

# Sizing Up The Universe

A Freshman Seminar

Robert Vanderbei

Princeton Club of Saint Louis  
McDonnell Planetarium  
Nov. 11, 2022

<http://vanderbei.princeton.edu>

# A Little About Me

- Born/Raised: Grand Rapids, MI
- Undergrad: Chemistry, 1976, Rensselaer Polytechnic Institute
- Grad: Applied Math, 1981, Cornell
- Postdocs:
  - NSF Fellow, Math, NYU
  - Visiting Lecturer, Math, Univ. of Illinois Urbana/Champaign
- Industry:
  - AT&T Bell Labs, Math Research Center
- Academia: Princeton, 1990-present
- Hobbies/Passions:
  - Soaring
  - Tennis
  - Astronomy
  - Photography
  - Math/Computation
  - Local Warming, Purple America, etc.

# Recent Events

# Welcome to the Universe in 3D



## Welcome to the Universe in 3D *A Visual Tour*

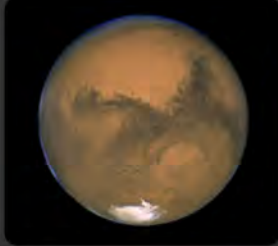
Neil deGrasse Tyson, Michael A. Strauss,  
J. Richard Gott, and Robert J. Vanderbei



### 3D Pictures from the Book



Moon



Mars



Comet Lovejoy



Jupiter and Ganymede



Mimas



Crab Nebula



Andromeda



Hubble Ultra Deep Field

# Neil deGrasse Tyson with Stephen Colbert



# Lunar Eclipse (3.5 Days Ago)



# Lunar Eclipse (3.5 Days Ago)



# Lunar Eclipse (3.5 Days Ago)



# My Astro Gear

# 10" Reflector, 4" Refractor, Telephoto Lens



Move equipment outside.



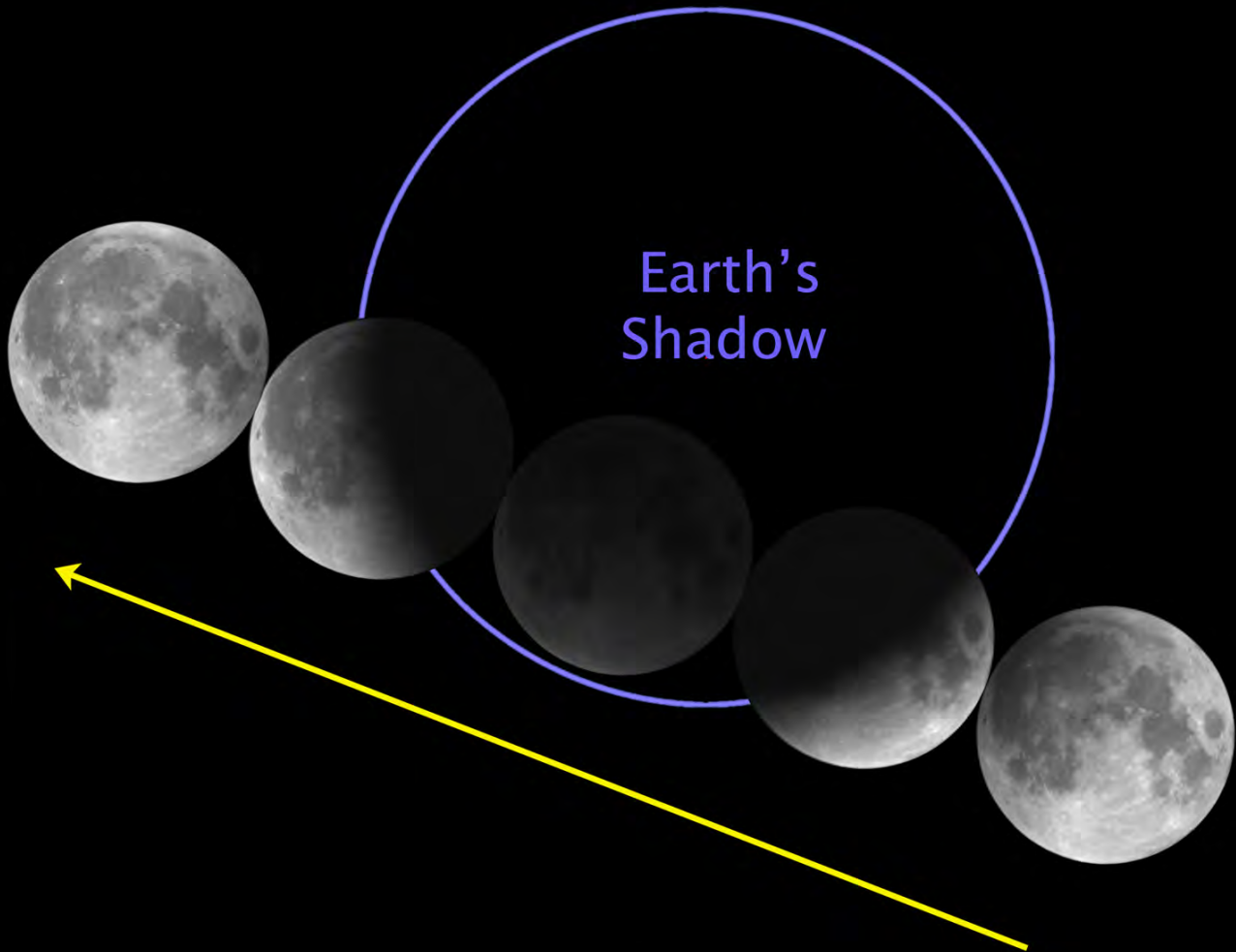
Ready To Go...



# Is The Earth Flat?

A Picture's Worth a Thousand Words...





How Aristarchus measured the size of the Moon.

# Halloween's Blue Moon

Oct. 31, 2020



# Crescent Moon

4:07pm Nov. 5, 2021



Moon

1.1 sec



# Moon and Mars



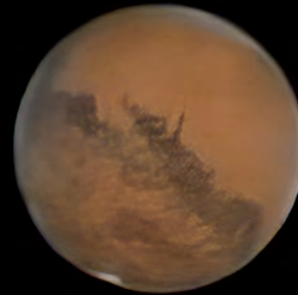
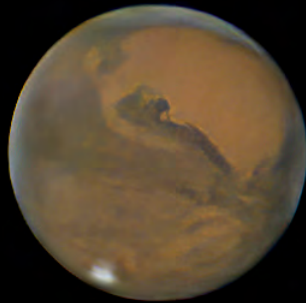
# Moon and Mars

1.1 sec and 3.3 min



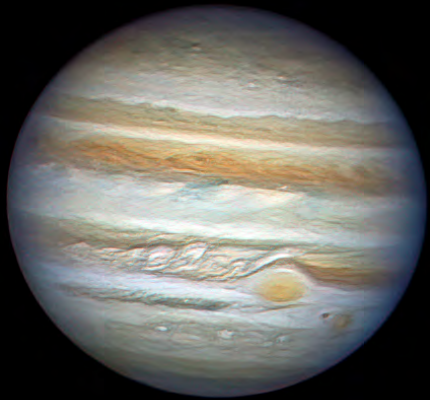
# Mars

Oct. 6 and 18, 2020



# Jupiter and Saturn

32 and 67 min



# Comet 103P / Double Cluster

1.2 min / 7,460 and 7,640 yrs



# Looking Out Beyond Our Solar System

# Distance Measurements

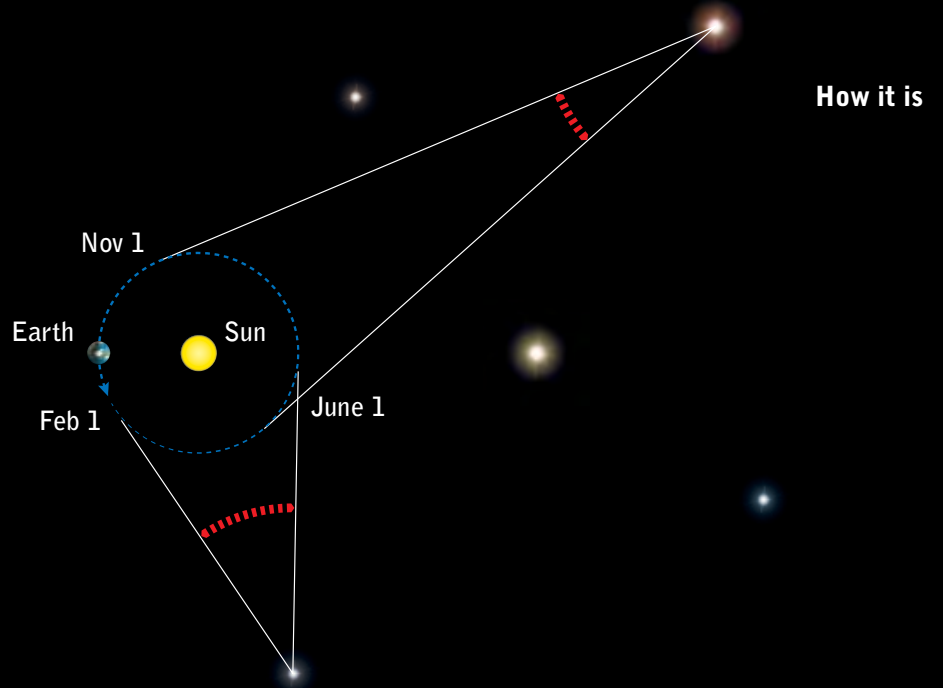
There are various ideas/methods for measuring distances.

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



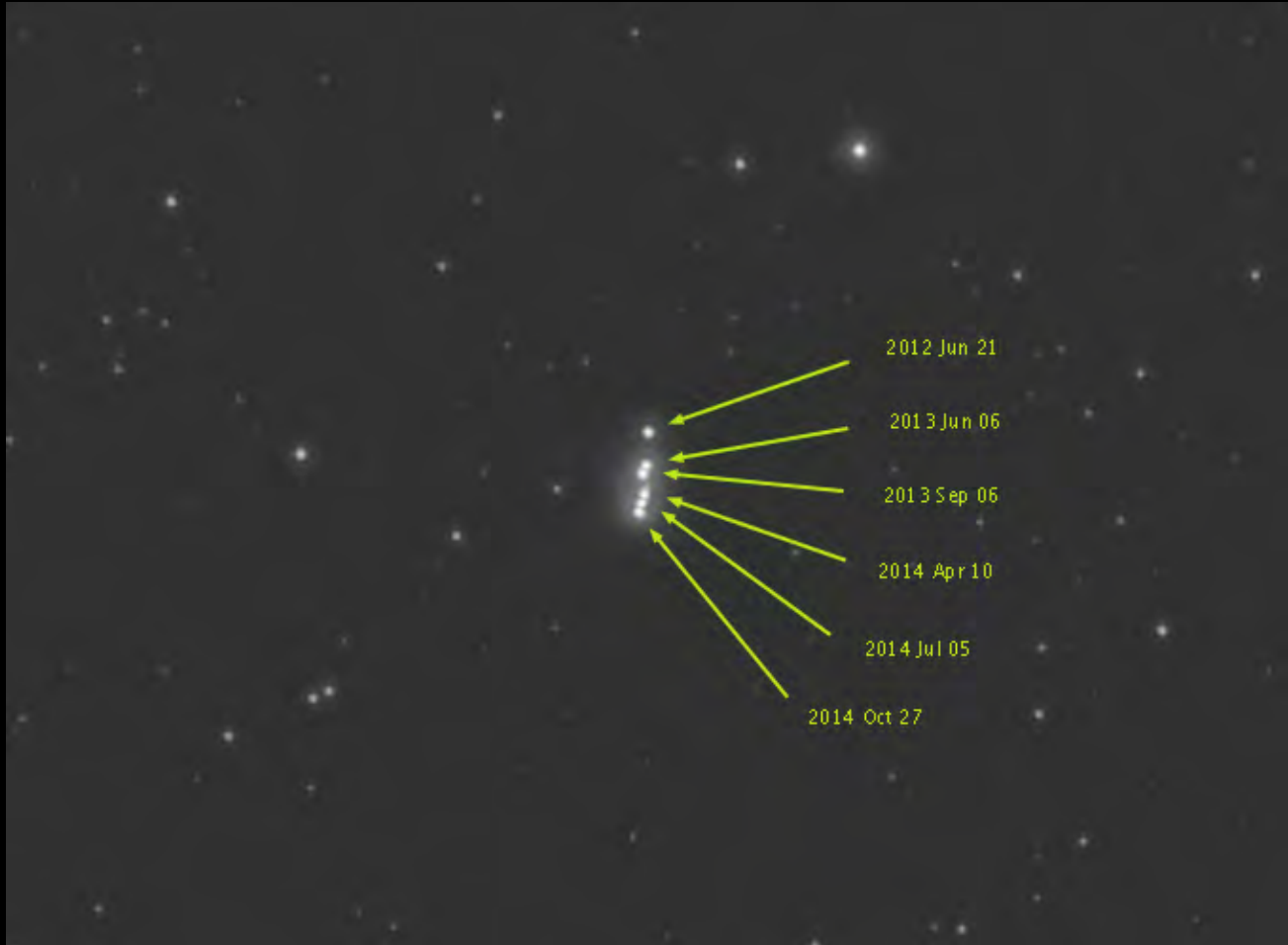
# Barnard's Star



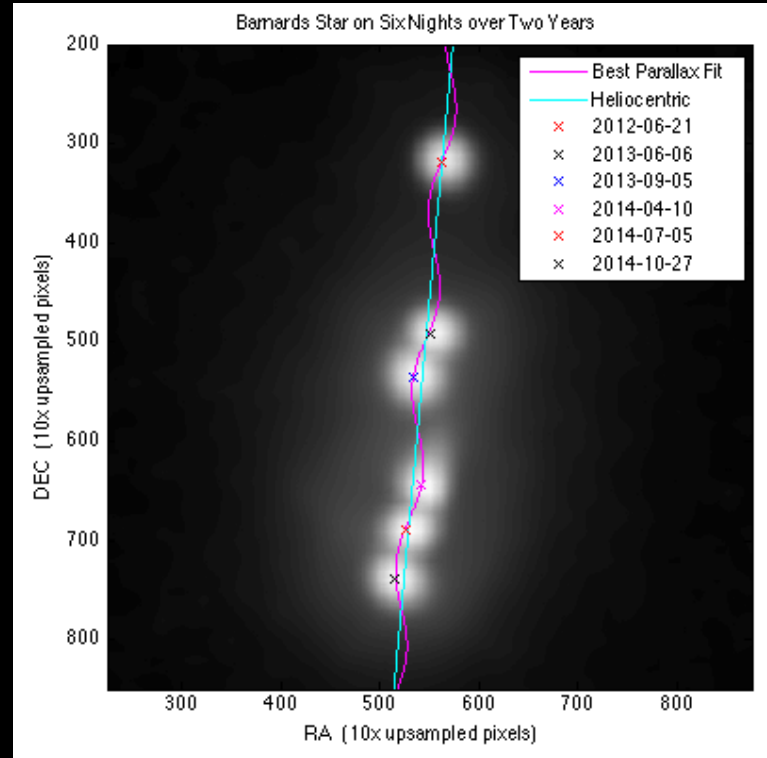
# Barnard's Star



# Barnard's Star Overlay



# Barnard's Star Closeup



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

# Orion Nebula: M42

1,344 yrs



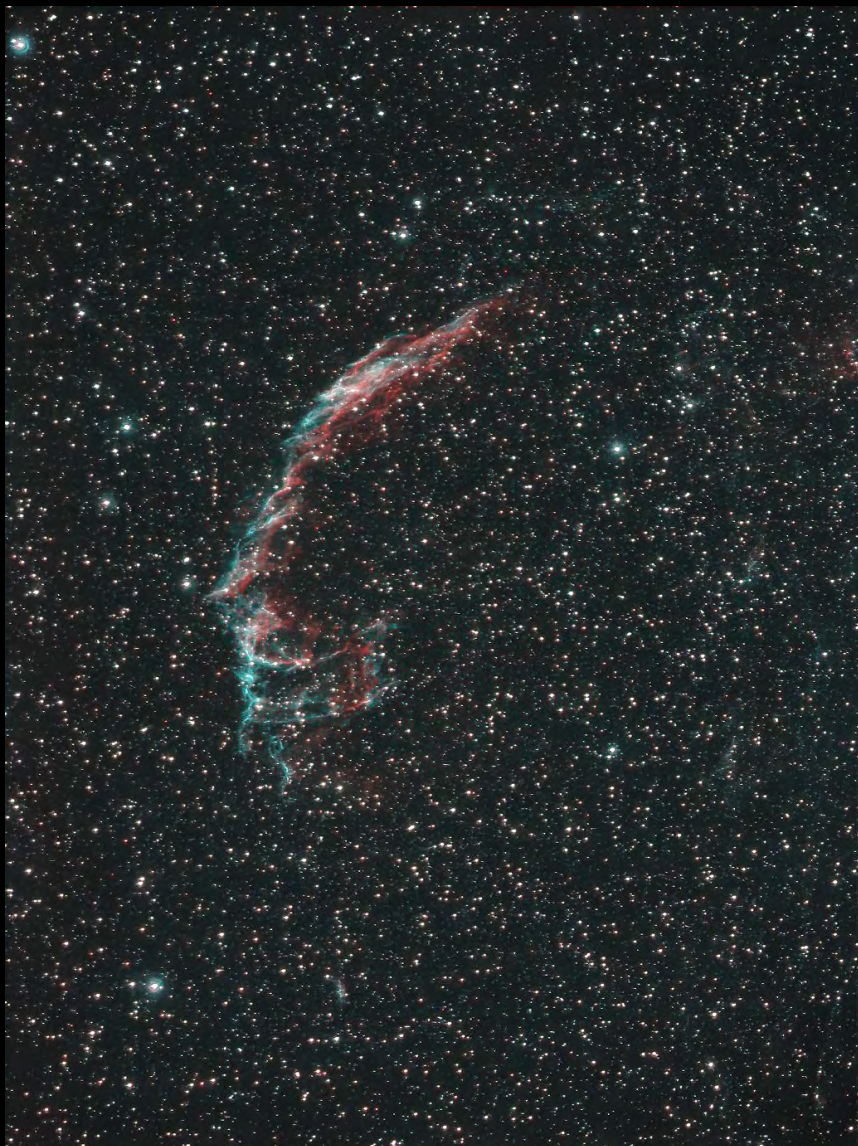
# Dumbbell Nebula

1,360 yrs



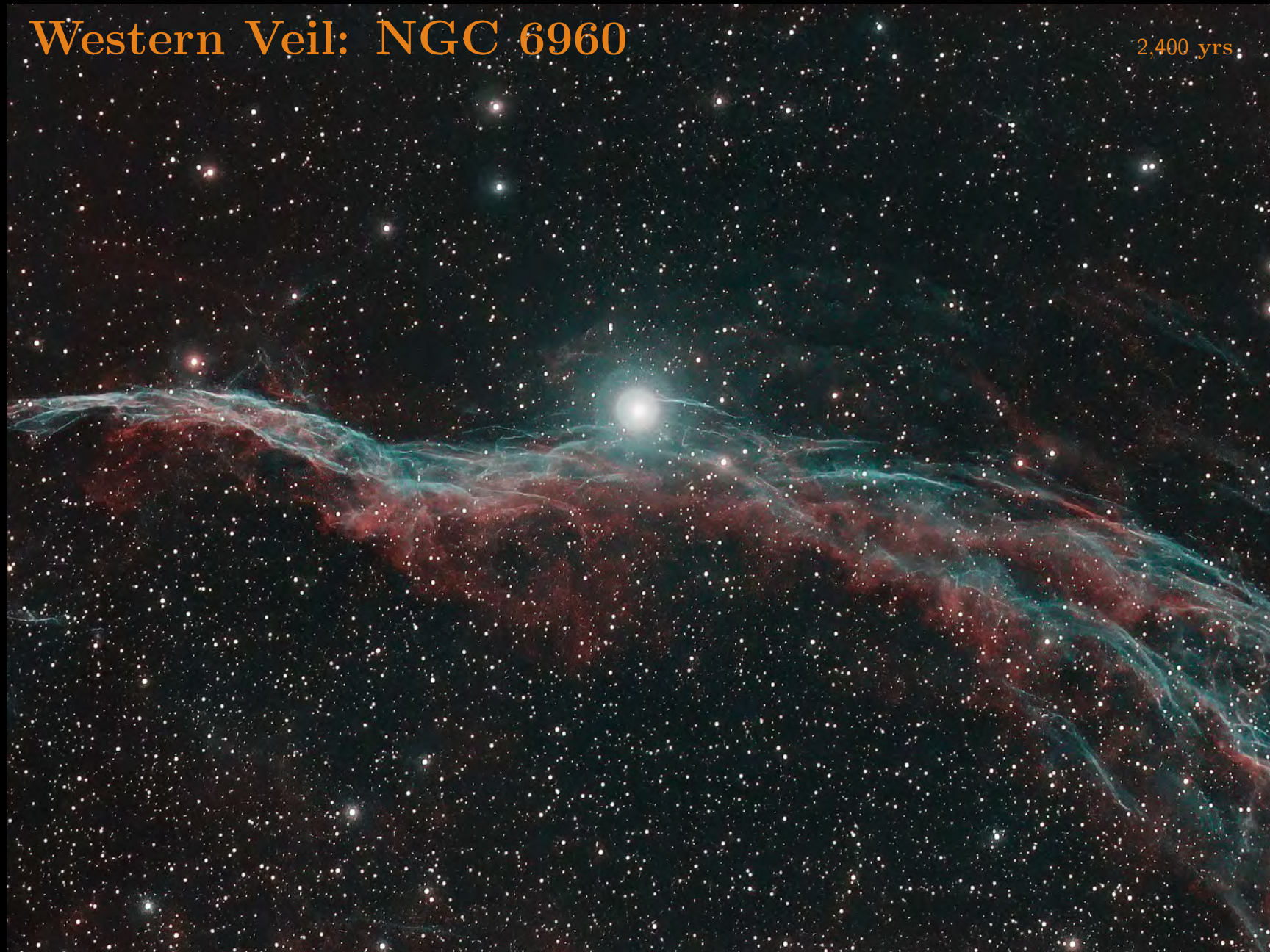
# Veil Nebula: NGC 6960 and 6992

2,400 yrs



# Western Veil: NGC 6960

2,400 yrs



# Eastern Veil: NGC 6992

2,400 yrs



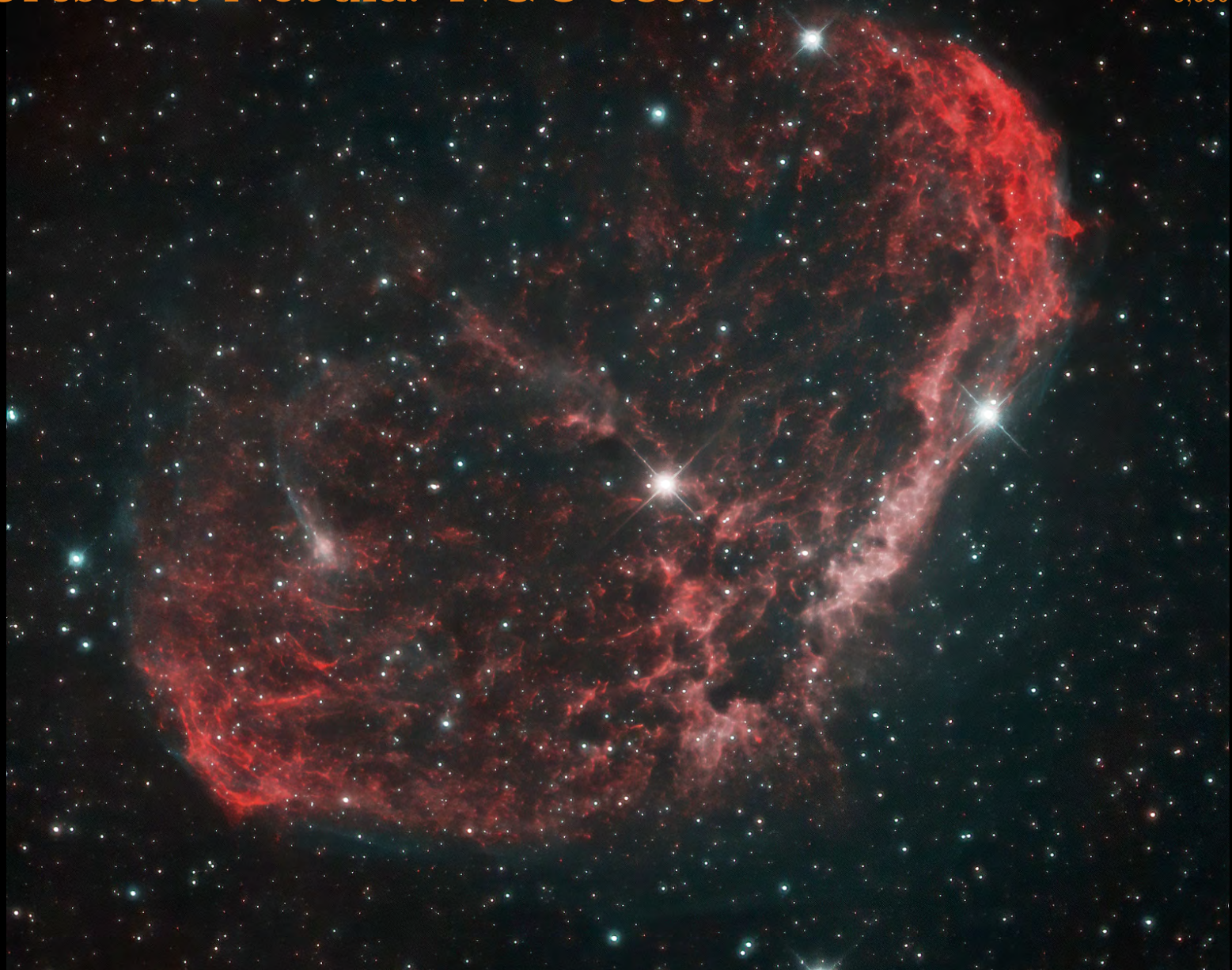
# Ring Nebula: M57

2,567 yrs



# Crescent Nebula: NGC 6888

5,000 yrs



# Jellyfish Nebula: IC 443

5,000 yrs



# Rosette Nebula: NGC 2237

5,200 yrs



# Eagle Nebula: M16

5,700 yrs



# Eagle Nebula: M16

5,700 yrs



# Crab Nebula

Mar. 26, 2019

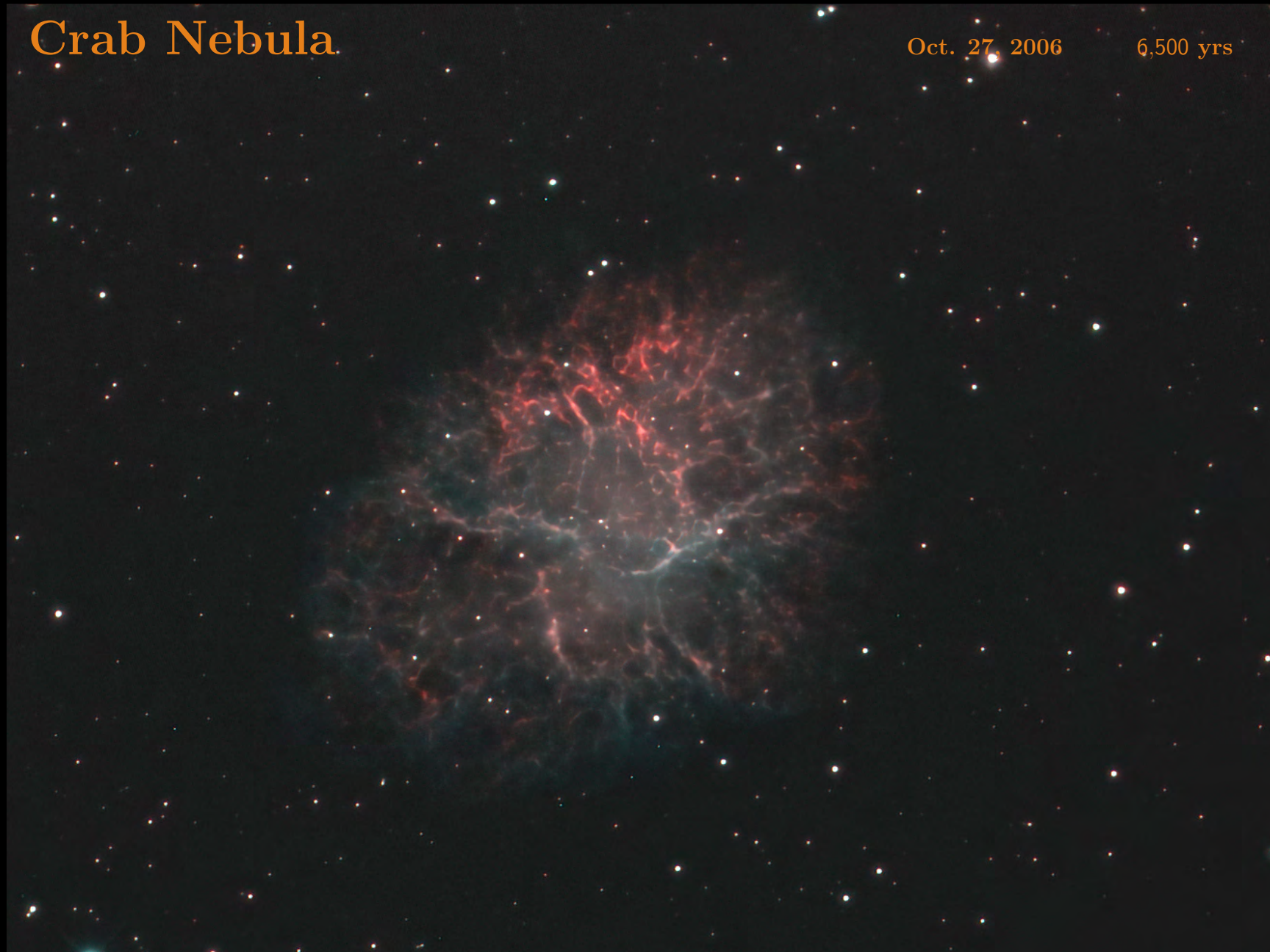
6,500 yrs



# 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



Go Tigers!



Questions?

