Introduction to Astronomy

4-H Idea Fair – Redmond, Oregon
February 15, 2014

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Pine Mountain Observatory volunteer

Astronomy

- Astronomy can be broadly defined as the observation and study of just about anything in the material universe beyond the Earth, although much about the Earth itself, including its origin and motions, should also be included.
- There are a number of more specialized fields of study such as astrophysics, cosmology and even astrobiology.
- Astronomy is a science which both amateurs and professionals can participate in and enjoy.

Types of Objects Observed

- Solar system – Sun, Moon, planets, comets, asteroids, meteors, etc.
- Milky Way – stars, double stars, open and globular star clusters, bright and dark nebulas, etc.
- “External” galaxies (beyond our own Milky Way)

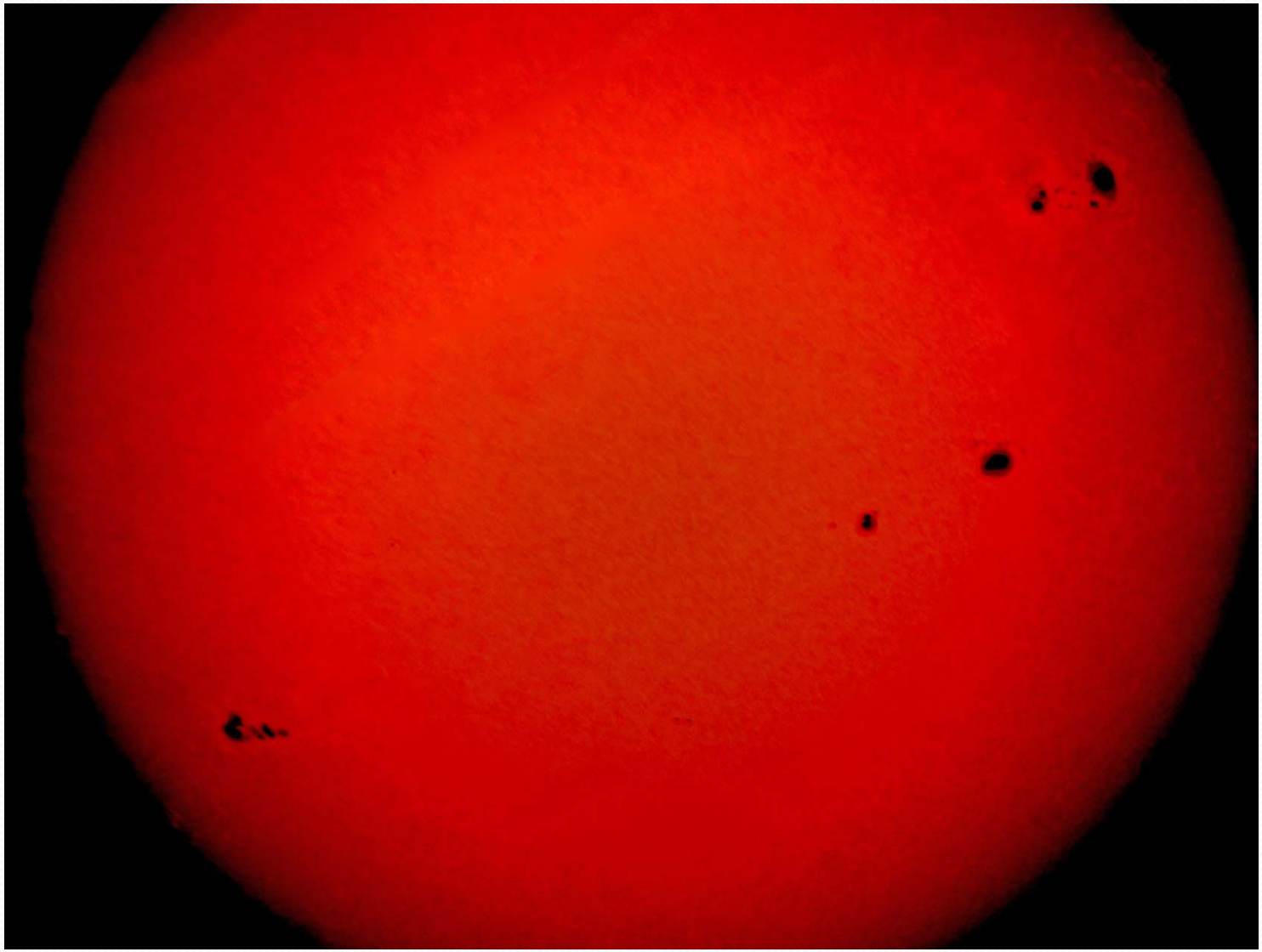
- Amateur observations are usually limited to visible light, whereas professionals cover the entire spectrum from radio waves to X-rays and gamma rays.

Solar System Objects

- Sun
- Moon
- Planets and their moons
- Dwarf planets (Pluto!)
- Comets
- Asteroids
- Meteors, etc.

Now let's look at some photos taken at Pine Mountain Observatory. Of course you should also view some of the many spectacular photos on the NASA website (nasa.gov) and elsewhere.

Sun (October 26, 2013)



Moon (July 13, 2013)

We will have two total lunar eclipses this year:

- Night of April 14-15 (best around 12:45 a.m.)
- Night of October 7-8 (best around 3:50 a.m.)

Jupiter

January 4, 2014 with four Galilean moons.
(Left: Europa, Right: Io, Ganymede, Callisto)

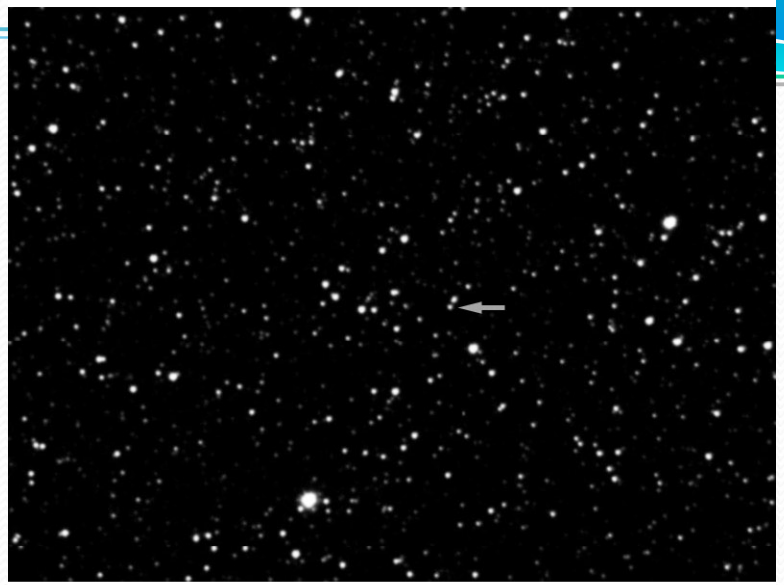
February 1, 2014 with “Red Spot” facing towards Earth.
(Black & white image with blue filter for contrast.)

Comet ISON (Nov. 13, 2013)

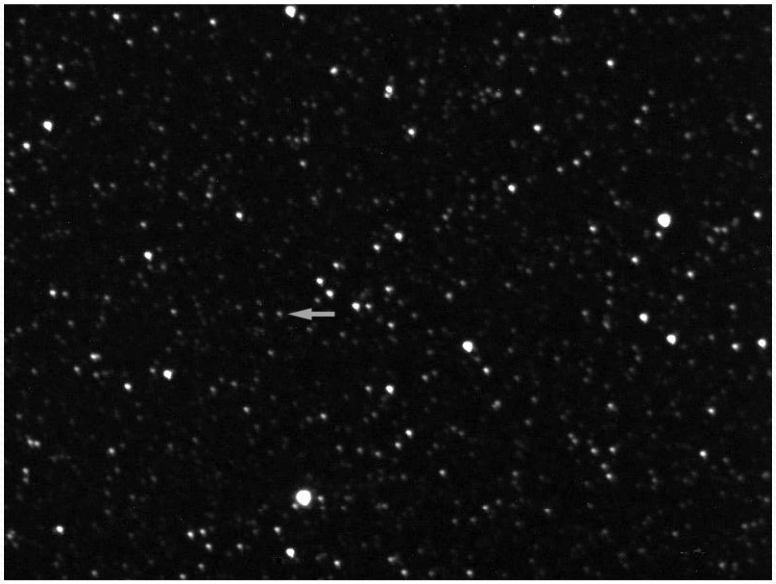
Pluto

Now considered one of a number of “dwarf planets” in the Kuiper belt beyond Neptune, although Pluto has at least five of its own moons!

Pluto found ...



Evening of 23 Oct 2013 at PMO



Evening of 26 Oct 2013 at PMO
Constellation: Sagittarius

Most of the motion visible during this three-night interval is due to the orbit of the Earth. Pluto takes 248 years to orbit the Sun.

Milky Way Objects

- Stars
- Double/multiple stars
- Open star clusters
- Globular star clusters
- Nebulas – star-forming
- Nebulas – “planetary”
- Nebulas – dark (dust)
- Supernova remnants
- “Milky” appearance from many distant stars

Properties of Stars

- Stars vary widely in their physical properties.
  - Mass – 0.05 to 100 or more times the mass of the Sun.
  - Size – from not much larger than Jupiter (10% diameter of Sun) up to supergiants a billion or more miles in size. Stellar remnants such as neutron stars are even smaller.
  - Surface Temperature – from about 5,000 F (red dwarf) to 10,000 F (Sun) to about 100,000 F.
  - Brightness – very wide range; less than 0.01% to 1 million times as bright as Sun. (Not including supernovas!)
  - Lifetime – also very wide range from about 1 million to 1 trillion years or more. (About 10 billion years for Sun.) *Estimated age of the universe is about 13.7 billion years.*

Nuclear Fusion in Stars

- "Main sequence" stars fuse hydrogen into helium.
- Near the end of the lifetime of a sun-like star, helium fuses into carbon.
  - A dense carbon-rich core will be left behind that becomes a white dwarf.
  - If enough material falls onto a white dwarf, it explodes as a Type I supernova.
- More massive stars can continue to generate energy by fusing elements up to iron.
- After that, gravitational collapse and rebound can trigger an explosion known as a Type II supernova, which generates elements heavier than iron.
  - A neutron star or black hole will be left behind.

Nebulas – Star-forming

M8 (Lagoon) – *bright red regions are ionized hydrogen gas.*

Nebulas – Star-forming

M16 (Eagle) – *Eagle-shaped feature is a dark (dust) nebula.*

Nebulas – Star-forming

M17 (Swan) – *One of the summer favorites at PMO.*

Nebulas – Star-forming

M20 (Trifid) – *Also contains a bluish reflection nebula (upper left).*

Nebulas – Star-forming

M42 and M43 (Orion Nebula)

Nebulas – “Planetary”

M27 (Dumbbell)

M57 (Ring)

These are associated with sun-like stars near the end of their lifetime, after the energetic “Red Giant” phase. The core of the star remaining in the center will become a white dwarf.

Nebulas – “Planetary”

NGC 7293 (Helix Nebula in Aquarius)

Nebulas – Supernova Remnant

M1 (Crab Nebula in Taurus – Supernova seen in 1054 A.D.)

Star Clusters – Globular

M13 (Hercules) at distance of 25,000 light years from Earth.

These clusters are 10 billion or more years old. About 150 remain in the Milky Way.

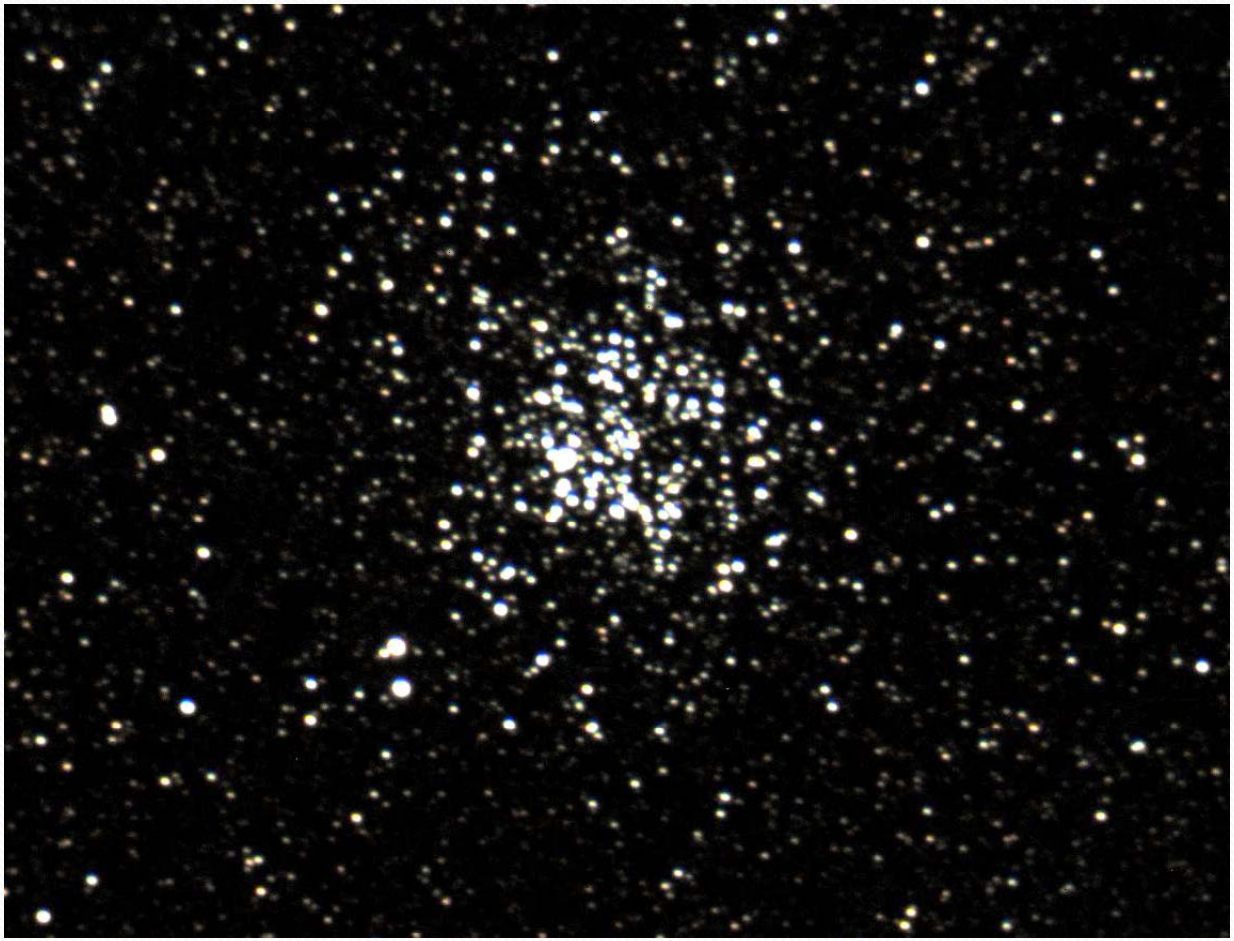
Star Clusters – Globular

M14 (Ophiuchus)

Star Clusters – Globular

M22 (Sagittarius) – less than 10,000 light years away.

Star Clusters – Open



M11 (Scutum – “Wild Duck” cluster)

This cluster is in the Sagittarius spiral arm of the Milky Way, about 5,000 light years away.

Star Clusters – Open

M35 (Gemini) and M37 (Auriga)

Open clusters are much younger (millions of years up to a billion or so).
They are common in our galactic neighborhood (spiral arms of the galaxy).

Star Clusters – Open

“Double Cluster” in Perseus

An excellent object pair to observe even with a small telescope.

Galaxies

- Starting forming shortly after birth of the known universe; some can now be observed and studied as they existed billions of years ago.
- “Local group” galaxies – Includes Andromeda galaxy, actually moving towards us (Milky Way) due to gravity.
- Galaxies beyond the local group are moving away (red-shifted) due to the expansion of the universe and become dimmer and harder to see with distance.
- Two major galaxy types and spiral and elliptical, although there are also irregular and dwarf galaxies.
- Galaxies can form clusters (like the local group) and superclusters extending over vast distances.

Properties of Galaxies

- Galaxies also vary widely in their physical properties.
  - Mass – large galaxies may be about 1 trillion solar masses, including unseen dark matter and black holes.
  - Size – from not much larger than large star clusters up to giants a million or more light years in size. (Main disk of Milky Way is about 100,000 light years across).
  - Stars – Milky Way probably has close to 400 billion stars; most are dim red dwarfs.
  - Brightness – Milky Way shines with a total luminosity of about 20 billion suns, but there is a wide range starting with much dimmer (< 1 million suns) dwarf galaxies.
  - Rotation – Sun takes 200 million years to go around!

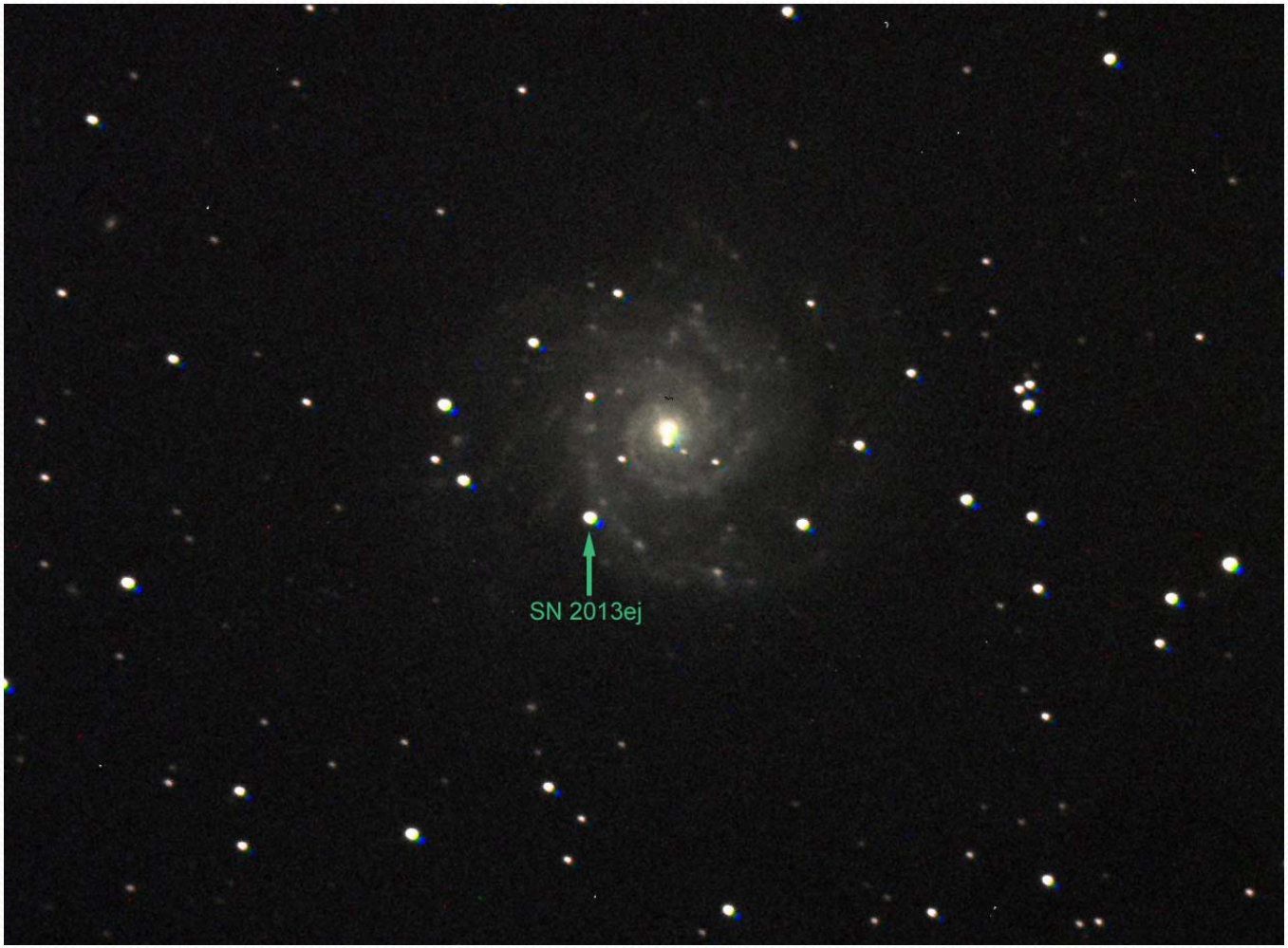
Galaxies – Spiral

M33 (Triangulum) – *“Pinwheel” Galaxy, part of the Local Group.*

Galaxies – Spiral

M101 (Ursa Major) – *another "pinwheel" a little farther away.*

Galaxies – Spiral

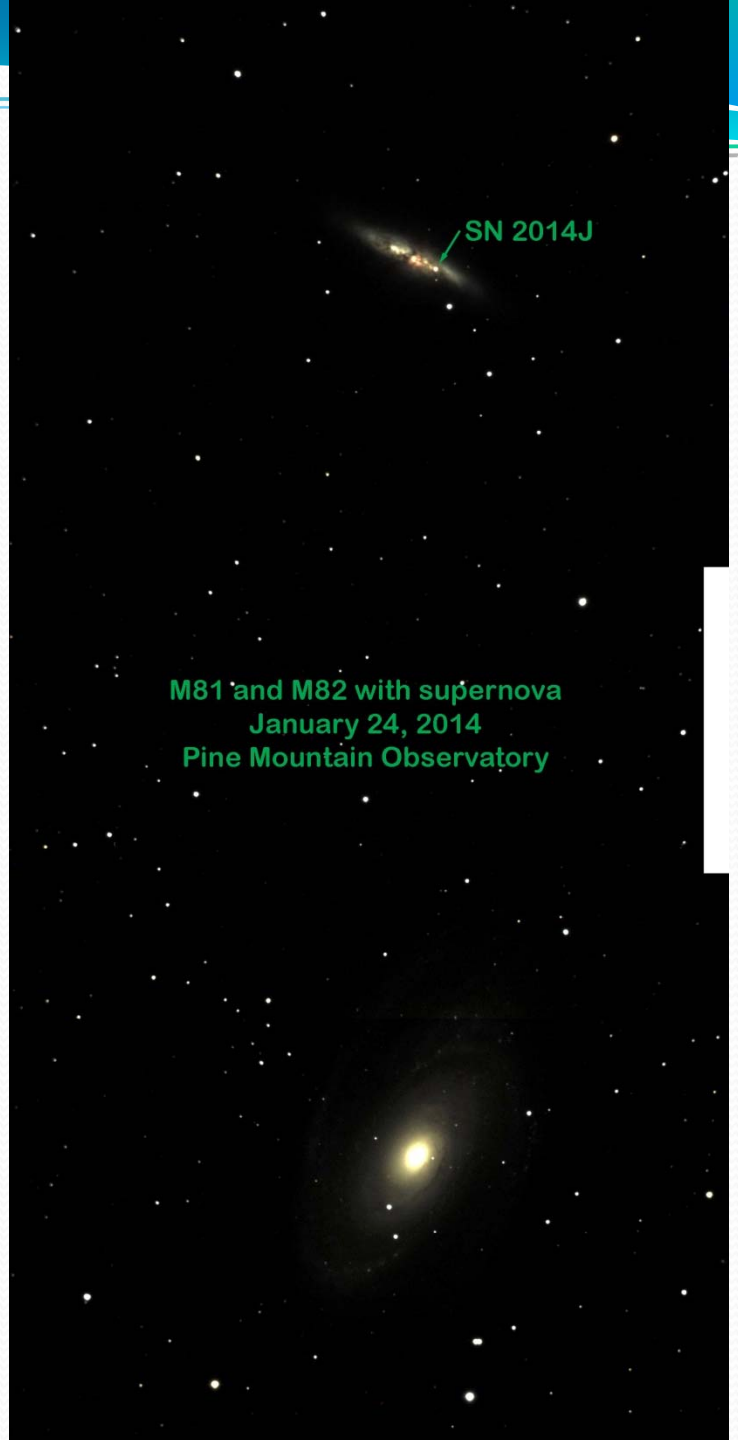


M74 (Pisces) – *Morning of 4 Aug 2013 with mag. 12.5 supernova.*

Galaxies – Spiral

NGC 253 (Sculptor) – *“local” galaxy less than 10 million l.y. away.*

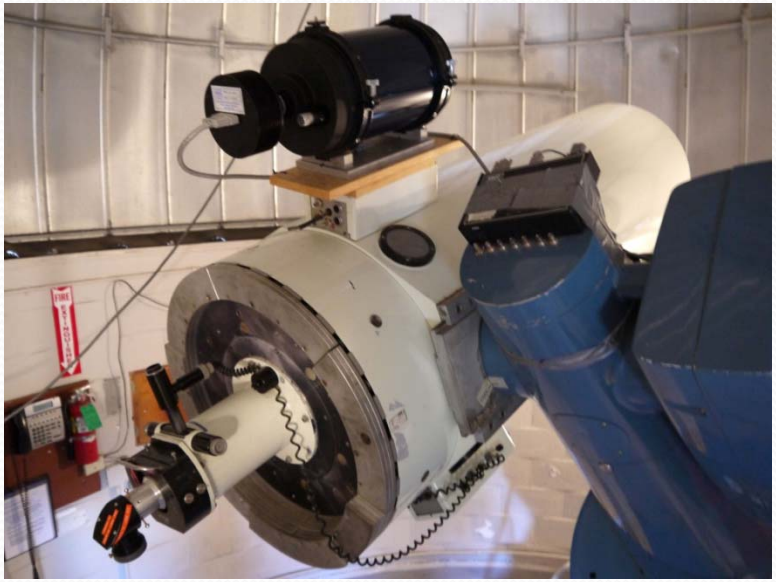
Another Super-nova!



These two galaxies, Messier 81 and 82, near the “Big Dipper” in the sky, can be seen in the same field of view in a small telescope, and are popular objects for amateur astronomers.

Pine Mountain Observatory

24-inch telescope building and dome.



24-inch Cassegrain reflecting telescope with 8-inch “piggyback” scope/camera.

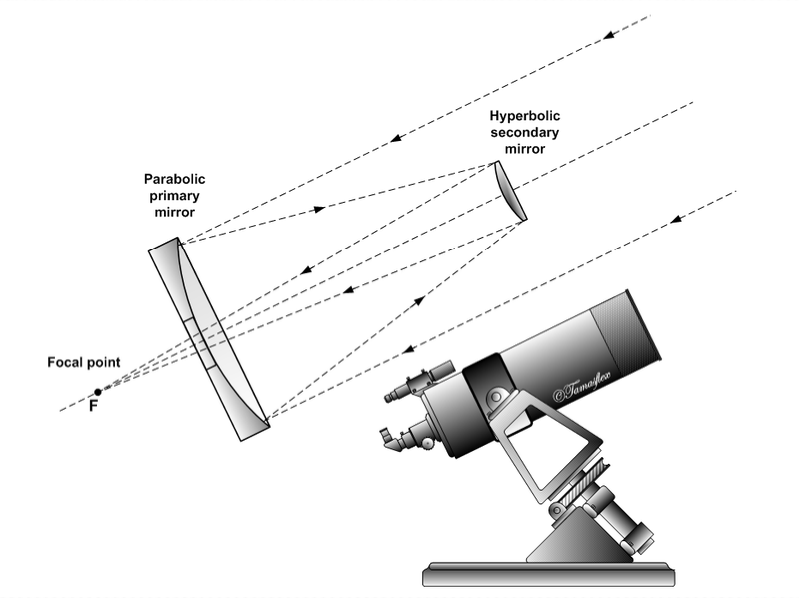
Pine Mountain Observatory

- Located about 26 miles SE of Bend, OR in “dark sky” country!
- Elevation of 6200+ feet.
- Operated by the University of Oregon Physics Department.
- U.S. Forest Service land.
- Telescopes of aperture 14, 15, 24 and 32 inches.
- Public viewing through the 24-inch and smaller (including portable) telescopes.
- Fridays and Saturdays Memorial Day weekend until the end of September.
- $5 suggested donation.
- Private groups by appointment starting at $100.

Telescopes

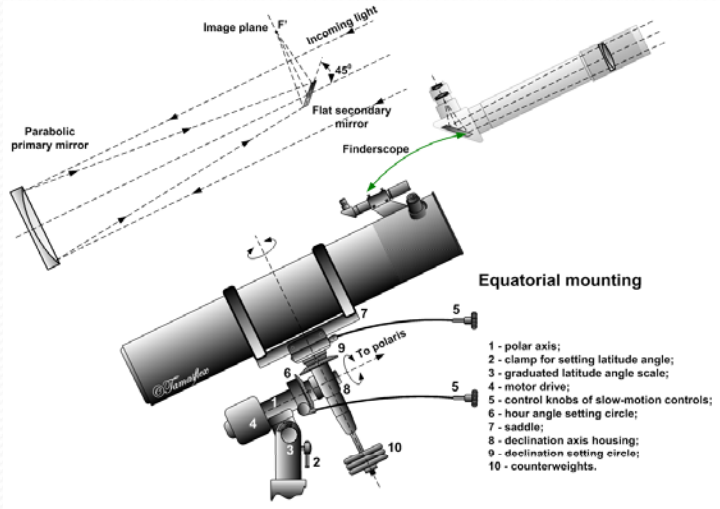
- Major design types:
- **Refractors** – bend light using lenses, like binoculars, most camera lenses and Galileo's first telescope (1610).
- **Reflectors** – gather and focus light using curved mirrors; first popularized by Isaac Newton (1668).
  Most astronomical telescopes today are reflectors because it's easier to make a large mirror than a large lens of sufficient optical quality.
- Major mounting types:
- **Equatorial** – telescope is aligned with the Earth's axis of rotation, allowing constant-rate tracking about one axis.
- **Altitude-Azimuth** – telescope is aligned with the horizon.

Reflector Telescopes



Cassegrain reflector
(Image by Szőcs Tamás Tamasflex, covered by GNU Free Documentation license)

- Achieves long effective focal length and good magnification with a short tube.
- The Schmidt-Cassegrain variety with a glass corrector plate is a popular medium-price design for serious amateurs and some professionals.



Newtonian reflector
(Image by Tamasflex from Wikimedia Commons)

- Usually installed in a tube or truss with opening (and eyepiece) on the side, as shown here.
- May use a variety of mounting systems including a simple box-like mount popularized by John Dobson. (Equatorial mount shown in diagram.)
- Sizes up to 8 or even 10 inches are now inexpensive (less than $1,000) for a Dobsonian.

Astronomy Websites/Software

- Sky & Telescope Magazine
  http://www.skyandtelescope.com/
- NASA (nasa.gov) including Astronomy Picture of the Day,
  http://apod.nasa.gov/apod/astropix.html
- Hubble Space Telescope
  http://hubblesite.org/
- Stellarium (free open-source software)
  http://www.stellarium.org/
- Cartes du Ciel (free open-source software)
  http://www.ap-i.net/skychart/en/start
  Used at PMO – excellent for advanced astronomers!
- Pine Mountain Observatory – http://pmo.uoregon.edu/