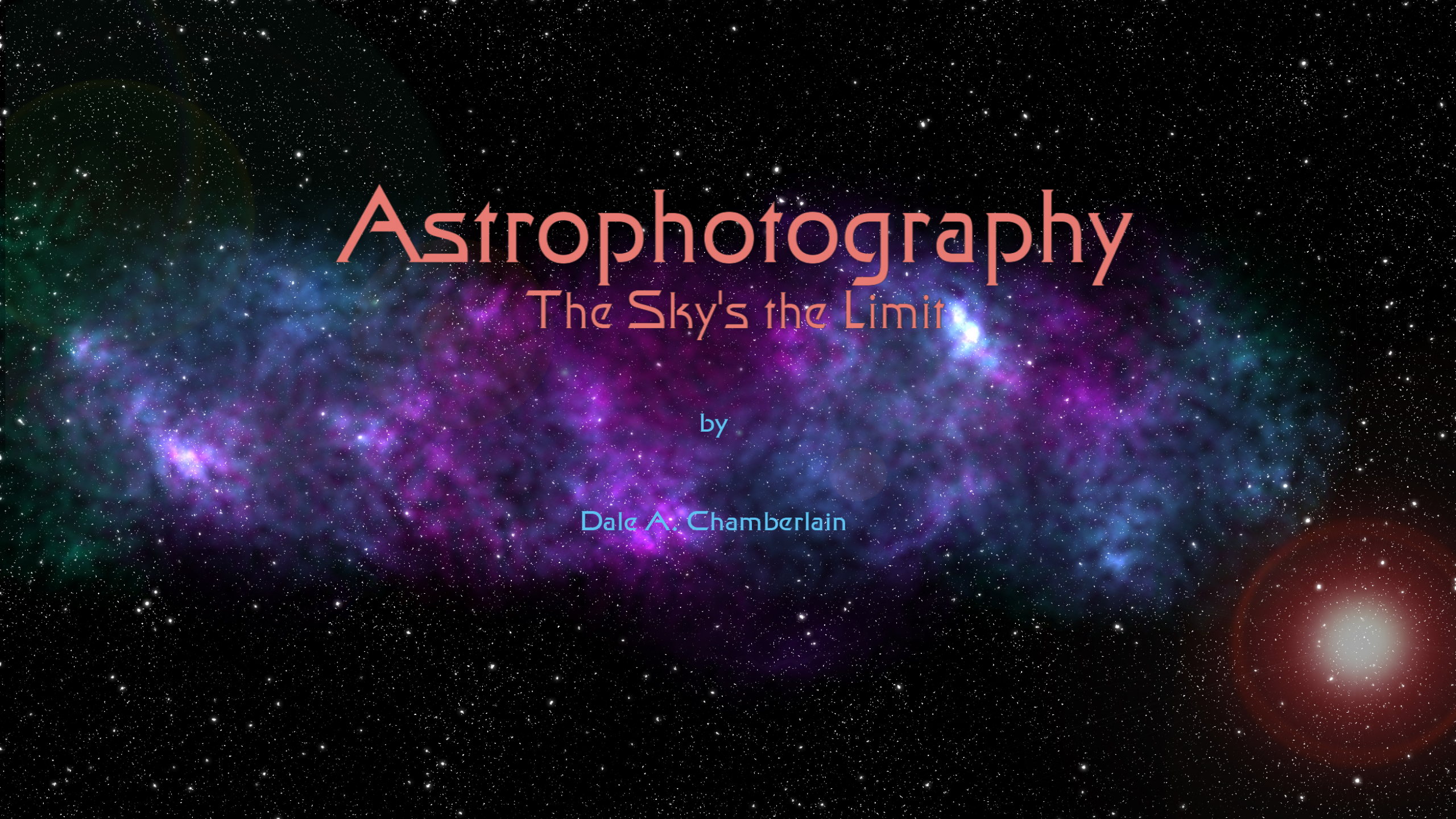

Astrophotography
The Sky's the Limit
by
Dale A. Chamberlain

# WHAT IS ASTROPHOTOGRAPHY?

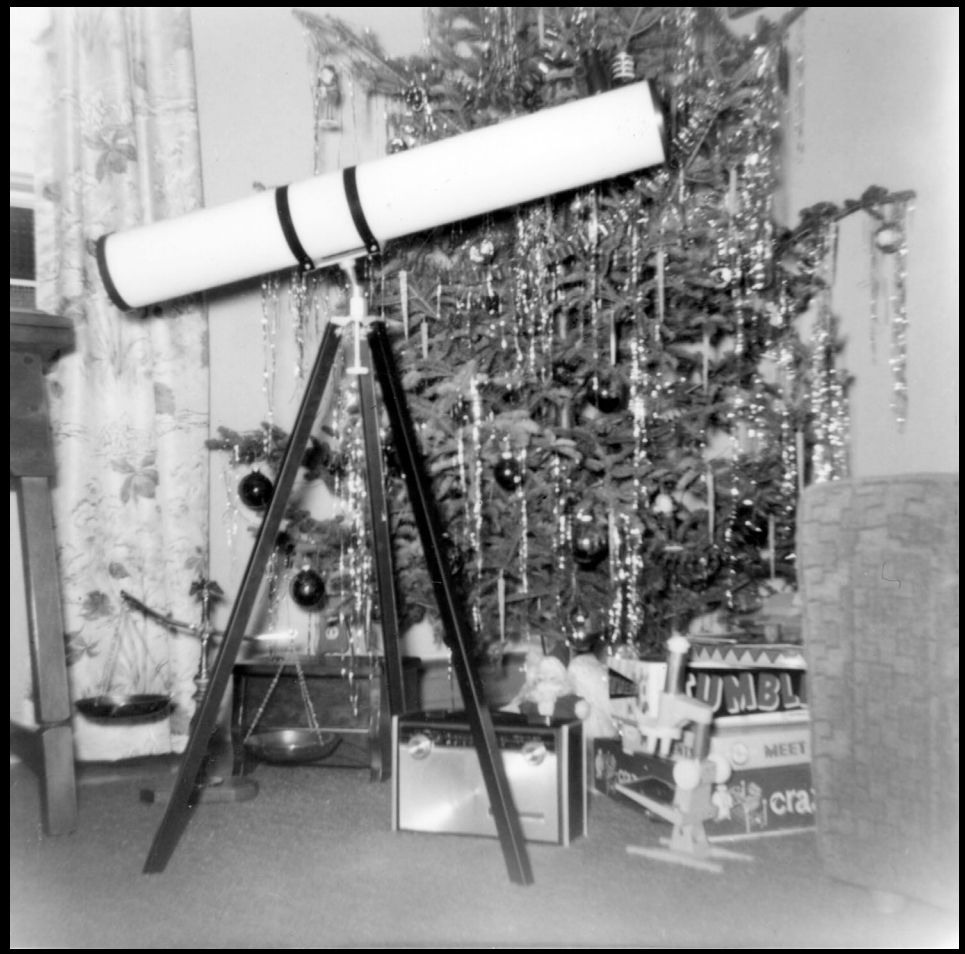
Simply put, ***the use of photography in astronomy; the photographing of celestial objects and phenomena***. *(Oxford dictionary)*

Using a camera with a super telephoto optical system *(over 300mm focal length in 35mm film format)* to acquire images of objects in deep space *(galaxies, nebulas, star clusters, etc.)* and/or the solar system *(sun, moon, planets, comets, etc.)*

Astrophotography can be accomplished with webcams, SLR, DSLR (digital single-lens reflex) and CCD (charge-coupled device) cameras.

This presentation is not about taking images of star trails, the Milky Way or shooting stars.

My first telescope…this is what got the stargazing bug in me



# EQUIPMENT: THE TELESCOPE

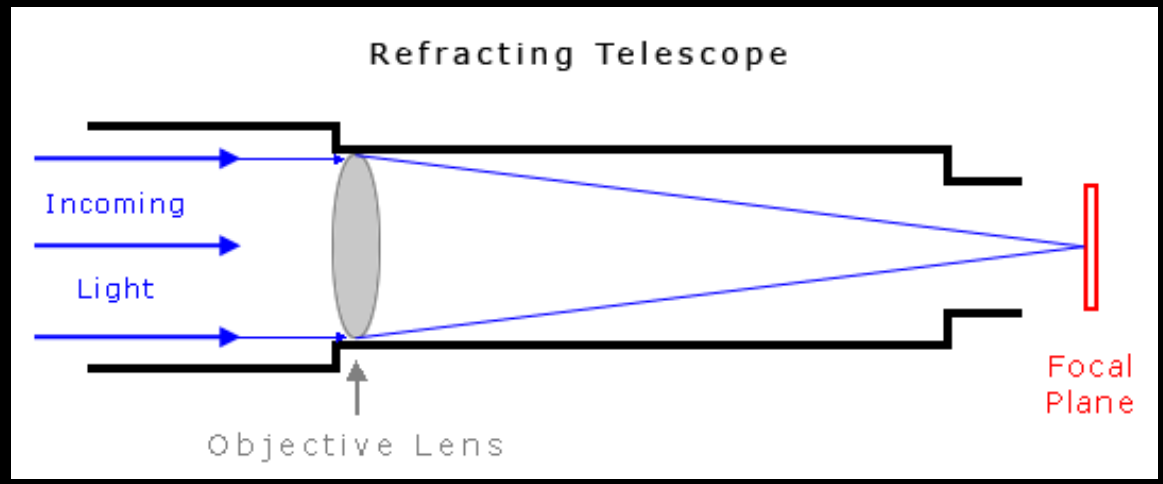
**This is the primary lens system for the camera. Many principles are the same between telescopes and camera lenses.**

- Some consumer grade telescopes advertise their "power" rating which is meaningless.
- The most important feature of a telescope is the **aperture** size.
  - ✓ The larger the aperture, the more light the scope can gather.
  - ✓ Aperture is measured in inches or millimeters (mm). There are 25.4 mm in an inch, so a 4-inch aperture telescope has an aperture of 101.6 mm.
- **Focal length** determines image magnification
  - ✓ The focal length of a telescope is the distance from the objective lens or mirror at which the light comes to focus.
  - ✓ The longer the focal length, the larger the image is that forms at the focal plane, and the higher the magnification of the telescope.
  - ✓ Focal length is also measured in inches or millimeters. Camera lenses usually give the focal length in millimeters. A simple lens with a focal length of 300 mm will form the image 300 mm behind the lens.
- **Focal ratio** is the relationship between the aperture and focal length.
  - ✓ Speed of the telescope as measured in f-stops.
  - ✓ An f/8 telescope will present more light to the imaging sensor in less time than an f/10 telescope.
- Many telescopes made for visual observing are not well suited for photographic imaging purposes.

# MANY TYPES OF TELESCOPES!

***Refractive Optics***

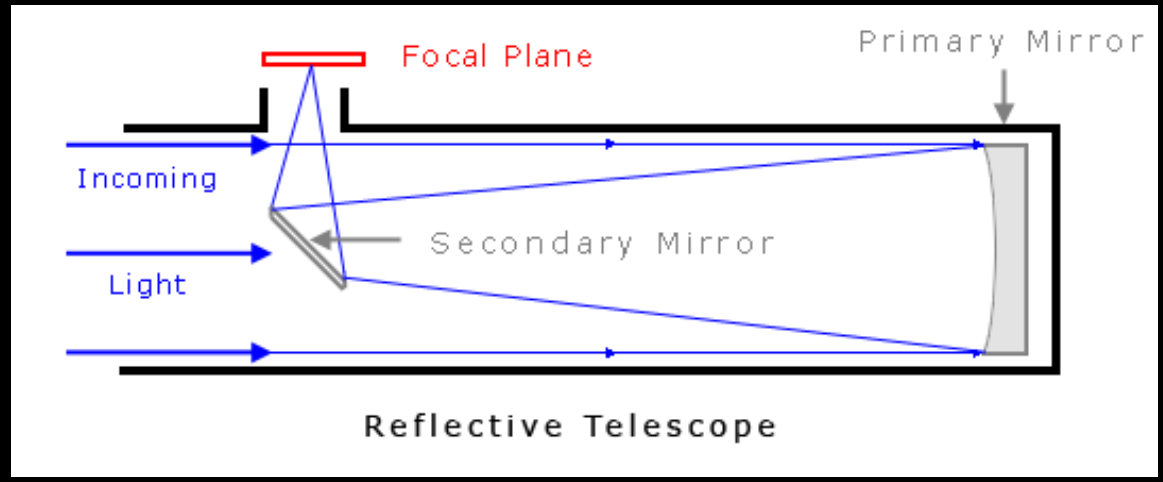
- ✓ **The "objective lens" is at the sky end of the scope**
- ✓ **Light is focused at the back end of the scope**
- ✓ **The first telescopes invented by Galileo**



# MANY TYPES OF TELESCOPES!

***Reflective Optics***

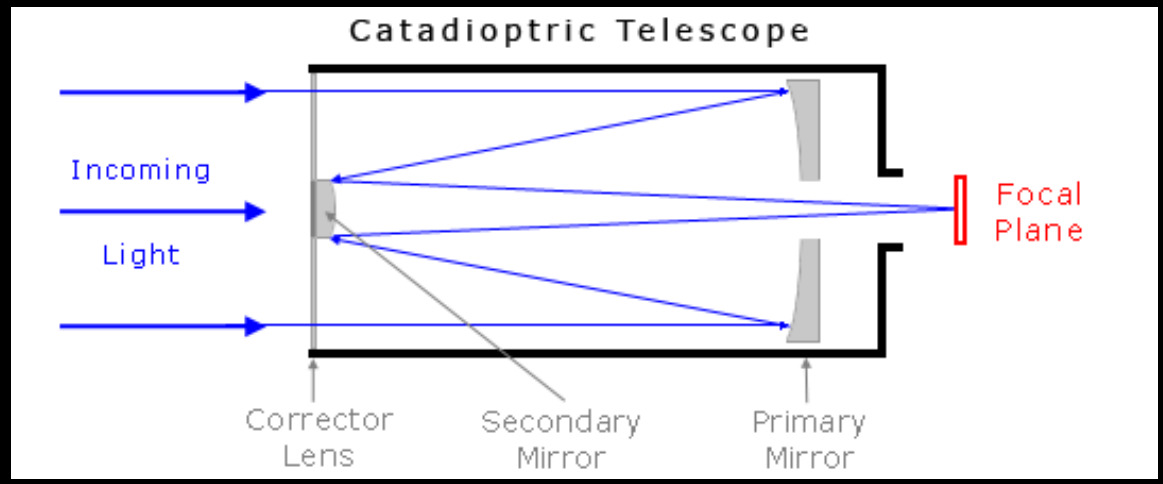
- ✓ *Open tube design using a primary concave mirror and a secondary mirror to reflect image to the focal plane.*
- ✓ *First produced by Sir Issac Newton in 1668*
- ✓ *Newtonian scopes are the lowest cost per inch of aperture*
- ✓ *Ritchey-Chretien are the types used in professional observatories. The Hubble is a Ritchey-Chretien.*



# MANY TYPES OF TELESCOPES!

***Catadioptrics***

- ✓ ***Uses principles of both refractive and reflective optics***
- ✓ ***Schmidt Cassegrain scopes has a folded-light path design resulting in a compact scope compared to the aperture.***



## Meade 10" f/10 LX200GPS Specifications

Optical design .....Schmidt-Cassegrain
Clear aperture.....254mm (10")
Focal length .....2500mm
Focal ratio (photographic speed) .....f/10
Coatings .....Meade EMC Super Multi-Coatings
Mounting .....Cast-aluminum, double-tine forks
Gears .....5.75"-dia. worm gears, both axes
Periodic Error Correction .....Both axes
Alignment .....Altazimuth or *equatorial w/optional wedge*
Pointing Precision .....2 arc-minutes in GO TO mode
Slew Speeds.....1x sidereal to 8°/sec in 9 increments
4-speed zero image-shift microfocuser
16-channel GPS receiver
True-level electronic sensor
Net telescope weight .....62 lbs.

# THE NEW TELESCOPE: ASTRO-TECH'S 14-INCH F/8 RITCHEY-CHRÉTIEN TELESCOPE

Optical design ..... Ritchey-Chrétien
Clear aperture.....356mm (14")
Focal length .....2850mm
Focal ratio (photographic speed) .....f/8
Coatings ..... 99% reflectivity dielectric multicoatings
3" dual speed Crayford with 2" and 1.25" adapters
Net telescope weight .....65 lbs. focuser adds 2.2 lbs.

# MOUNT

**Mount: The part which holds the telescope and provides all of the movement of the scope, such as tracking to the earth's movement. There are two types: Equatorial and non-equatorial mounts.**

| Equatorial (required for astrophotography) | Non-Equatorial (good for viewing only) |
|---|---|
| Fork on wedge | Altazimuth |
| German-Equatorial | Ball and Socket |

An ***equatorial mounting*** has one axis aligned parallel to the axis of rotation of the Earth by pointing it at the North or South celestial pole. This axis is called the *polar*. The other axis is called the *declination axis*. This axis allows movement of the scope at right angles to the polar axis. Any object in the sky can be found by moving in these two axes. Once an object is found, both axes are locked down, and just the polar axis turns to track the object.

**Non-Equatorial** mounts require both axes to move after the object is found. This is fine for visual observing, but will not be accurate enough for long exposure imaging.

**These mounts are either built with GPS units and a database of objects, or interface with a computer. Once the mount is aligned, it is capable of pointing the telescope to any object in the sky automatically.**

You will also need a camera that allows you to keep the shutter open for several minutes at a time. This usually means a DSLR or CCD camera and not a Digital Snapshot Camera.

# Equatorial mounts: Fork wedge and German Equatorial

A wedge is required for a fork mount telescope such as the Meade LX200 series. Payloads must be light since counterweights cannot be used. Good for compact sized telescopes such as a Schmidt-Cassegrains, but not good for longer scopes.


A German Equatorial mount is a classic design that can be fitted with much heavier equipment and maintain the center of balance at the pier. Counterweights are used to maintain balance of heavier equipment.

This is a Paramount MEII GE mount.

The mount is set to the same angle as the latitude of the observing location. For example since the latitude of my back yard is 39° 0'9.79"N I would set the mount to 39 degrees and locate the North Star (Polaris) to polar align the telescope.


# PIER

A pier is used to permanently mount the telescope and mount. The pier can be thought of as a tripod, only much stronger. It must be rated to hold the weight of the telescope and mount and provide rock solid steadiness.

It is absolutely imperative for reducing vibrations or movements of any kind when exposing for an astrophotography image.

For mine, it is bolted to a 4’ buried column of reinforced concrete and isolated from the floor of the observatory.

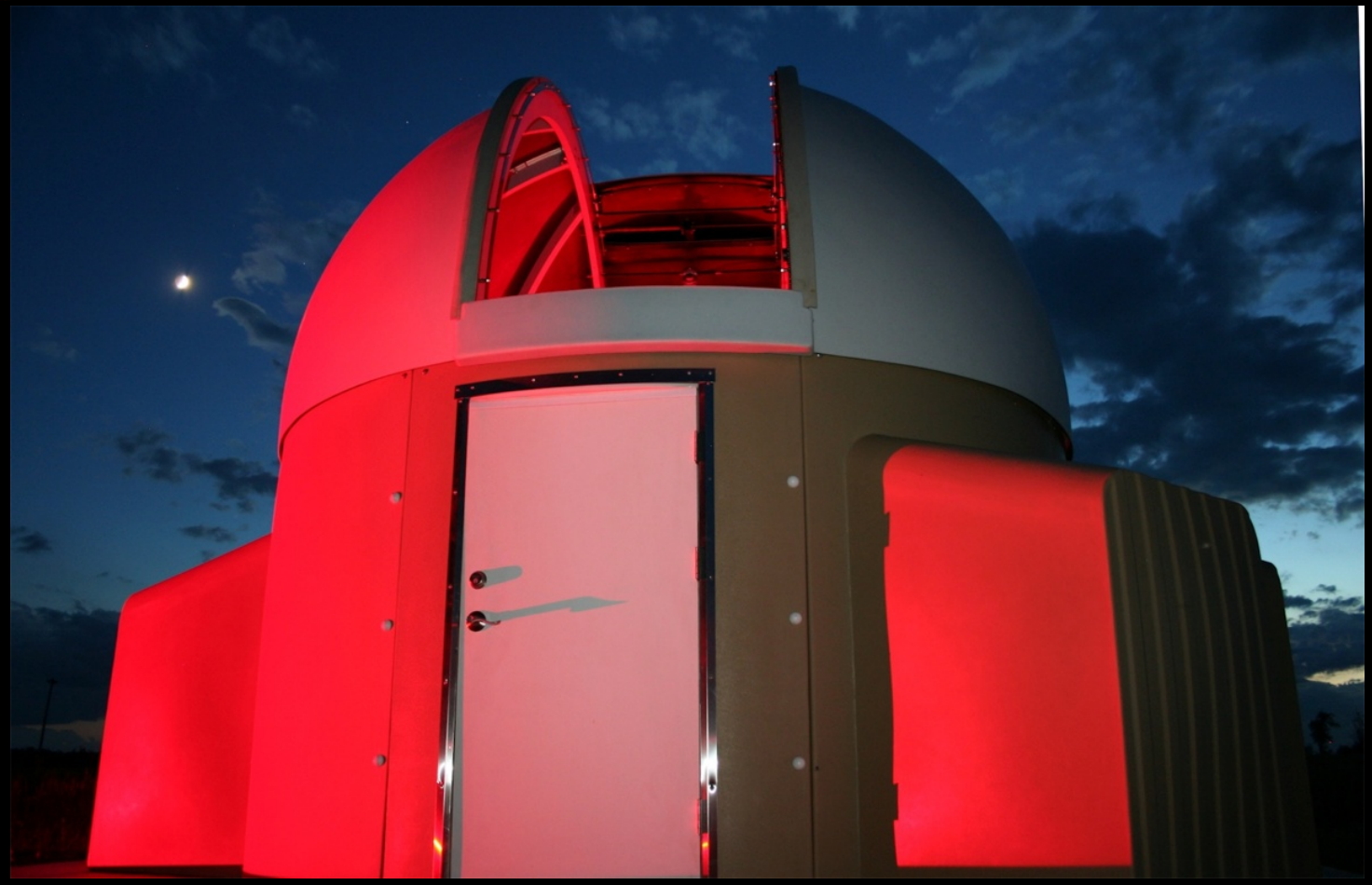
# PIER

A much heavier duty pier is required for the new telescope and mount. The telescope weighs 67 pounds without camera and the mount adds another 84 pounds. This pier is mounted to ¾" bolts in 48" of reinforced concrete which is isolated from the observatory floor to avoid vibration.

# OBSERVATORY

- A permanent structure used to house the telescope, mount and pier and supporting equipment such as computers.
- Personal observatory designs can be varied.
- My first was a slide off roof shed, 8’ x 10’ built in 2003 and now being replaced.

# OBSERVATORY



- My second is a round dome type, Skyshed PODMAX  12’ x 12’ built in Fall 2016.
- Observatory 2.0 will house the Astrotech RC 14” telescope, Paramount MXII mount and the Skyshed HD pier.
- The dome will move with the telescope.

# Camera

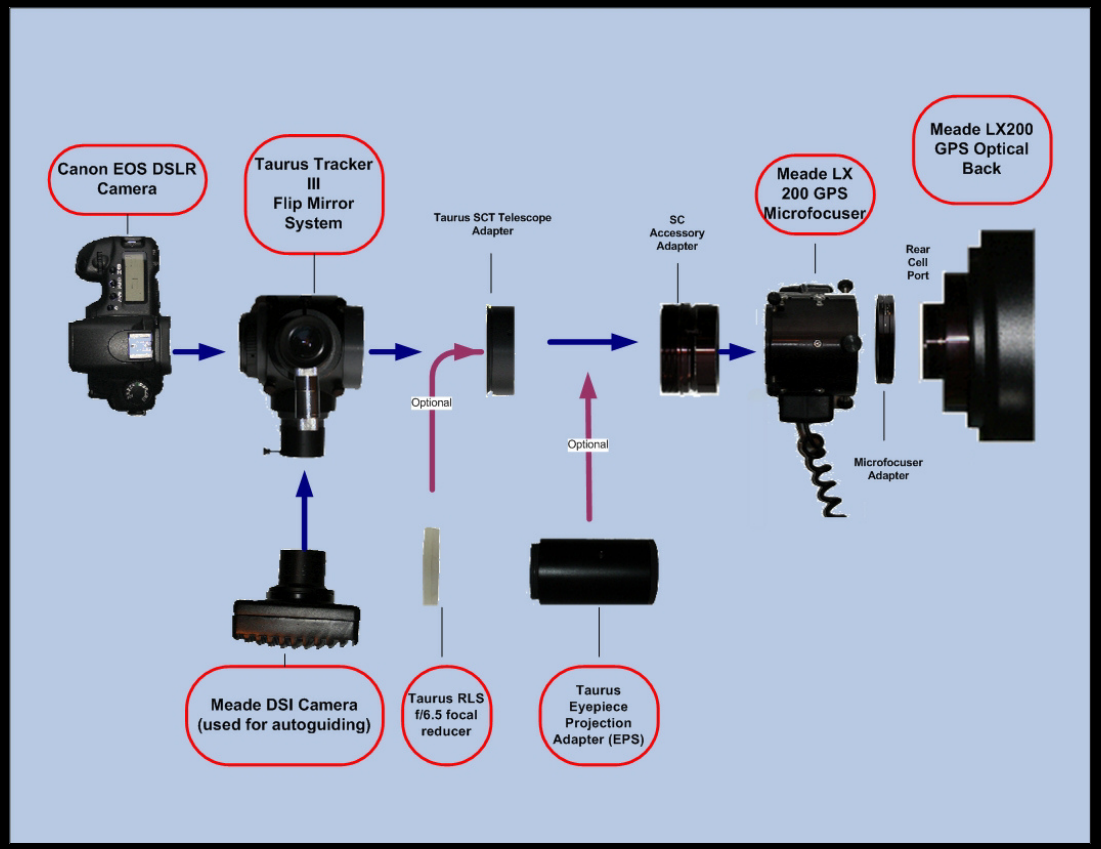
In 2005, Canon was the first camera manufacturer to introduce a DSLR for astrophotography. It was the Canon EOS 20Da. It was the first to feature live preview which was helpful in astrophotography focusing. DSLRs typically come with an IR filter installed over the sensor. This camera did not have the IR filter which would allow the red from hydrogen gas in deep space to come through. This was an 8.2MP camera with a 1.6x field of view crop.


Canon has since released a second camera for astrophotography called the Canon EOS 60Da in 2012. Nikon introduced its first astrophotography DSLR in 2015 called the D810A. It is the first full frame DSLR astrophotography camera.

However, given advancements in DSLR camera design, most any modern DSLR camera can be used. Just be aware that the red intensity of hydrogen might be muted. But noise reduction has improved remarkably.

# Camera Set up

The camera attaches to the rear cell of the telescope, or optical tube assembly (OTA). A flip mirror system is used to pass light to the camera, the observing lens and the auto guiding camera. The auto guide camera is used to compensate for variations in scope movement due to periodic error.



# Imaging Set up

*Deep Sky Astrophotography*

- Always set camera mode to Manual- Bulb
- Use either a remote shutter release, computer controlled shutter release or intervalometer
- Aperture is always fixed to the aperture of the telescope
- ISO setting depends on the noise level of your camera (use dark frame subtraction if camera supports it)
- Long exposures from 30 seconds to several minutes (depends on the mount)
- Focus setting is manual (focus on a star or moon first)
- Take many, many exposures.
- Use a computer to stack the best exposures (Images Plus, Registax, DeepSky Stacker, MaximDL, Pixinsight)
- Post-processing in Photoshop for noise reduction, unsharp mask, etc.

*Solar System Photography*

- Use of a Barlow lens (akin to a teleconverter) to increase magnification of planets such as Venus, Mars, Jupiter and Saturn. Comets may be an exception depending on how close they are.
- Video sometimes works better than separate images
- Fast shutter speeds necessary where objects are bright (Moon, Saturn, Jupiter, Venus)
- Use computer to stack the image frames from video. Software can detect bad frames. Registax can stack frames from a video clip.

# Deep Sky Images

Scope: Meade LX200GPS 10"f/10
Guiding: Unguided
Camera: Canon EOS 20Da DSLR
Exposure: ISO 1600 30 x 15 sec., 2 x 20 sec.
Software: Images Plus/Photoshop CS 2/Paint Shop Pro XI

**M57 – The Ring Nebula**

- Approximately 2300 light years from Earth
- Called a "planetary nebula"
- This is what our sun will look like in 4.5 billion years
- Star was like our sun but became a red giant before expelling it's outer shell leaving a white dwarf in the center.

# Deep Sky Images

Scope: Meade LX200GPS 10"f/10
Guiding: Unguided
Camera: Canon EOS 20Da DSLR
Exposure: ISO 1600 1 x 90 sec.
Software: Photoshop CS 2/Paint Shop Pro X

**M13 – The Hercules Cluster**

- Approximately 25,100 light years from Earth
- Called a "globular cluster"
- A spherical collection of old stars that orbits a galactic core as a satellite.
- There are about 150-158 known globular clusters in our galaxy.

# Deep Sky Images

Scope: Takahashi FS-60C Apochromatic Refractor (Focal length 355mm f/5.9)
Mount: Meade LX200GPS
Camera: Canon EOS 20Da DSLR
Exposure: ISO 800 50 x 30 sec.
Software: Images Plus/Adobe Photoshop CS

**M45 – Pleiades Star Cluster**

- Approximately 444 light years from Earth
- Called an "open cluster"
- A loose grouping of middle aged hot stars formed within the last 1000 million years.
- Also called the "Seven Sisters" it is visible as a fuzzy patch in the sky without binoculars or a telescope

# Deep Sky Images

Scope: Meade LX200GPS 10"f/10
Guiding: Unguided
Camera: Canon EOS 10D DSLR
Exposure: ISO 400 1 x 70 sec.
Lens: Prime Focus with f/6.3 Reducer

**M42 – The Great Nebula in Orion**

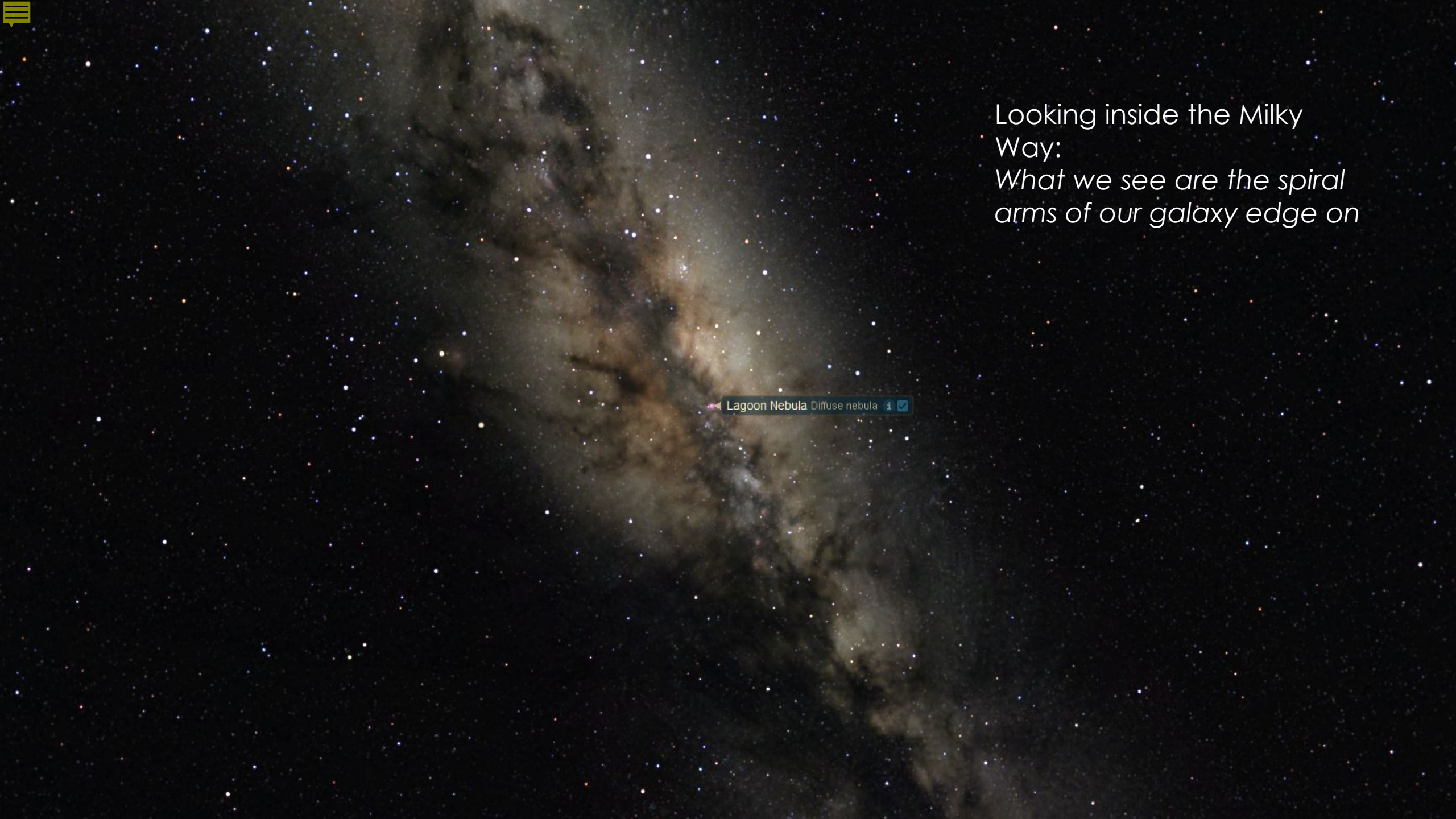
- Approximately 1,344 light years from Earth
- Called an "diffuse nebula" because they are extended with no well-defined boundaries
- Closest region of massive star formation to Earth
- Astronomers have learned much about star and planetary formation from the Orion nebula

# Deep Sky Images

Scope: Takahashi FS-60C Apochromatic Refractor
Mount: Meade LX200GPS
Camera: Canon EOS 20Da DSLR
Exposure: ISO 800 49 x 30 sec.
Software: Images Plus/Paint Shop Pro XI

**M31 - Andromeda Galaxy**

- Approximately 2.5M light years from Earth
- Closest galaxy to the Milky Way and much larger containing a trillion stars.
- Expected to collide with the Milky Way in 3.75 billion years.
- Andromeda appears large in the sky, requiring a shorter focal length to capture it in its entirety.




Looking inside the Milky Way:
*What we see are the spiral arms of our galaxy edge on*

# Deep Sky Images

Scope: Takahashi FS-60C Apochromatic Refractor
Mount: Meade LX200GPS, unguided
Camera: Canon EOS 20Da DSLR
Exposure: ISO 1600 30 x 30 sec.
Lens: Prime Focus
Software: Images Plus/Adobe Photoshop CS/Paint Shop Pro

**M8 & M20 Lagoon and Trifid Nebulas**

- The Lagoon Nebula is approximately 4000-6000 light years from Earth and the Trifid Nebula is about 5200 light years from Earth
- Lagoon Nebula is an emission nebula with new star forming regions.
- The Trifid is another emission nebula but also an open cluster of stars, a reflection nebula and a dark nebula.
- Both nebulas exist within a spiral arm of the Milky Way.

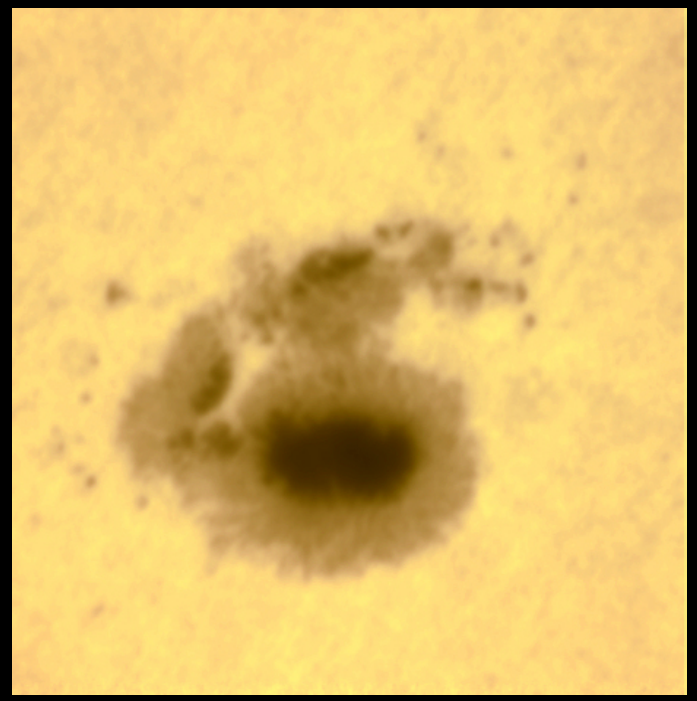
# Solar System Images

Scope: Meade LX200GPS 10"f/10
Camera: Canon EOS 20Da DSLR
Exposure: ISO 800 1 x 30 sec.
Lens: Prime Focus with f/6.3 Reducer
Software: Photoshop

**Comet Holmes 17P/Holmes**

- Comet Holmes was discovered by Edwin Holmes on November 6, 1892, while he was conducting regular observations of the Andromeda Galaxy (M31)
- During its 2007 return, Holmes unexpectedly brightened from a magnitude of about 17 to about 2.8 in a period of only 42 hours, making it visible to the naked eye.
- It also briefly became the largest object in the Solar System, as its coma (the thin dissipating dust ball around the comet) expanded to a diameter greater than that of the Sun

# Solar System Images



Scope: Meade LX200GPS 10"f/10
Camera: Philips ToUcam Pro (webcam)
Lens: Prime Focus with Orion Solar Filter
Software: AstroVideo/Registax/Paint Shop Pro 9

**Sun - Sunspots**

- Never point a camera lens or telescope directly at the sun without a solar filter
- A sunspot is an area of intense magnetic activity
- Light and dark spots have been detected on other stars and are called "starspots"
- This was taken May 1, 2005

# Solar System Images

**Mars**

- Fourth planet in our solar system
- This was taken September 6, 2003
- Second smallest planet
- Has rocky terrain with polar ice caps

Scope: Meade LX200GPS 10"f/10
Camera: Quickcam 4000
Lens: Prime Focus
Filter: Televue Bandmate Mars Type A
Software: Registax

# Solar System Images

**Jupiter**

- Fifth planet in our solar system
- Jupiter is a gas giant not rocky like Earth
- Its 4 largest moons are visible through the telescope
- This was taken June 6, 2005

Scope: Meade LX200GPS 10"f/10
Camera: Philips ToUcam Pro
Lens: Prime Focus
Software: Images Plus/Paint Shop Pro

# NEW AND IMPROVED

The new telescope and mount are several times more accurate in tracking

The scope is larger and faster and will be able to collect more light over longer periods. This should produce more details in photographs.

Focusing is more precise. Bahtinov masks did not exist until 2005.

Experiment with tele-extenders to get better magnification of solar system objects.

DSLR cameras have higher resolution, and support video now which should help in solar system objects.

# Thank You!

Visit https://chamberlainobservatory.com