

Sizing Up The Universe

A First-Year Seminar

Robert Vanderbei

June 26, 2025

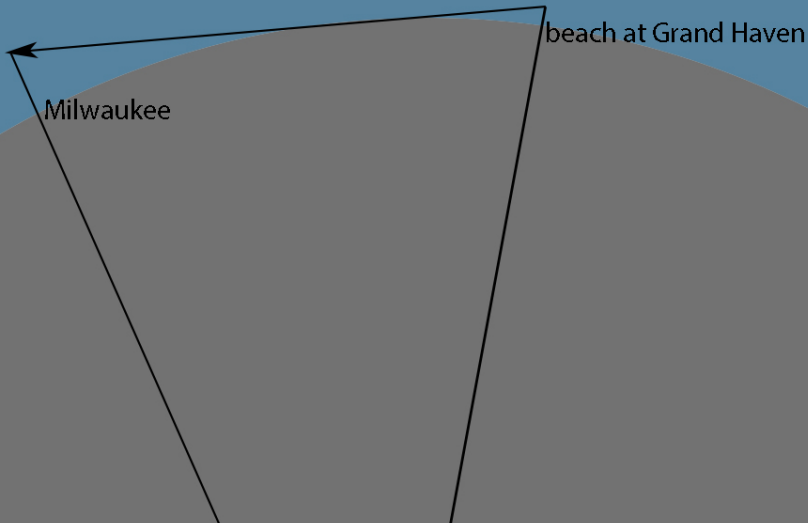
A Little About Me

- ▶ 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.

Looking West Over Lake Michigan. See Milwaukee?



Oh Right... the Earth is Not Flat



Distance Measurements

The distance from the beach near Grand Haven to Milwaukee is about 86 miles.

The radius of Earth is about 4000 miles.

My camera was about 7 feet above water level.

Distance Measurements

The distance from the beach near Grand Haven to Milwaukee is about 86 miles.

The radius of Earth is about 4000 miles.

My camera was about 7 feet above water level.

Light into my camera that's tangential to Lake Michigan was 0.86 miles high over Milwaukee.

Distance Measurements

The distance from the beach near Grand Haven to Milwaukee is about 86 miles.

The radius of Earth is about 4000 miles.

My camera was about 7 feet above water level.

Light into my camera that's tangential to Lake Michigan was 0.86 miles high over Milwaukee.

The tallest building in Milwaukee is the U.S. Bank Center. It's 600 feet tall, aka 0.11 miles.

Distance Measurements

The distance from the beach near Grand Haven to Milwaukee is about 86 miles.

The radius of Earth is about 4000 miles.

My camera was about 7 feet above water level.

Light into my camera that's tangential to Lake Michigan was 0.86 miles high over Milwaukee.

The tallest building in Milwaukee is the U.S. Bank Center. It's 600 feet tall, aka 0.11 miles.

To see just the very top of the U.S. Bank Center, I would have had to have been 2060 feet about water level. That's a lot more than seven feet.

Distance Measurements

The distance from the beach near Grand Haven to Milwaukee is about 86 miles.

The radius of Earth is about 4000 miles.

My camera was about 7 feet above water level.

Light into my camera that's tangential to Lake Michigan was 0.86 miles high over Milwaukee.

The tallest building in Milwaukee is the U.S. Bank Center. It's 600 feet tall, aka 0.11 miles.

To see just the very top of the U.S. Bank Center, I would have had to have been 2060 feet about water level. That's a lot more than seven feet.

The tallest building on Earth is Burj Khalifa in Dubai. It's 2717 feet tall, aka 0.51 miles.



A close-up.

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

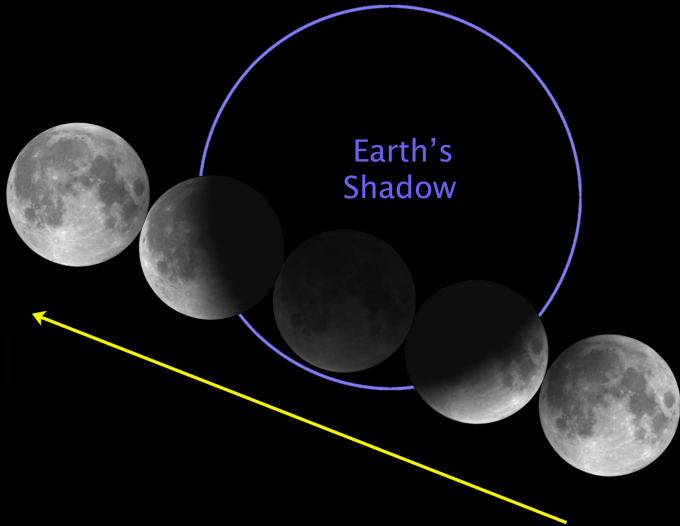
7 feet \Rightarrow 4977 miles. 5.56 feet \Rightarrow 3960 miles.



Is The Earth Flat?

A Picture's Worth a Thousand Words...





How Aristarchus measured the size of the Moon.

Kinda Recent Events

Solar Eclipse seen in Plattsburgh NY (Apr. 8, 2024)



Lunar Eclipse seen on Poe Field (Nov. 8, 2022)



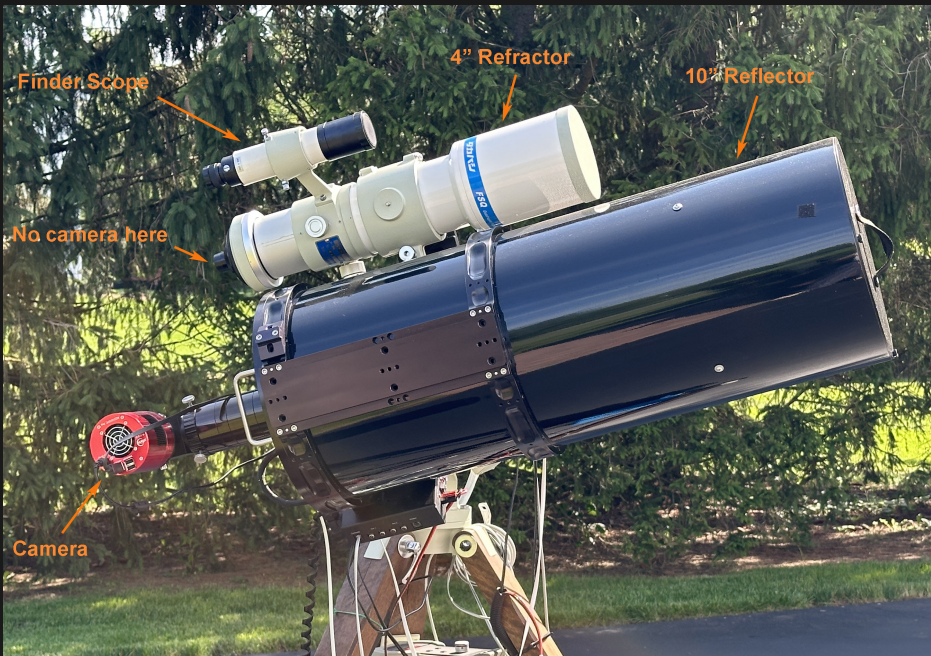
Lunar Eclipse seen on Poe Field (Nov. 8, 2022)



Lunar Eclipse (Nov. 8, 2022)



Equipment: 10" Reflector, 4" Refractor, Digital Camera



Move equipment outside.



Ready To Go...



Halloween's Blue Moon

Oct. 31, 2020



Moon

1.1 sec



Moon and Mars



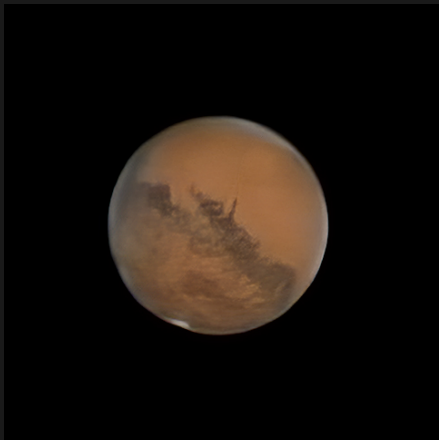
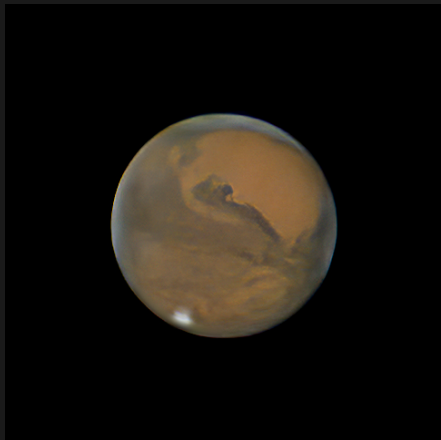
Moon and Mars

1.1 sec and 3.3 min



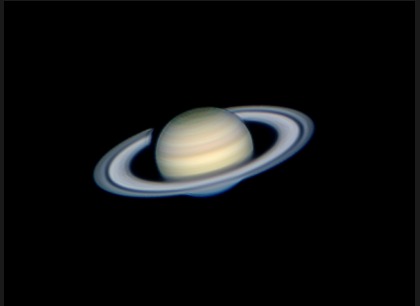
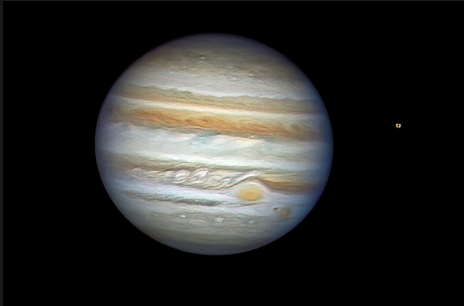
Mars

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

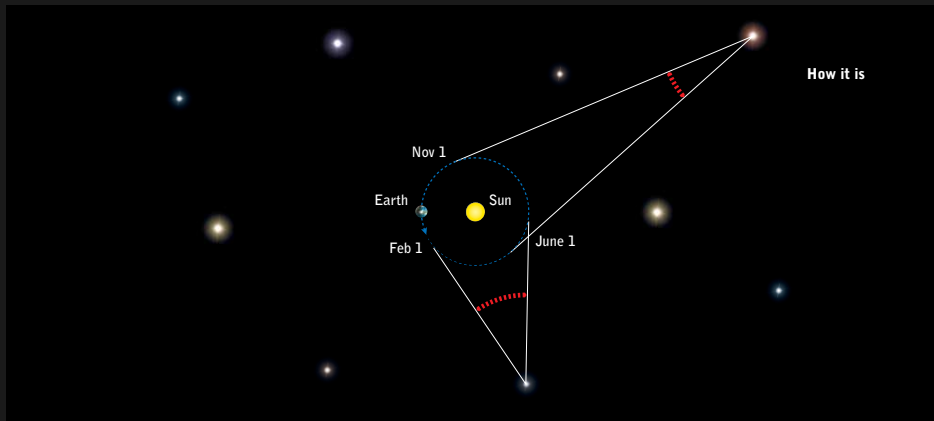
There are various ideas/methods for measuring distances.

The simplest is called **parallax**.

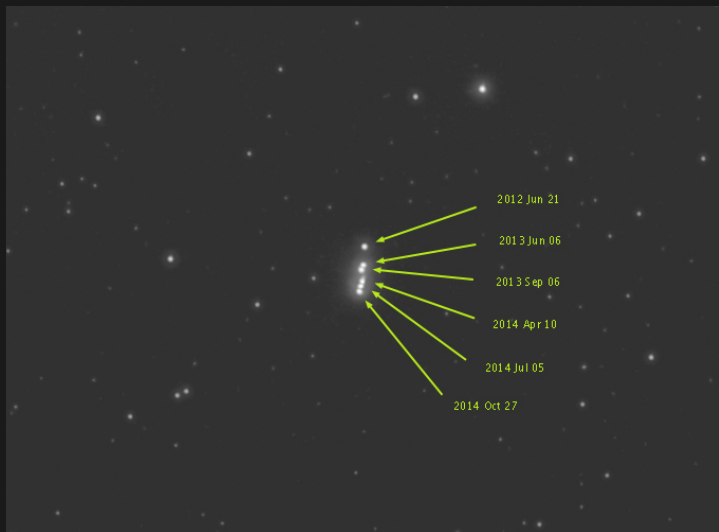
Using parallax, we can measure the distance to nearby stars.

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

Parallax: Distance to the Stars

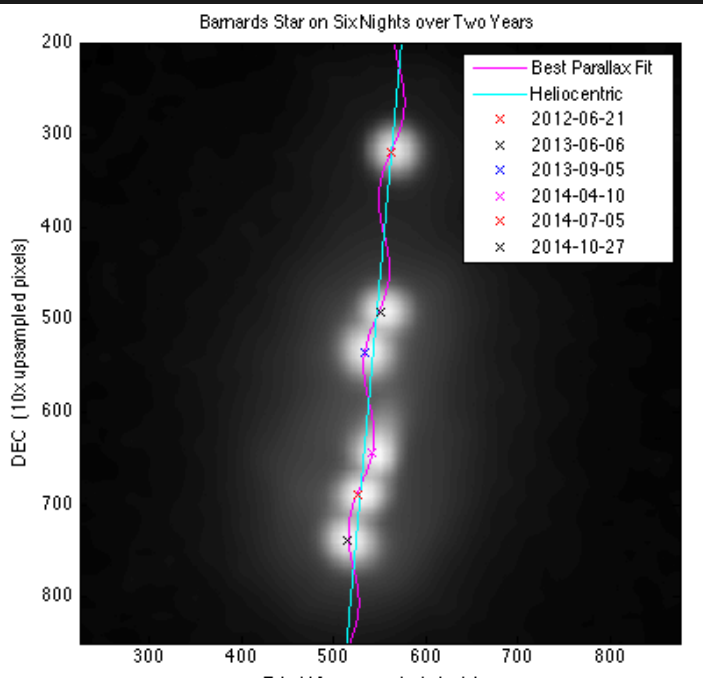


Barnard's Star Overlay



Barnard's Star Closeup

6.0 yrs



Orion Nebula: M42

1,344 yrs



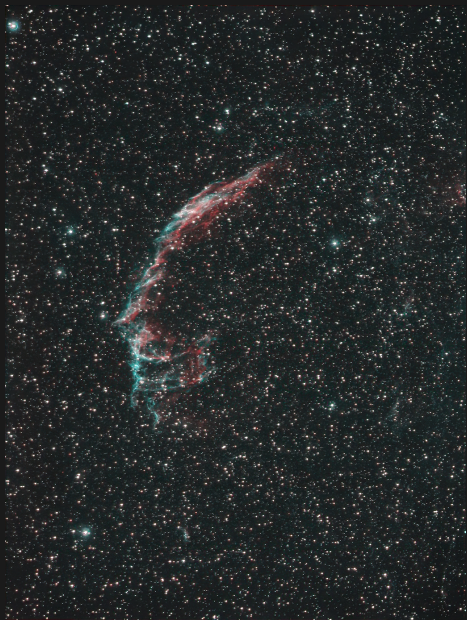
Dumbbell Nebula

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

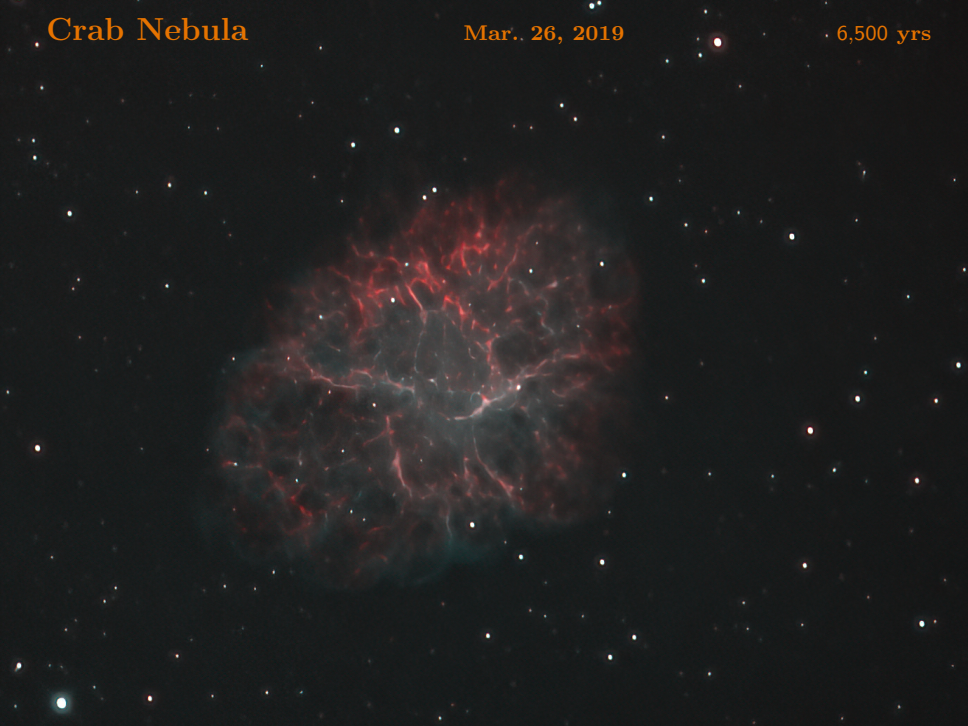
5,700 yrs



Crab Nebula

Mar. 26, 2019

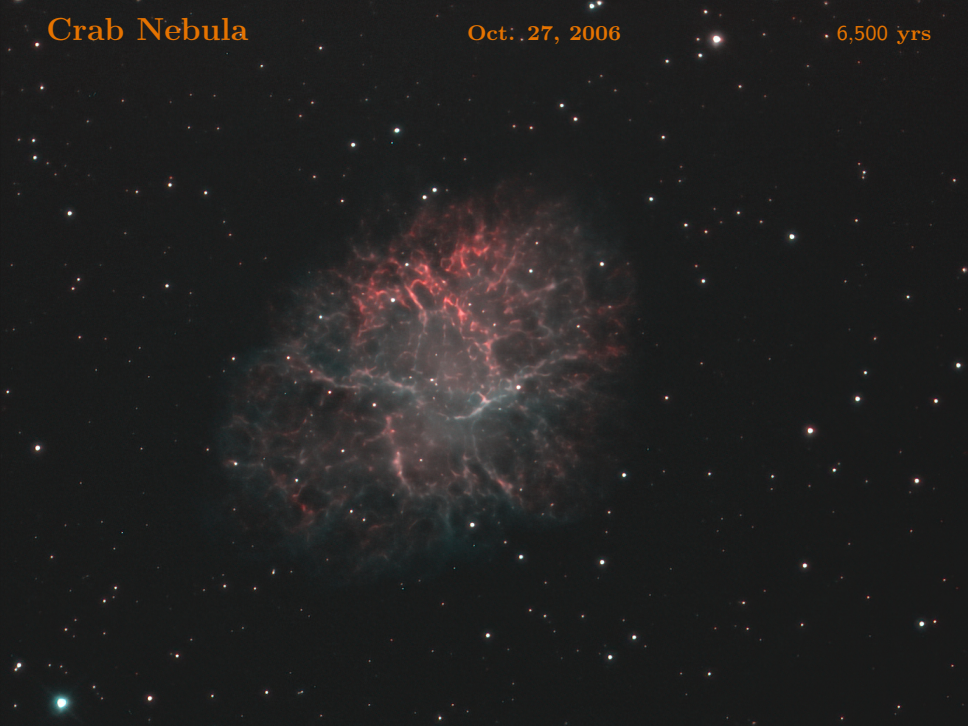
6,500 yrs



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



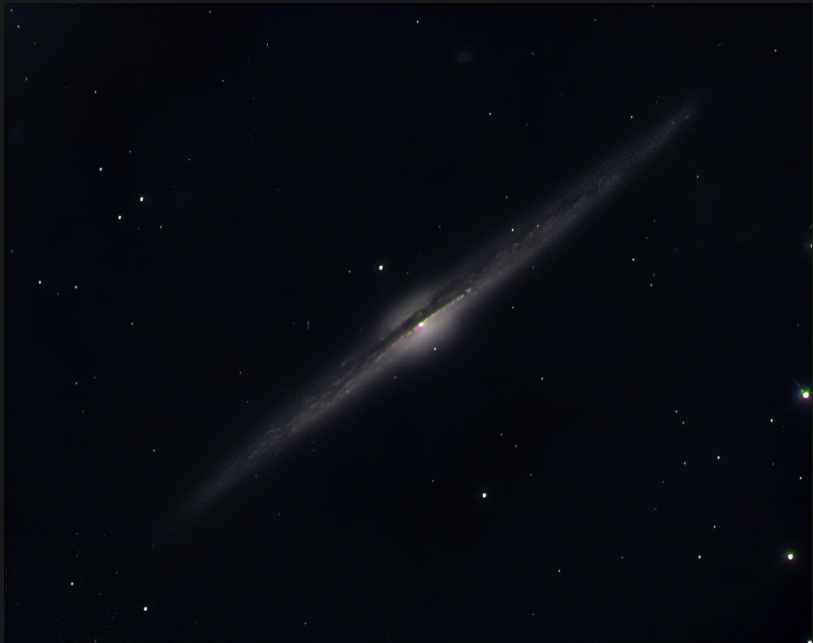
The Leo Trio

32,000,000 yrs



The Needle Galaxy (NGC 4565)

42,700,000 yrs



Go Tigers!



Questions?

