

Astronomy...
Things Both Near and Far

Robert Vanderbei

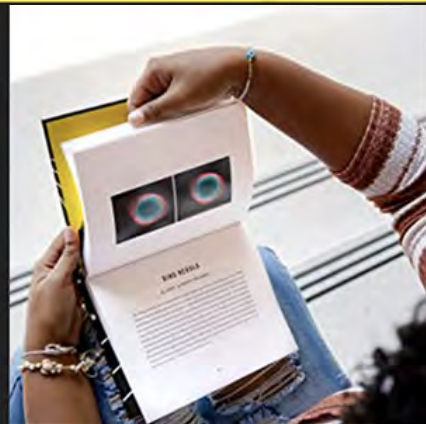
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Welcome to the Universe in 3D *A Visual Tour*

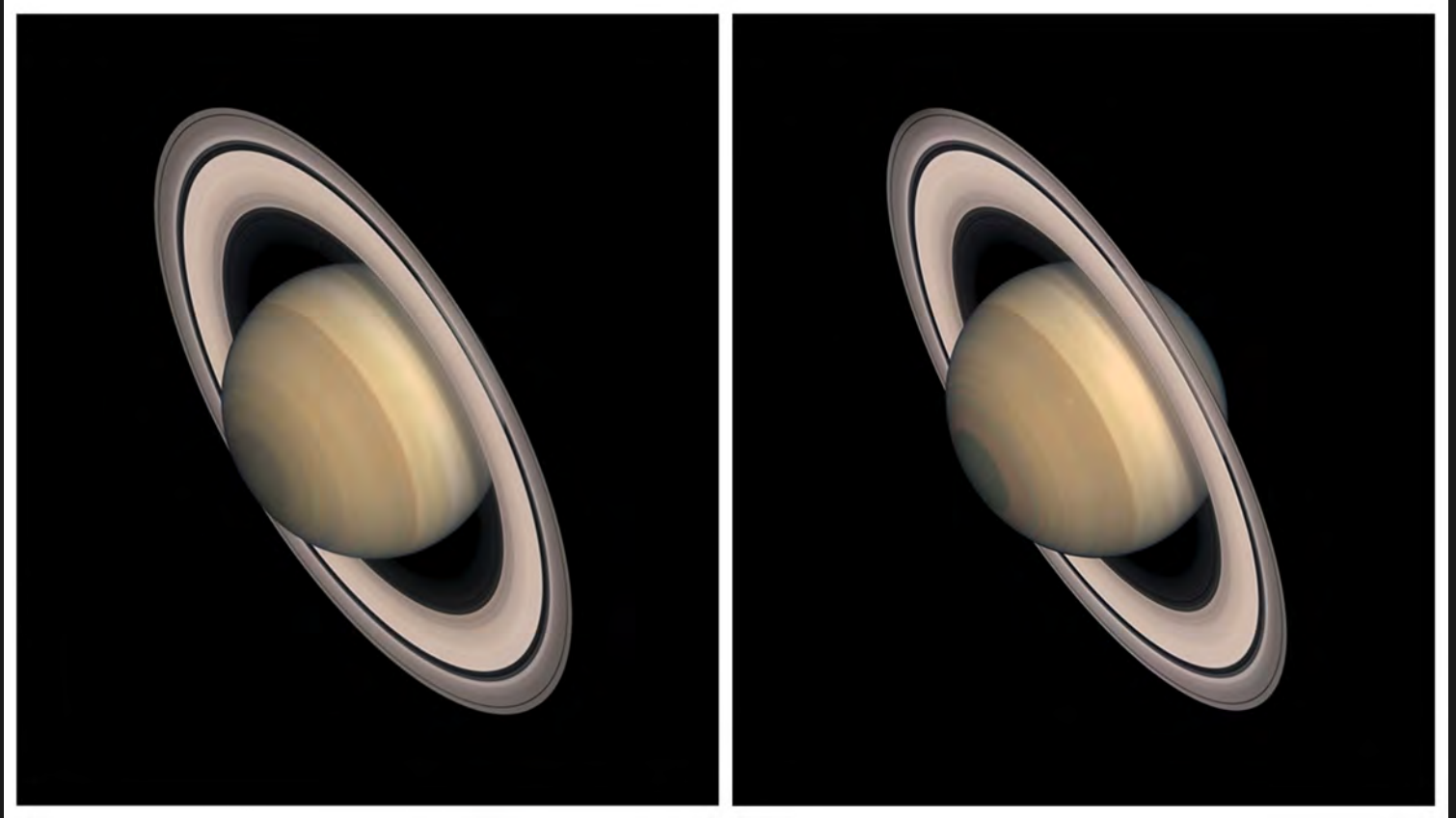
Neil deGrasse Tyson, Michael A. Strauss,
J. Richard Gott, and Robert J. Vanderbei



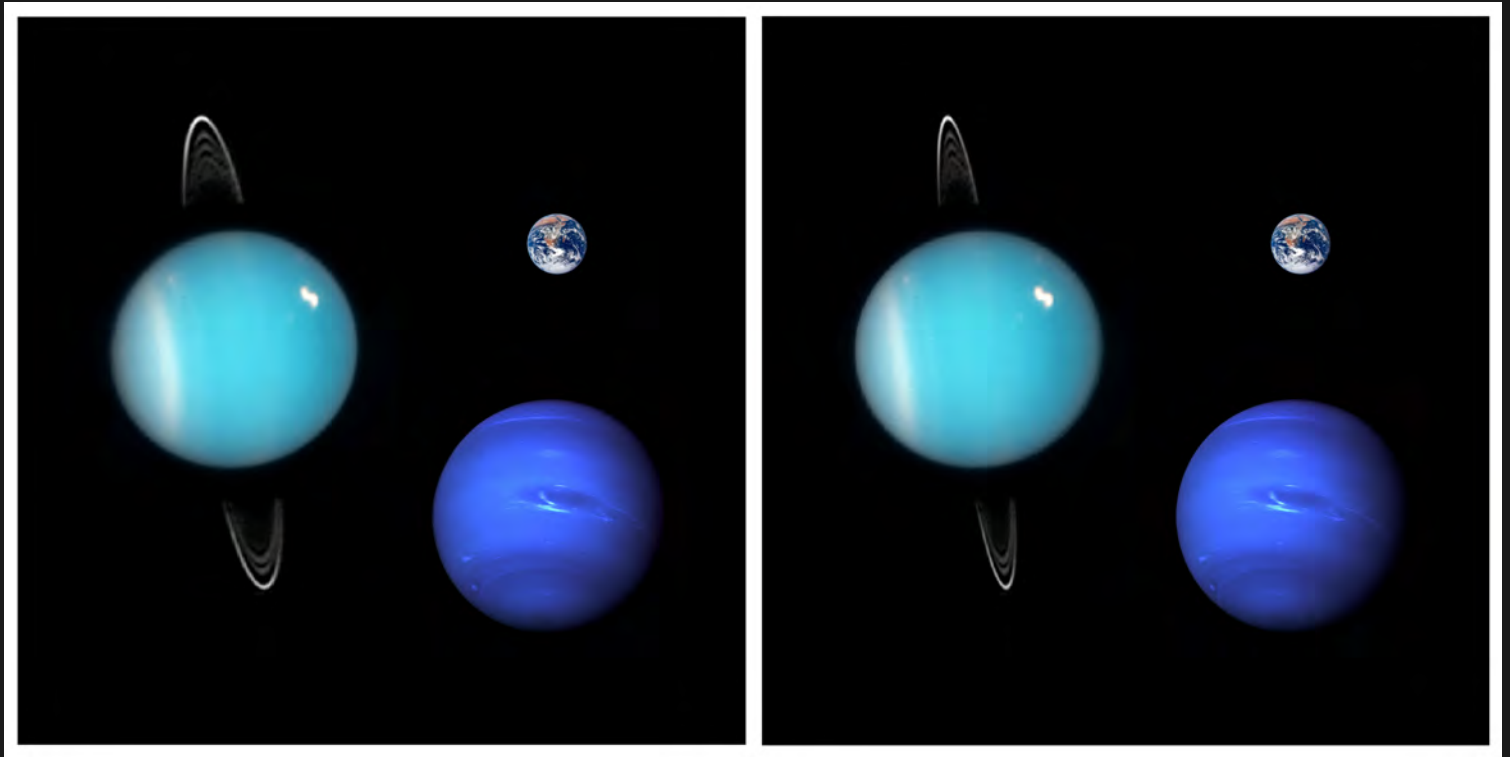
Neil deGrasse Tyson with Stephen Colbert



April 19, 2022



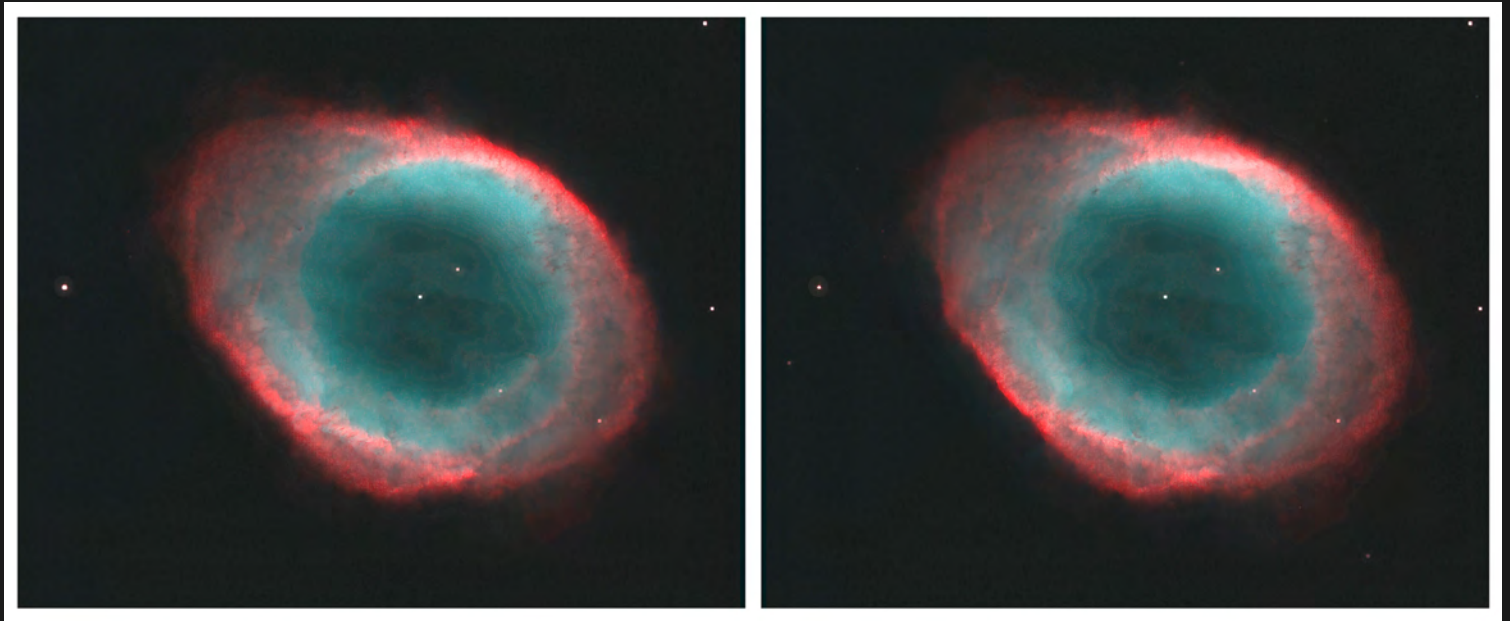
Uranus, Neptune, Earth



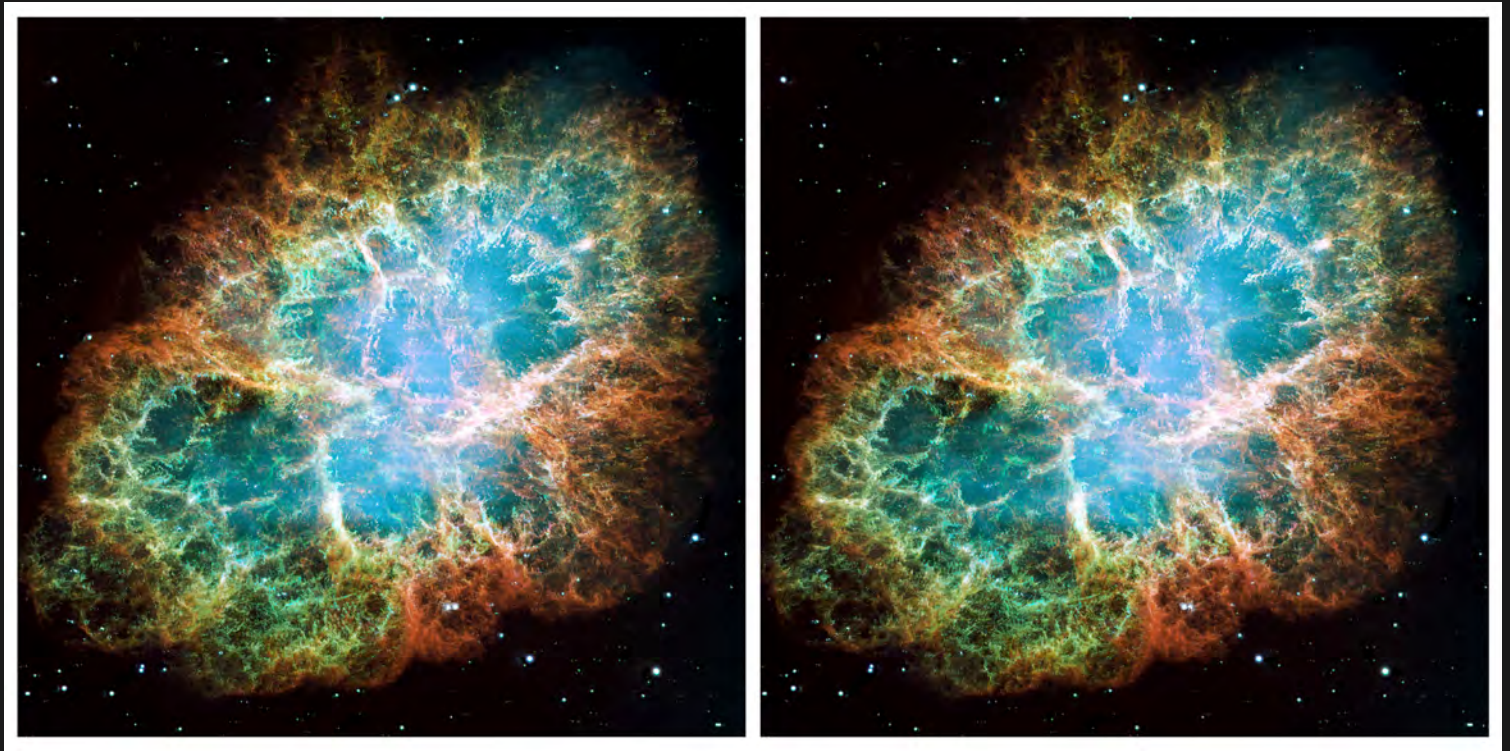
Pluto, Charon



Ring Nebula



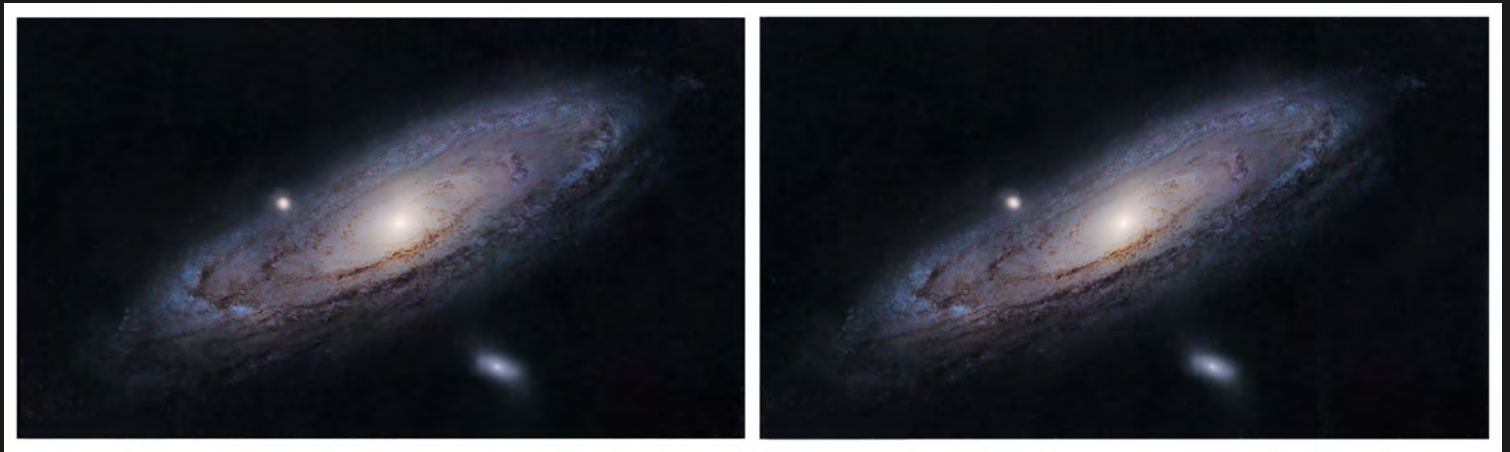
Crab Nebula



Great Globular Cluster in Hercules



Andromeda Galaxy



Coma Cluster



Hubble Ultra Deep Field



Parallax



Parallax

Left Eye View

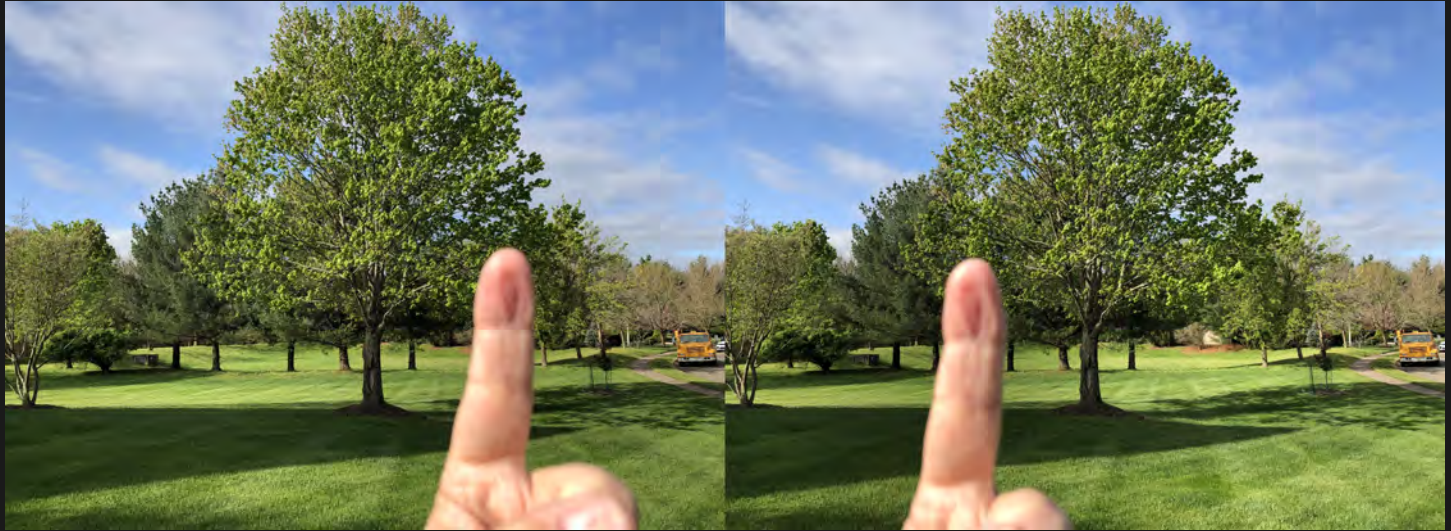


Parallax

Right Eye View



My Finger – Parallax



My Finger – Left Eye



My Finger – Right Eye



My Finger – Both Eyes



Let's Go Astro

10" Reflector, 4" Refractor, Telephoto Lens



Move equipment outside.



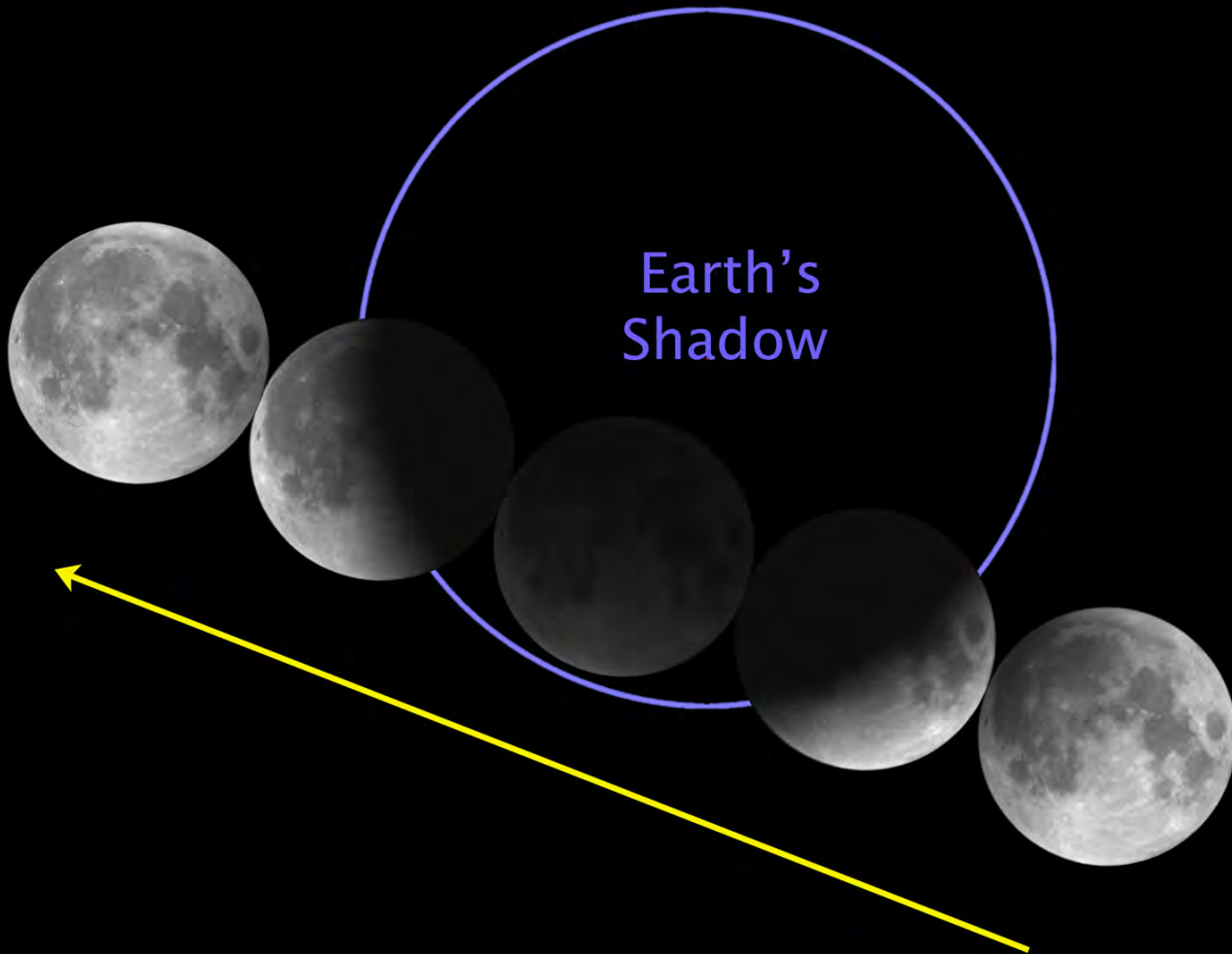
Ready To Go...



Is The Earth Flat?

A Picture's Worth a Thousand Words...





How Aristarchus measured the size of the Moon.

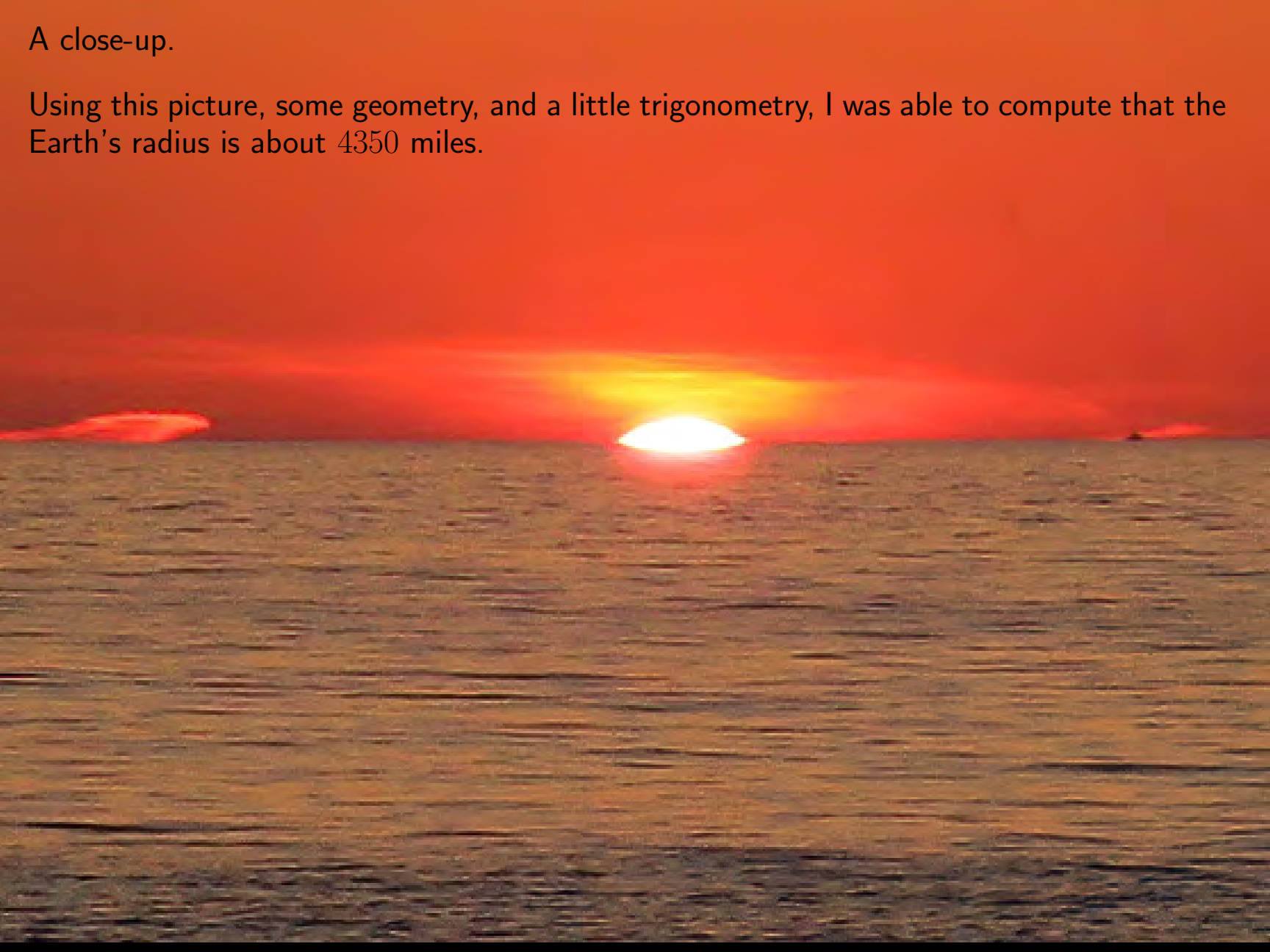
How Big Is Earth?

A picture I took of a sunset over Lake Michigan.



A close-up.

Using this picture, some geometry, and a little trigonometry, I was able to compute that the Earth's radius is about 4350 miles.



BETTER ANSWER: Earth's Diameter \approx 8,000 miles

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.



Next total lunar eclipse visible from the "east coast" is on March 14, 2025 at 3am.

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

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

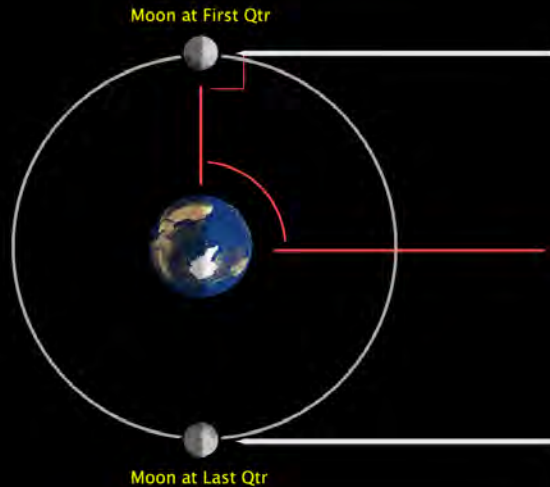
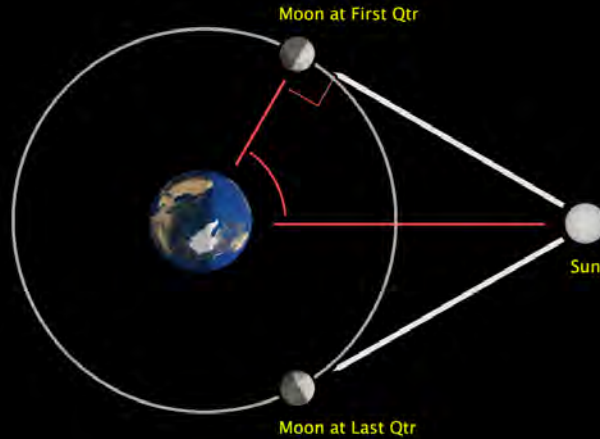
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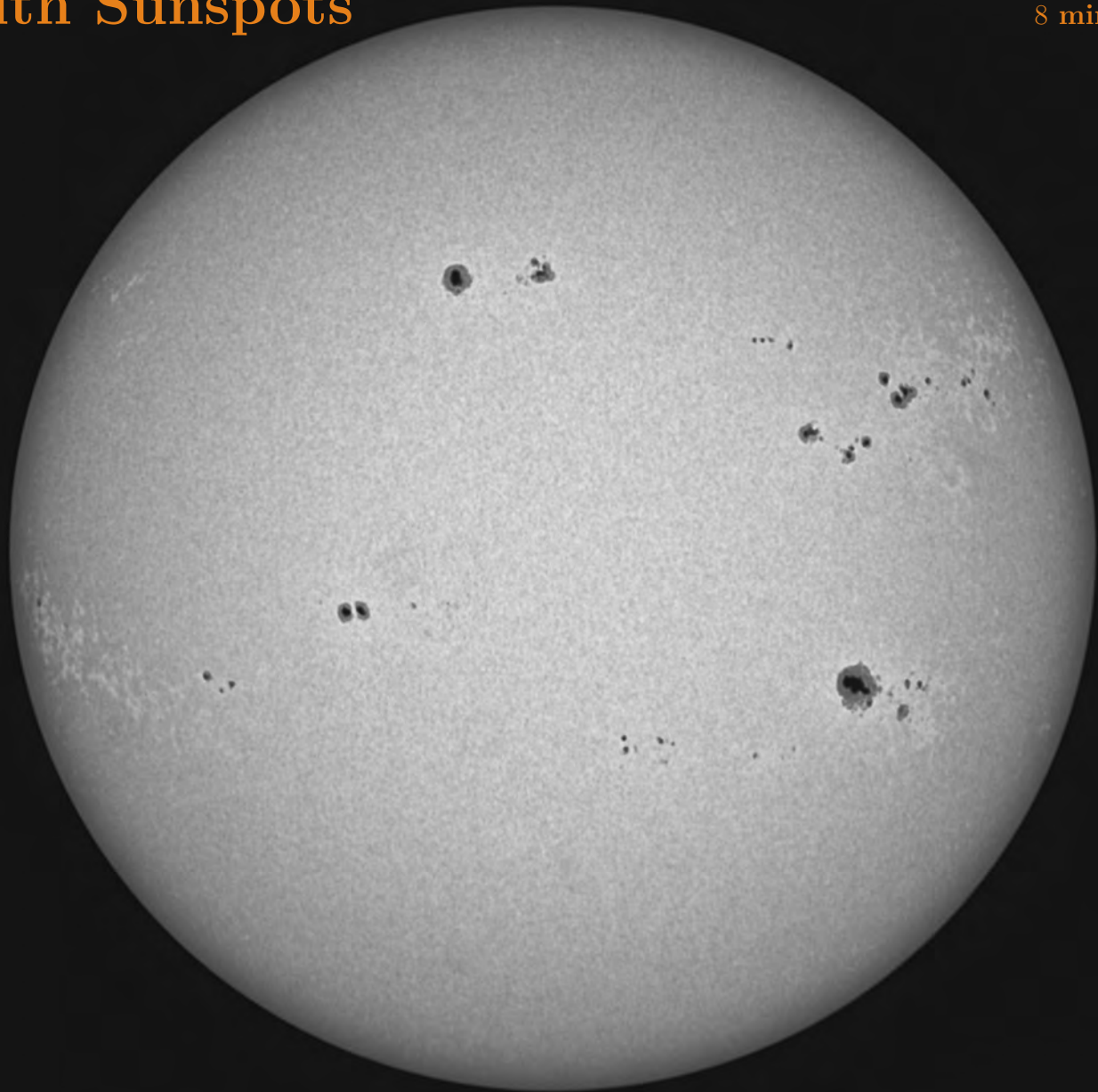
Which Is Further Away... Sun or Moon?

The Sun is about 400 times further away...



Sun with Sunspots

8 minutes (pg 21)



Crescent Moon

4:07pm Nov. 5, 2021



Full Moon

1.2 sec



Moon and Mars



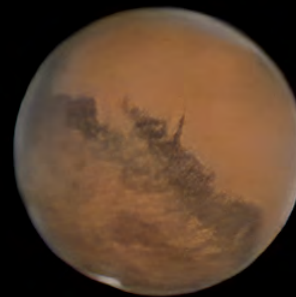
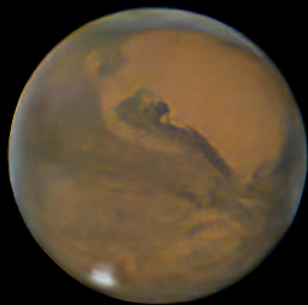
Moon and Mars

1.2 sec and 3.3 min



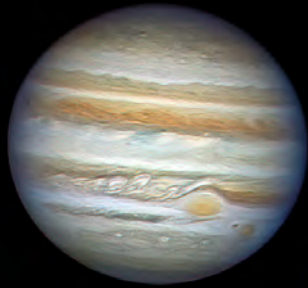
Mars

Oct. 6 and 18, 2020 (pg 33)



Jupiter and Saturn

32 and 67 min (pgs 51,59)



Comet 103P / Double Cluster

1.2 min / 7,460 and 7,640 yrs (pg 47)



Looking Out Beyond Our Solar System

Distance Measurements

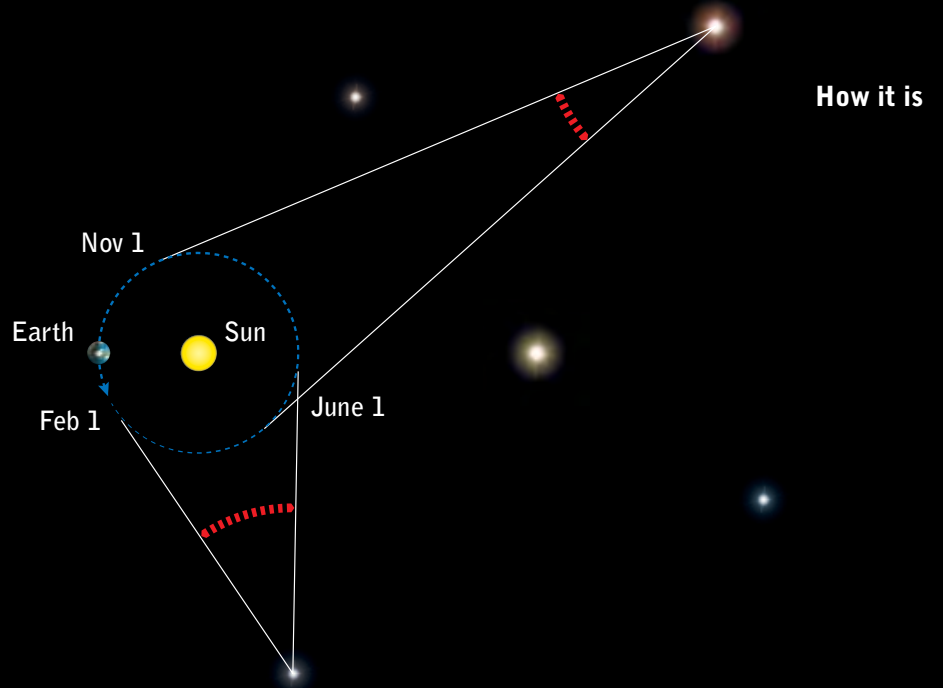
There are various ideas/methods for measuring distances.

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



The Pleiades (Subaru): M45

444 yrs



Orion Nebula: M42

1,344 yrs



Dumbbell Nebula: M27

1,360 yrs



Veil Nebula: NGC 6960 and 6992

2,400 yrs



Western Veil: NGC 6960

2,400 yrs



Eastern Veil: NGC 6992



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



Crab Nebula: M1

Mar. 26, 2019

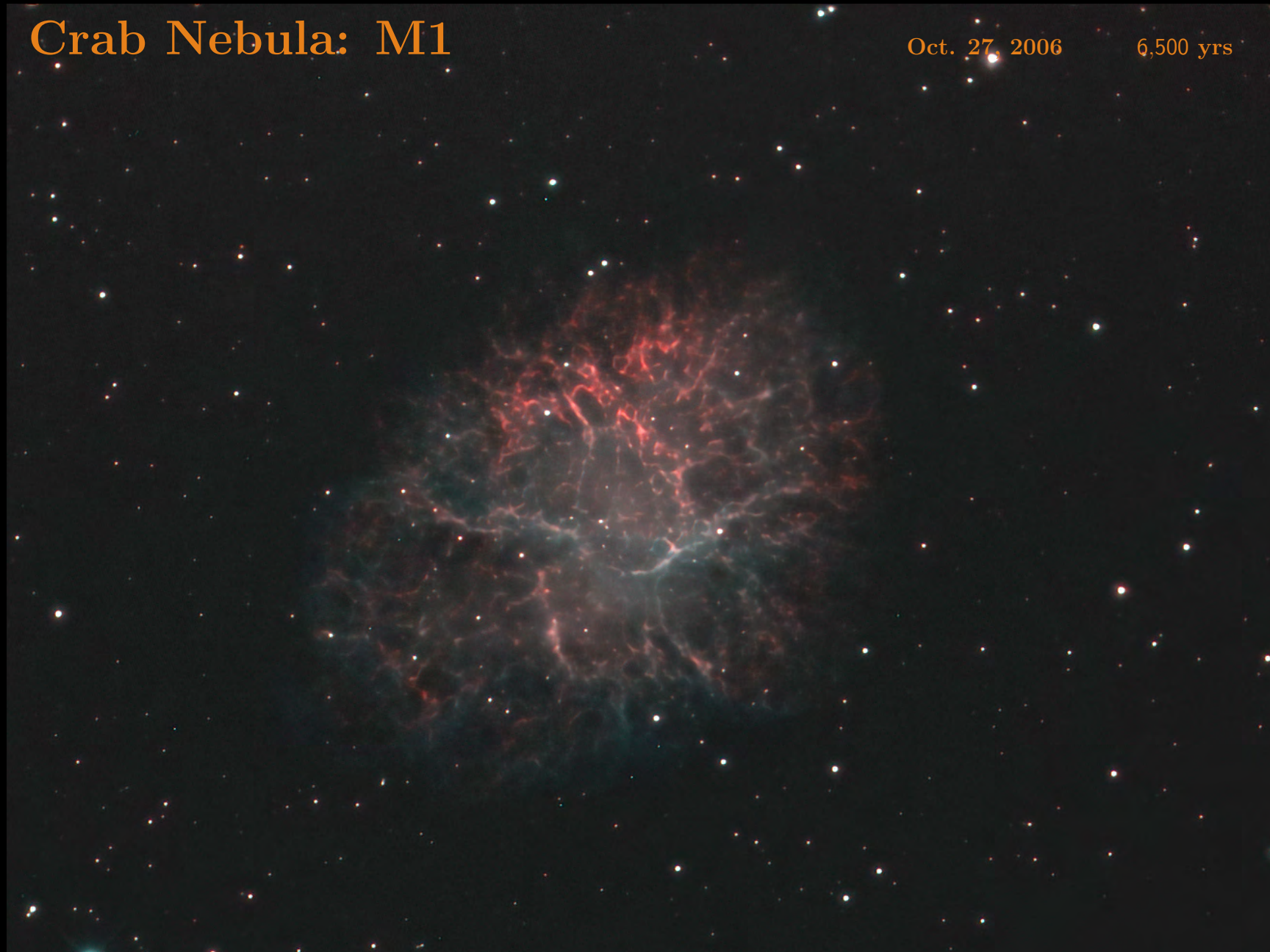
6,500 yrs



Crab Nebula: M1

Oct. 27, 2006

6,500 yrs



Bubble Nebula: NGC 7635

$9,100 \pm 2,000$ yrs



Globular Cluster: M13

22,200 yrs



Looking Out Beyond Our Milky Way

The Andromeda Galaxy: M31

2,450,000 yrs



M81 and M82

12,000,000 yrs



The Pinwheel Galaxy: M101

20,900,000 yrs



The Pinwheel Galaxy: M101

20,900,000 yrs



The Whirlpool Galaxy: M51

31,000,000 yrs



The Whirlpool Galaxy: M51

31,000,000 yrs



The Whirlpool Galaxy: M51

31,000,000 yrs



The Leo Trio: M65, M66, NGC 3628

32,000,000 yrs



The Needle Galaxy: NGC 4565

42,700,000 yrs



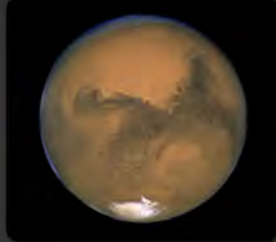
Welcome to the Universe in 3D



3D Pictures from the Book



Moon



Mars



Comet Lovejoy



Jupiter and Ganymede



Mimas



Crab Nebula



Andromeda



Hubble Ultra Deep Field

Questions?

Ring Nebula

with Diffraction Grating

