# Lunar Exploration

Culpeper Astronomy Club Meeting June 24, 2019



# Overview

- Introductions
- The Moon
- The Apollo Missions
- Constellations
- Observing Session (Tentative)

# **Observing Sessions**

- Morning Calm Observatory 24 May 2019
  - 30 inch Obsession and Brandon 94 refractor
  - Observed:
    - About 20 galaxies, mostly in Virgo constellation with the 30 inch
    - Several double stars (Albireo, Cor Caroli, Algeiba, Epsilon Lyrae, Mizar-Alcor) with the Brandon 94
    - Coat Hanger asterism at wide-angle
    - Jupiter and Saturn
- Culpeper 28 May 2019
  - 4.5 inch Refractor/G-11
  - Observed:
    - 13 Double Stars in Hercules
    - Globulars (M3, M5, M13, M92)
    - Open Clusters
    - Jupiter





#### Loaner Scope

- Celestron 102GT refractor
  - 4 inch aperture, f/9.8 (1000mm)
  - Alt-Az Mount
  - RACI Viewfinder
  - Two Eyepieces (25mm, 10mm)
  - 2x Barlow
  - Magnification (40–200x)



#### Jupiter's GRS Unfurling

- The Great Red Spot (GRS) is largest storm in the solar system—wider than Earth with winds blowing 350 mph
- Has been shrinking; once wide enough to swallow three Earths
  - Has led to speculation the GRS could break up or disappear within our lifetimes
  - Now appears to be unraveling; perhaps the streamers are part of this process
- The plume of gas is enormous, stretching more than 10K km from the central storm to jet stream that appears to be carrying it away
- Each streamer appears to disconnect from the Great Red Spot and dissipate
  - After about a week, a new streamer forms and the process repeats





# The Moon

- The Moon, with a diameter of about 2,159 miles, is larger than Pluto
  - Is a bit more than 27% the size of Earth, a much larger ratio than any other planets
  - Has a great effect on the planet and very possibly is what makes life on Earth possible
- The Moon's orbit around Earth is elliptical
  - Orbit ranges from 225,623M to 252,088M
  - Average distance of 238,855 miles
  - "Supermoon" is Full Moon at perigee
- Like the Earth, the Moon has a crust, mantle and core
  - May have a solid iron core surrounded by a softer, somewhat molten liquid iron outer core
  - The outer core may extend as far out as 310 miles (500 km)





#### Largest Moons of the Solar System



# The Moon

- Moon phases and the moon's orbit are unique
  - The moon always shows us the same side
  - How much of it we see depends on the moon's position relative to Earth and the Sun
- Tidal forces from Earth slowed down the Moon's rotation
  - A phenomenon called tidal locking
  - Periods of rotation and revolution both 27.3 days
- About 18 percent of the far side is occasionally visible from Earth due to libration
- Remaining 82 percent unobserved until 1959; photographed by the Soviet Luna 3 space probe





# The Far Side

- The far side's terrain is rugged with a multitude of impact craters and relatively few flat lunar maria
- It has one of the largest craters in the Solar System, the South Pole–Aitken basin





#### Lunar Eclipse

- Lunar eclipses occur when Earth's shadow blocks the sun's light, which otherwise reflects off the moon
- There are three types total, partial and penumbral — with the most dramatic being a total lunar eclipse, in which Earth's shadow completely covers the Moon
- The Moon turns red "Blood Moon" because of the way the Moon is illuminated by sunlight
  - has been filtered and refracted by the earth's atmosphere
- Next lunar eclipse visible in NA:
  - May 26, 2021: Total eclipse. Visible from North and South America, Europe, Africa

#### Key moments of the lunar eclipse

The Jan. 31 total eclipse will last for 1 hour, 16 minutes. (Pacific Standard Times)





# Moon's Origins

- Leading explanation is that a giant impact (Mars-sized rock called Theia) knocked the raw ingredients for the Moon off the primitive molten Earth and into orbit
  - Impactor was roughly 10 percent the mass of Earth or about the size of Mars
  - Because Earth and the moon are so similar in composition have concluded that the impact must have occurred about 95 million years after the formation of the solar system, give or take 32 million years
  - New studies in 2015 gave further weight to this theory, based on simulations of planetary orbits in the early solar system
- Although the large impact theory dominates the scientific community's discussion, there are several other ideas for the moon's formation, these include:
  - Earth captured the moon
  - The Moon fissioned out of the Earth
  - Earth may even have stolen the moon from Venus

#### Surface Features -I

- The Lunar Mare:
  - These dark regions -- Latin for "seas" -- are solidified lava flows from between 3-3.5 billion years ago: a billion years younger than the majority of the lunar surface
- Montes Apenninus:
  - The Moon's highest mountain range outlines Mare Imbrium, extending for over 400 km
  - Contains Mons Huygens, the Moon's tallest mountain, and the Hadley–Apennine valley, where Apollo 15 landed



# Surface Features - II

- Copernicus crater:
  - Visible as the bright spot amidst the dark Mare
  - Copernicus, at 107 km in diameter, offers the greatest visual contrast of any lunar crater to human eyes
- Tycho crater:
  - A highly-reflective impact crater over 100 km in diameter in the southern lunar highlands
  - Prominent rays emanate from the impact site
  - Samples collected by Apollo 16 determined Tycho's young age: 108 million years



#### Apollo Landing Sites





# Apollo Missions (8, 10 and 13)

- Apollo 8 (Dec 1968): First Circumlunar Mission
  - First manned spacecraft to leave low Earth orbit, reach the Moon, orbit it, and return
  - No Lunar Module (LM)
- Apollo 10 (May 1969): Dress rehearsal
  - Descended to 50K feet
  - Provided calibration data
  - LM not equipped for landing
- Apollo 13 (Apr 1970): Frau Mauro Landing
  - Aborted due to system failure
  - Oxygen tank exploded two days after launch



# Apollo 11 Mission (Jul 1969)

- Objective: Achieve national goal of manned lunar landing and safe return to Earth by end of decade
- Neil Armstrong, Buzz Aldrin, Michael Collins
- Criteria for final site selection:
  - Needed to be smooth, with relatively few craters
  - Approach free of large hills, tall cliffs or deep craters that might confuse the landing radar
  - Reachable with minimum amount of propellant
  - Provide good visibility during the landing approach, meaning that the Sun would be between 7 and 20 degrees behind the LM
  - Less than 2 degree slope in the landing area
- Single EVA; returned 47.8 lbs of rocks















LRO, March 7, 2012

#### Apollo 12 Mission (Nov 1969)

- Primary mission objectives included:
  - Extensive series of lunar exploration tasks by the lunar module crew
  - Deployment of the Apollo Lunar Surface Experiments Package, or ALSEP, which was to be left on the moon's surface to gather seismic, scientific and engineering data
- The astronauts also were to retrieve portions of the Surveyor III spacecraft, which had soft-landed on the moon April 20, 1967, a short distance from the selected landing site of Apollo 12
- Conducted two EVA's; collected 77lbs of rocks



# Apollo 12 Mission (Nov 1969)









#### Apollo 14 Mission (Feb 1971)

- Landed in the Fra Mauro region, the intended landing site of the aborted Apollo 13 mission
- Astronauts used the Modularized Equipment Transporter (MET) to haul equipment during two EVAs (later missions would use the Lunar Roving Vehicle).
- They collected samples, took photographs, and the nearby Cone crater
- One of the more famous moments came at the end of the second EVA when Apollo 14 commander Alan Shepard hit 2 golf balls on the Moon



# Apollo 14 Mission (Feb 1971)



# Apollo 15 Mission (Aug 1971)

- First flight of the Lunar Roving Vehicle (LRV) which astronauts used to explore the geology of the Hadley Rille/Apennine region
- The LRV allowed Apollo 15, 16 and 17 astronauts to venture further from the Lunar Module
- Total surface traverses increased from hundreds of meters to tens of kilometers during Apollo 15 and 16; just over 100 kilometers during Apollo 17
- During stay of 66 hr 54 min 53 sec, three EVA's totaling approximately 18.5 hr were performed
- Approximately 76 kg of lunar material including soil, rock, core-tube, and deep-core samples were returned to Earth





# Apollo 16 Mission (April1972)

- Primary objectives were (1) to inspect, survey, and sample materials and surface features at a selected landing site in the Descartes region; (2) emplace and activate surface experiments
- The Descartes landing site is in a highlands region of the moon's southeast quadrant, characterized by hilly, grooved, furrowed terrain
- First study of highlands area
- Collect 213 lbs of rocks





# Apollo 16 Mission (April1972)











# Apollo 17 Mission (Dec 1972)

- The lunar landing site was the Taurus-Littrow highlands and valley area
- This site was picked as a location where rocks both older and younger than those previously returned from other Apollo missions might be found
- Hosted the first scientist-astronaut to land
  on Moon, Schmitt
- Returned 243 lbs of rock



# Apollo 17 Mission (Dec 1972)









# Back to the Moon - 2024

- Conduct unmanned SLS/Orion first flight in 2020 to the lunar vicinity
- Conduct a crewed flight sending Americans around the Moon in 2023
- Establish a human tended lunar orbiting platform for crews to visit from earth, to transit to and from the lunar surface, and to depart to and return from Mars
- Lunar landing by 2024: South Pole likely destination
  - It's a place that no human has ever gone before
  - It contains water ice, a critical resource for the long-term exploration of deep space



25 50 75 100 125 150 175 200 225 250 275 300

# Constellations

- Will explore three:
  - Hercules: Hero
  - Cygnus: Swan
  - Lyra: Lyre
- Summer Triangle





# HERCULES – "THE HERO"

- The fifth largest constellation in the sky; has no first magnitude stars
- Rasalgethi: (Alpha Herculis)
  - Multiple star system 360 LY Distant
  - Primary star is a red giant; 400X Sun
  - Orange-Green Pair
- Hercules contains two Messier objects:
  - Messier 13 (M13, NGC 6205) Globular Star Cluster
  - Messier 92 (M92, NGC 6341) Globular Star Cluster



# CYGNUS – "THE SWAN"

- Cygnus: Easy to find as it features a well-known asterism known as the Northern Cross
- Double Stars
  - Albireo: Marks the head of the swan; also known as "the beak star"; yellow primary-blue companion
  - 61 Cygni: "Bessel's Star"; composed of a pair of two dwarfs; first star to be measured
- Deep Sky Objects
  - "Veil Nebula" (NGC6990/2/5)
  - "Fireworks" Galaxy NGC 6946
  - M39 Open Star Cluster



# Lyra – "The Lyre"

- Lyra represents the lyre of Orpheus, the musician and poet in Greek mythology
- Epsilon Lyrae, The "Double Double"
  - Multiple star system about 162 LY distant
  - Apparent visual magnitude 4.7
  - Can be resolved into two binaries when observed through a telescope
- Beta Lyrae, Eclipsing Double
  - Pair of stars in a very tight orbit
  - Light varies gently and continuously over its 12.9-day period
- Deep Sky Objects:
  - M57 Planetary Nebula
  - M56 Globular Star Cluster



# Meteor Showers

- Some of the best are listed below along with dates when the most meteors are visible
  - Quadrantids, January 3-4 (Comet 2003 EH1)
  - Lyrids, April 22-23 (Comet Thatcher)
  - Perseids, August 12-13 (Comet Swift-Tuttle)
  - Orionids, October 20-21 (Halley's Comet)
  - Leonids, November 17-18 (Comet Tempel-Tuttle)
  - Geminids, December 13-14 (Asteroid 3200 Phaethon)
  - Ursids, December 23-24 (Comet 8P/Tuttle)
- The name of each shower refers to the constellation to which the meteors trace their apparent paths



#### Upcoming Events

- Next Meeting: July 22, 2019
- Primary Topics: Big Bang Theory; Isaac Newton
- Perseid Meteor Shower: August 12-14