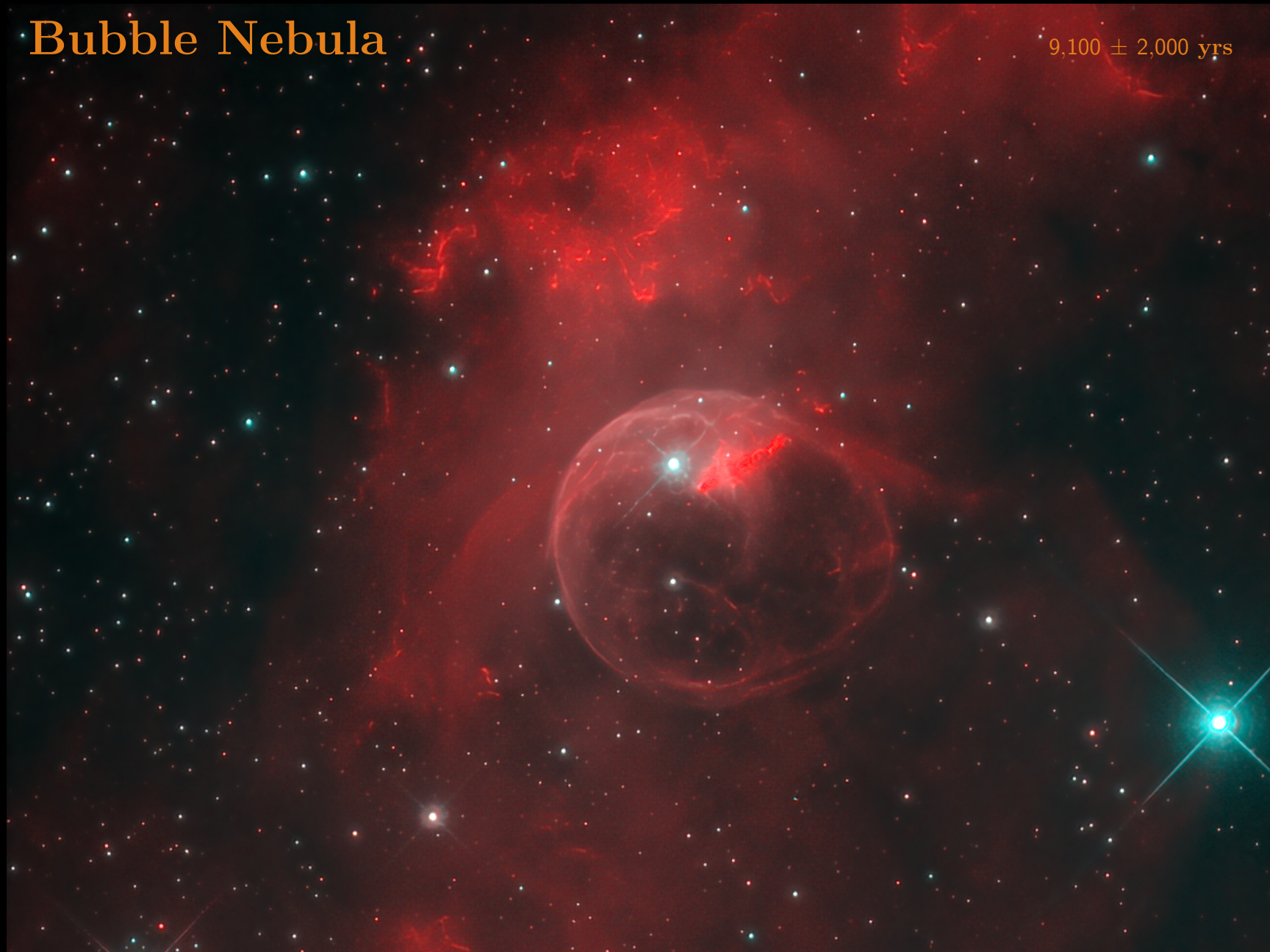
Oct. 27, 2006

6,500 yrs



Bubble Nebula

$9,100 \pm 2,000$ yrs



Globular Cluster M13

22,200 yrs



Looking Out Beyond Our Milky Way

The Andromeda Galaxy

2,450,000 yrs



M81 and M82

12,000,000 yrs



The Whirlpool Galaxy

31,000,000 yrs



The Whirlpool Galaxy

31,000,000 yrs



The Whirlpool Galaxy

31,000,000 yrs



The Leo Trio

32,000,000 yrs



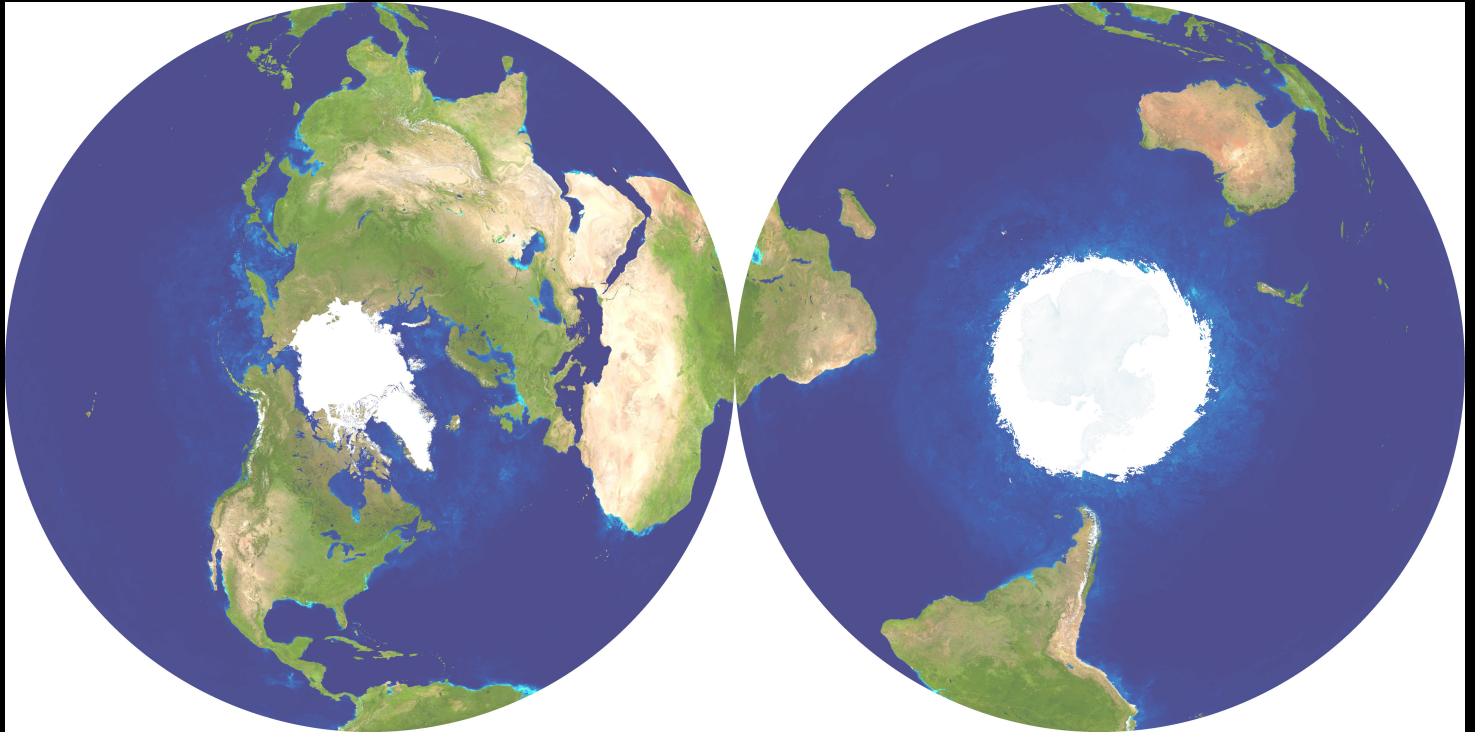
The Needle Galaxy (NGC 4565)

42,700,000 yrs



Questions?

Gott-Goldberg-Vanderbei Map



It's a Two-Sided Map



Some Details...

How Far to the Moon?

Angular Size of the Moon.

Using my iPhoneX, I took 16 pics to make a 360° panorama from the middle of the road in front of my house. I used Photoshop to assemble the pics:



Here's a closeup of my neighbor's car as seen at the left edge and the right edge:



The horizontal pixel distance of the car's rear view mirror as seen on the left and on the right is $38108 - 83 = 38025$ pixels.



Using the same camera I took a picture of the crescent Moon:



Here's a closeup showing that the Moon's diameter is 59 pixels:



Using these pixel measurements, we can compute the angular size of the Moon:

$$\begin{aligned} \text{Moon Size} &= \frac{59}{38025} \times 360^\circ = 0.56^\circ \\ &\approx 1/2 \text{ deg} \end{aligned}$$

From a lunar eclipse, we can determine that the Earth is about 4 times larger than the Moon. Earth's diameter is about 8,000 miles. Hence, Moon's diameter is about 2,000 miles.



ANSWER: Distance to the Moon \approx 240,000 miles

Moon's diameter = 2,000 miles

Moon's orbital circumference = 2,000 miles $\times \frac{360 \text{ deg/circumference}}{1/2 \text{ deg/Moon diameter}}$

Moon's distance = $\frac{\text{Moon's orbital circumference}}{2\pi} \approx \frac{\text{Moon's orbital circumference}}{6} = \frac{2,000 \times 720}{6} = 240,000 \text{ mi}$

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Distance Measurements

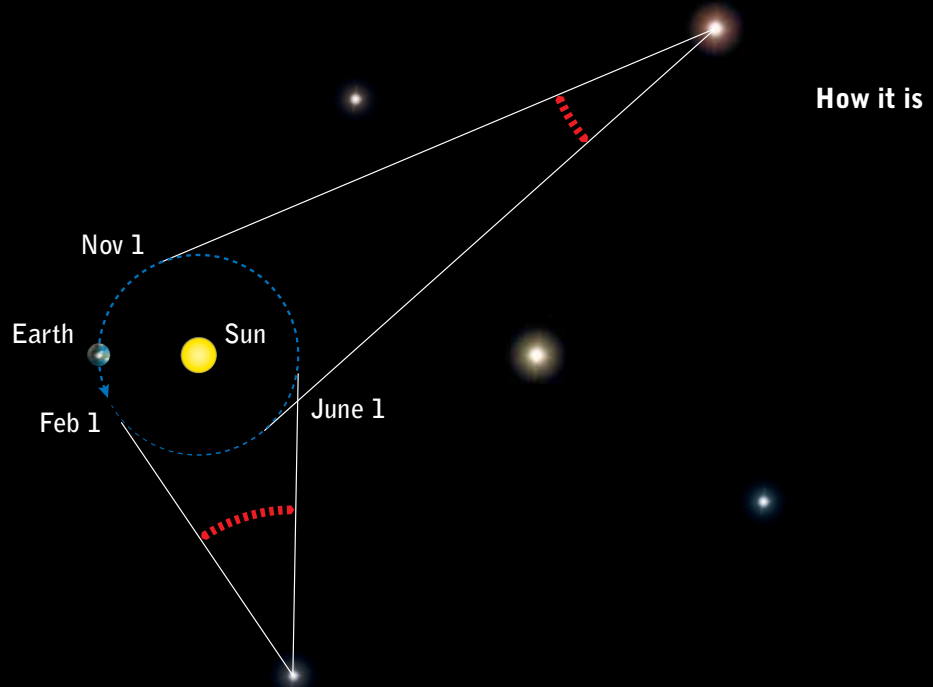
There are various ideas/methods for measuring distances.

The simplest is called *parallax*.

Using parallax, we can measure the distance to nearby stars.

For things further away, we need more clever/subtle methods.

Parallax: Distance to the Stars



Barnard's Star



Barnard's Star



Barnard's Star



Barnard's Star



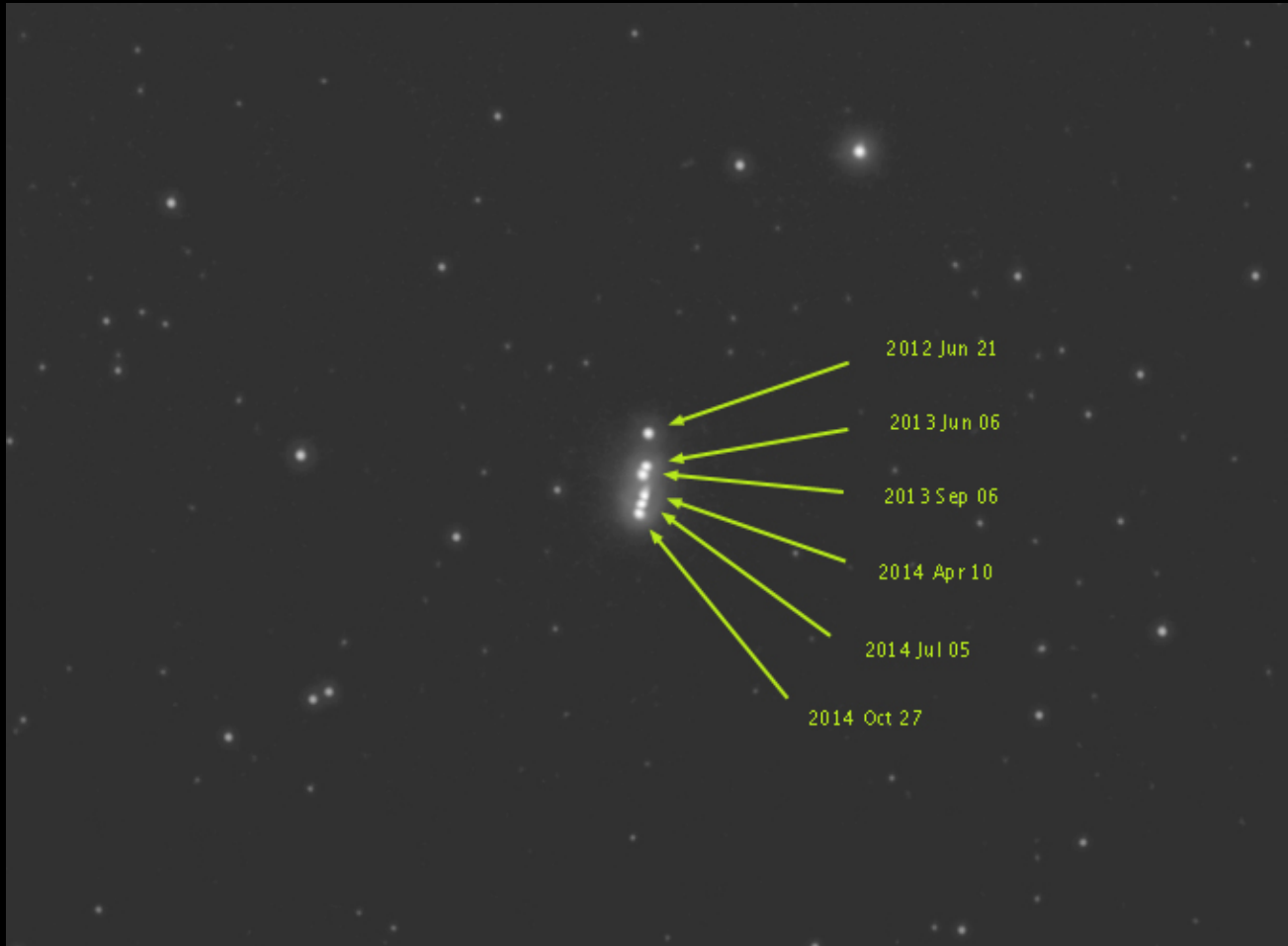
Barnard's Star



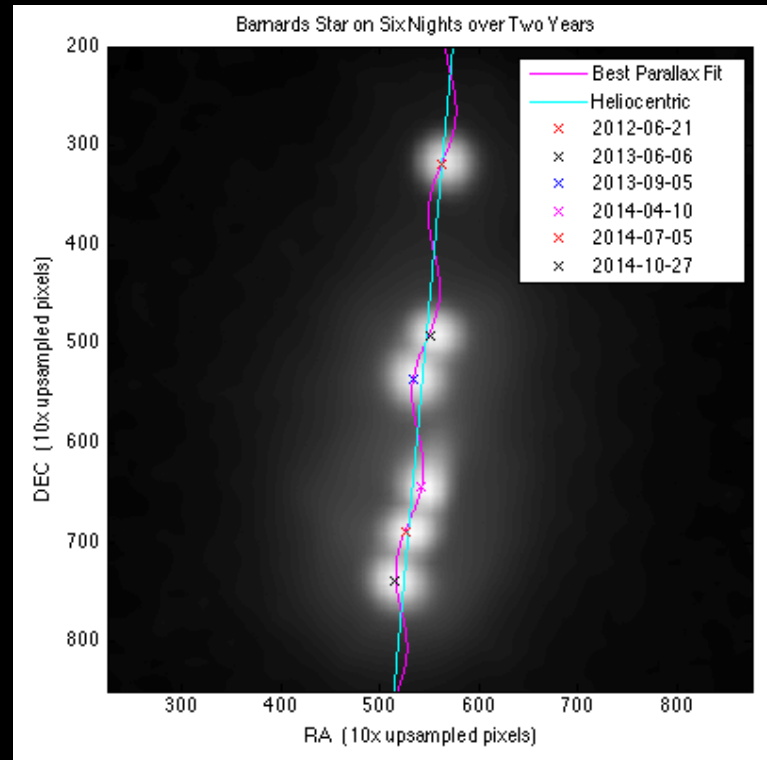
Barnard's Star



Barnard's Star Overlay



Barnard's Star Closeup



The measured parallax is 0.5478 arcsecs. Corresponds to a distance of 5.97 lightyears.