DSLR on a Tripod
3.5 Questar
The Sun at Sunrise
The Sun in the Daytime
The Sun in H
The Moon
The Planets
Ritchey-Chretien and Takahashi FSQ

1. Mount

2. Camera
   Computer
   Software

3. Telescope (OTA)
Move equipment outside.
Ready To Go...
MiniMoon and SuperMoon
Lunar Eclipse Dec 21, 2010
The Pictures Are Better Than The Visual View
Saturn
M1 Crab Nebula 2019
Parallax: Distance to the Stars

How it is

So Why Didn't people believe Aristarchus?

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 circles 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
M27  Dumbbell Nebula
M27  Dumbbell Nebula
M13

Hertzsprung-Russell Diagram

Hertzsprung-Russell Diagram for M13

Brightness (apparent magnitude) vs. Color index (B-R)
Whirlpool Galaxy
Whirlpool Galaxy
M16  The Eagle Nebula (aka Pillars of Creation)
M31 – The Andromeda Galaxy
M42  Great Orion Nebula
M45  Pleiades (aka Subaru)
Western Veil Nebula
Eastern Veil Nebula
Bubble Nebula
Helix Nebula
Elephant Trunk
Rosette Nebula
Rosette Nebula
Pelican Nebula
Questions?
A Little About Me

Born/Raised: Grand Rapids, MI

Undergrad: Chemistry, 1976, Rensselaer Polytechnic Institute (RPI)

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.
M1 Crab Nebula

**What**: Supernova remnant

**When**: Oct. 27, 2006

**Where**: Driveway

**Telescope**: 10" Ritchey-Chretien

**Camera**: Starlight Xpress SXV-H9

**Exposure**: Luminance=60min, Hα=140min, O-III=20min

**Sub-Exposures**: 20-minutes, guided

**Distance**: 6500 ± 1600 lightyears

**Diameter**: 11 lightyears
M13  Great Globular Cluster in Hercules

What: Gravitationally bound cluster of stars
When: Oct. 27, 2006
Where: Driveway
Telescope: 10" Ritchey-Chretien
Camera: Starlight Xpress Trius SX-694
Exposure: Luminance=6min, Red=8min, Green=6min, Blue=6min
Sub-Exposures: 20-second, unguided

Distance: 22 000 lightyears
Diameter: 168 lightyears
**M16 The Eagle Nebula (aka Pillars of Creation)**

**What:** Young star cluster and diffuse emission nebula

**When:** June 26 2005, July 17 2006, July 8 2007

**Where:** Driveway

**Telescope:** 10" Ritchey-Chretien

**Camera:** Starlight Xpress SXV-H9

**Exposure:** Hα=266min, O-III=66min

**Sub-Exposures:** 4-minute, 6-minute, 10-minute, guided

**Distance:** 5700 ± 400 lightyears

**Pillar Height:** 95 lightyears
M27  Dumbbell Nebula

What: Planetary nebula

When: Aug. 6, 2016

Where: Driveway

Telescope: 10" Ritchey-Chretien

Camera: Starlight Xpress Trius SX-694

Exposure: H =90min, O-Ill=80min

Sub-Exposures: 10-minute, guided

Distance: 1360 ± 200 lightyears

Diameter: 14 lightyears
M31 — The Andromeda Galaxy

What: Nearby galaxy
When: Oct. 26, 2008
Where: Driveway

Telescope: 4" Takahashi FSQ refractor
Camera: Starlight Xpress SXV-H9
Exposure: Luminance=80min, Red=40min, Green=40min, Blue=40min
Sub-Exposures: 2-minute, unguided

Distance: 2,500,000 lightyears
Diameter: 220,000 lightyears
M42  Great Orion Nebula

*What:* Young star cluster and diffuse emission nebula

*When:* Nov. 25, 2006

*Where:* Driveway

*Telescope:* 10” Ritchey-Chretien

*Camera:* Starlight Xpress SXV-H9

*Exposure:* Hα=32min, O-III=35min

*Sub-Exposures:* 1-minute, guided

*Distance:* 1 344 ± 20 lightyears

*Diameter:* 24 lightyears
M45  Pleiades (aka Subaru)

**What:** Open star cluster  
**When:** Jan. 3, 2008  
**Where:** Driveway  
**Telescope:** 4" Takahashi FSQ refractor  
**Camera:** Starlight Xpress SXV-H9  
**Exposure:** Red=16min, Green=20min, Blue=122min  
**Sub-Exposures:** 2-minute, unguided  

**Distance:** 444 lightyears
Veil Nebula

**What:** Supernova remnant

**When:** July 25 2008, July 24 2008

**Where:** Driveway

**Telescope:** 4" Takahashi FSQ refractor

**Camera:** Starlight Xpress SXV-H9

**Exposure:** H =60min, O-III=60min.  
*Exposure:* H =52min, O-III=24min

**Sub-Exposures:** 2-minute, 4-minute, unguided

**Distance:** 1470 lightyears

**Diameter:** 70 lightyears
Bubble Nebula

What: Emission nebula w/ stellar wind
Where: Driveway
Telescope: 10” Ritchey-Chretien
Camera: Starlight Xpress SXV-H9 and Trius SX-694
Exposure: H =350min, O-III=230min
Sub-Exposures: 10-minute, 20-minute, guided

Distance: 9 100 ± 2000 lightyears
Diameter: 8 2 lightyears
Helix Nebula

**What:** Planetary nebula

**When:** Oct. 2, 2008

**Where:** Driveway

**Telescope:** 4” Takahashi FSQ

**Camera:** Starlight Xpress SXV-H9

**Exposure:** H =86min, O-III=54min

**Sub-Exposures:** 2-minute, guided

**Distance:** 714 ± 70 lightyears

**Diameter:** 5.7 lightyears
Elephant Trunk

What: Star birth area in interstellar medium

When: Aug. 29, 2016

Where: Driveway

Telescope: 10” Ritchey-Chretien

Camera: Starlight Xpress Trius SX-694

Exposure: H =156min

Sub-Exposures: 6-minute, guided

Distance: 22,000 lightyears

Diameter: 168 lightyears
IC434  The Horsehead Nebula

What:  Dark nebula (dust cloud)
When:  Oct. 8, 2004
Where:  Driveway

Telescope:  4" Takahashi FSQ refractor
Camera:  Starlight Xpress SXV-H9
Exposure:  H=116min, G=18min, B=18min
Sub-Exposures:  2-minute, unguided

Distance:  1,400 lightyears
Running Man Nebula

**What:** Bright reflection nebula

**When:** Jan. 28, 2008

**Where:** Driveway

**Telescope:** 4" Takahashi FSQ refractor

**Camera:** Starlight Xpress SXV-H9

**Exposure:** Red=24min, Blue=100min

**Sub-Exposures:** 2-minute, unguided

**Distance:** 1,500 lightyears

**Diameter:** 15 lightyears