Astronomy...
Things Both Near and Far

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Crescent Moon
Crescent Moon

4:23pm Dec. 18, 2020
Super Full Moon

June 14, 2022
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 and Mars
Moon and Mars

1.2 sec and 3.3 min
Jupiter and Saturn

32 and 67 min
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
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
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 ± 2,000 yrs
Globular Cluster M13

22,200 yrs
Looking Out Beyond Our Milky Way
The Andromeda Galaxy

2,450,000 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?
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 $360^\circ$ 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:

$$\text{Moon Size} = \frac{59}{38025} \times 360^\circ \approx 0.56^\circ \approx 1/2 \text{ deg}$$
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 = $\frac{\text{Moon’s orbital circumference}}{2 \pi} \approx \frac{\text{Moon’s orbital circumference}}{6} = \frac{2,000 \times 720}{6} = 240,000$ mi
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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

So why didn’t people believe Aristotle?

Because Aristotle had a killer argument for why Earth did not move. If Earth circled the sun, the stars should show a parallax effect—and this was not seen. As Earth circled the sun, Earth’s position relative to the stars should oscillate, causing the stars’ positions to oscillate once a year in the sky. This is explained in the figure opposite. The true situation is as shown at the top—just as Aristarchus envisioned it. Earth circulates the sun once a year. Assume the stars and the sun remain at fixed positions. How does it look from Earth? We are riding on Earth, so it looks to us like Earth is not moving.

It looks to us like the sun moves in a small circle of radius 1 AU around Earth once a year (that’s why it circles the celestial sphere once a year). The stars do not move relative to the sun, so as seen from Earth, stars must, like the sun, also seem to move in 1 AU circles over the course of a year. We should be able to see the stars trace these circles in the sky every year. These parallax circles represent the reflex motion of the stars relative to Earth produced by the motion of Earth as it circles the sun, creating changing viewing angles during the year to those stars (top right). If the distance from Earth to the sun is 1 AU, then the radius of all these parallax circles would also be 1 AU. The angular radius of the parallax circle depends on the distance to the star. A nearby star has a larger angular oscillation in the sky as seen from Earth than a distant star (bottom right).

If we look at a constellation, the nearby stars should oscillate more during the year than the distant stars. So the positions of nearby stars should shift during the year relative to more distant stars. The ancients thought that the stars were close enough that these oscillations should have been visible to the naked eye. But none were seen. Aristotle thought that proved Earth didn’t move.

Aristarchus proposed an answer—no parallax effects were seen because the stars were infinitely far away. Parallax effects get smaller the farther away the stars are. Put the stars twice as far away, and the parallax effects become half as large. Put them infinitely far away, and the parallax effects disappear entirely. It was almost the right answer.

In 1453 Nicolaus Copernicus (1473–1543) published a sun-centered model based on Aristarchus’s work. In it he was able to explain in a simple manner the main motions seen in the solar system. Mercury and Venus oscillate back and forth ahead of and behind the sun as the sun circles the sky once a year. Copernicus said this is because they, like Earth, orbit the sun but are closer to the sun than Earth is.

Before Copernicus, people had explained this motion with epicycles: The planet was supposed to circle a point that itself circled Earth. The big circle carrying the point was called the deferent, and the small circle around that point was called the epicycle. Venus and Mercury had large deferent circles exactly synchronized with the sun. Their epicycles produced their oscillations around the sun. The outer planets (Mars, Jupiter, Saturn) had big deferent circles that traced their slow orbits around the sky and epicycles with periods of one year each, which in reality showed the reflex (parallax) motion relative to Earth caused by Earth’s movement around the sun.
Barnard’s Star
Barnard’s Star
Barnard’s Star
Barnard’s Star
Barnard’s Star
Barnard’s Star
Barnard’s Star Overlay

- 2012 Jun 21
- 2013 Jun 06
- 2013 Sep 06
- 2014 Apr 10
- 2014 Jul 05
- 2014 Oct 27
The measured parallax is 0.5478 arcsecs. Corresponds to a distance of 5.97 lightyears.