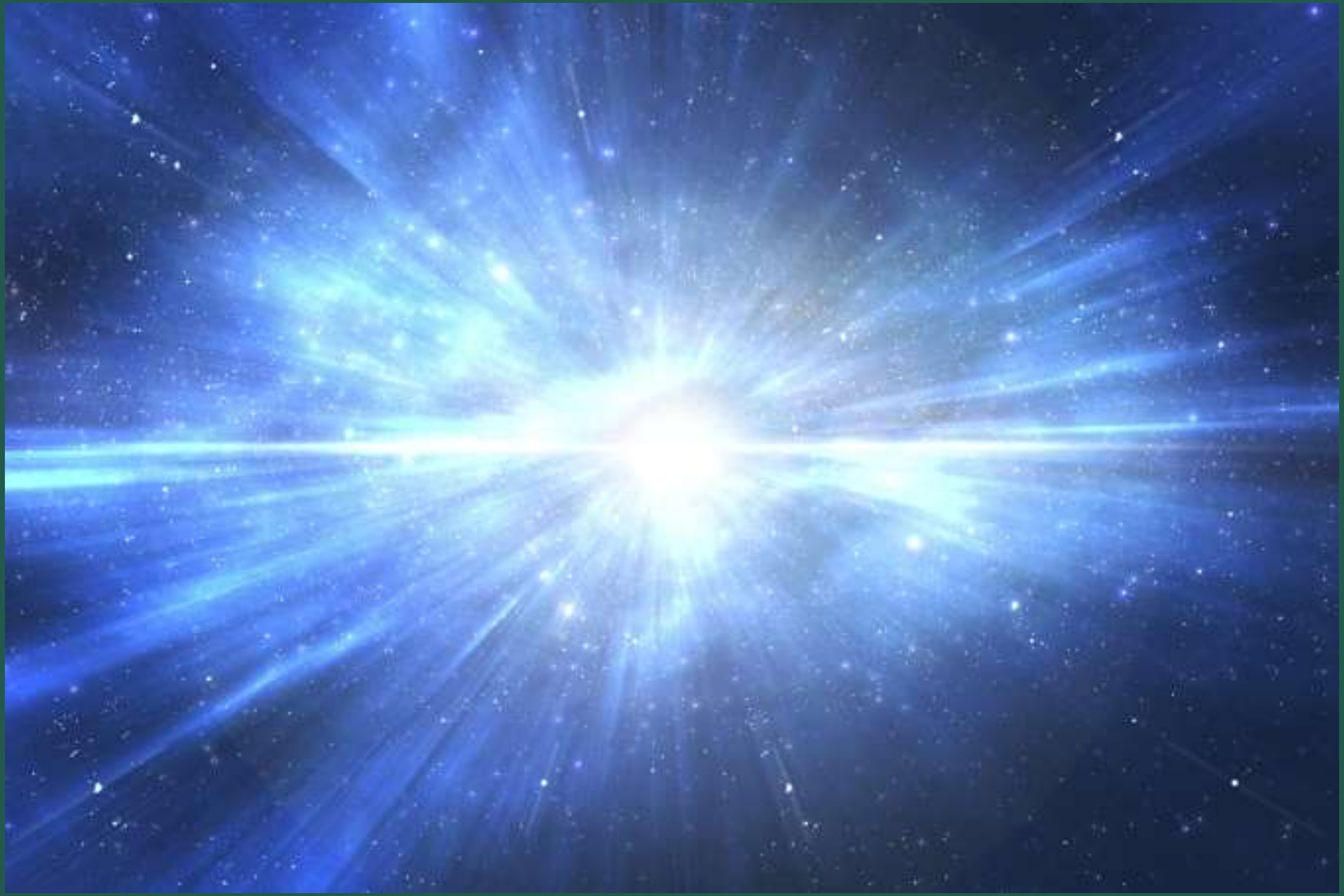
Sir Isaac Newton; The "Big Bang Theory"

Culpeper Astronomy Club
July 22, 2019

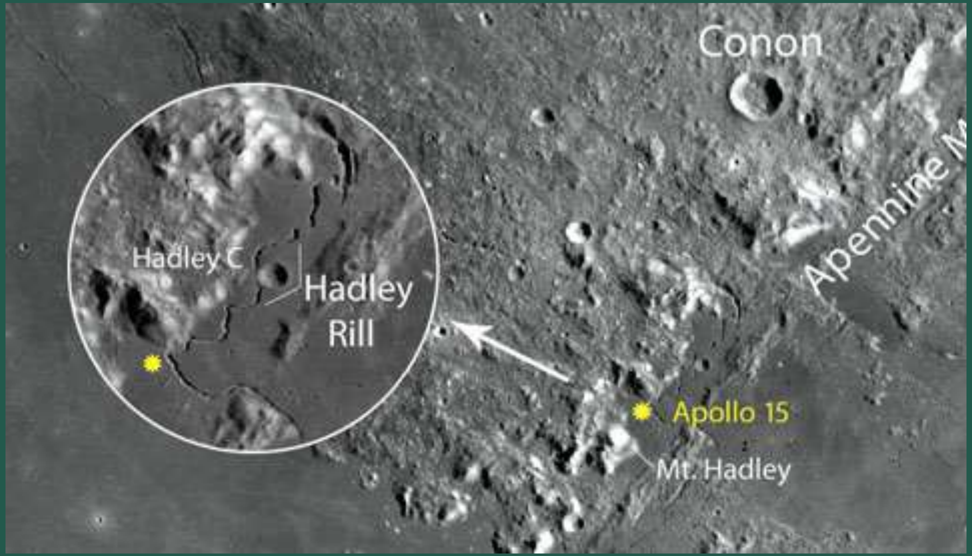


Overview

- Observing Sessions
- Special Topics
- Sir Isaac Newton
- Big Bang Theory
- Constellations
- Observing Session

Observing Sessions

- Lunar Observing Session – 10 July 2019
  - <u>Objective</u>: Observe the Apollo 11, 15, 16, and 17 landing sites
  - Used MCO’s 30 inch Obsession; my 4 inch Unitron refractor; Barry’s 4.5 inch Astroblast tabletop reflector
  - Included three visitors from CAS
  - Sky conditions deteriorated during the evening
  - Observed and video taped the Apollo 11 and 15 sites
  - Observed several DSO’s (M13, …)



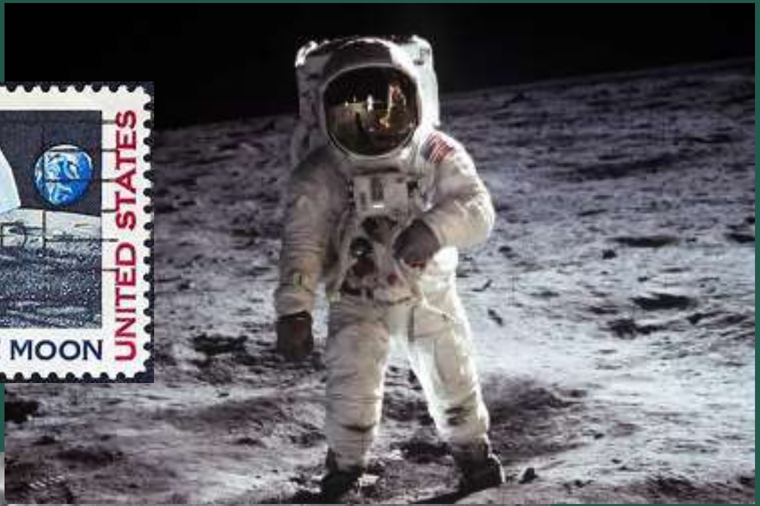
Apollo 11 - 50th Anniversary

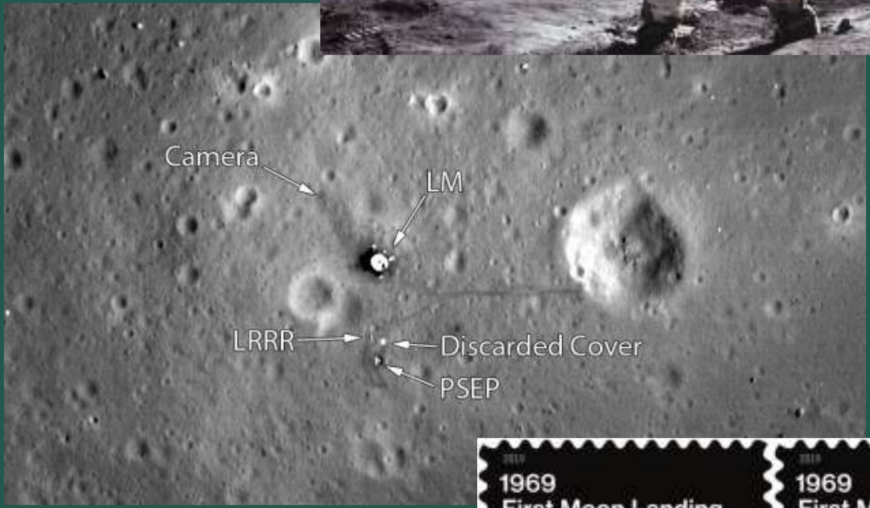
July 16, 1969 – Liftoff from Kennedy Space Center; Neil Armstrong, Buzz Aldrin, and Michael Collins set out on the three-day journey to the moon

July 20, 1969 – Lunar Landing; after several maneuvers, astronauts Armstrong and Aldrin take the Lunar Module to the Moon

July 20, 1969 – First Man on the Moon; after a 3 hour rest, Armstrong and Aldrin begin a 2.5 hour EVA on the surface of the moon

July 24, 1969 – Splashdown; the crew splashes down just over 8 days after they left earth.



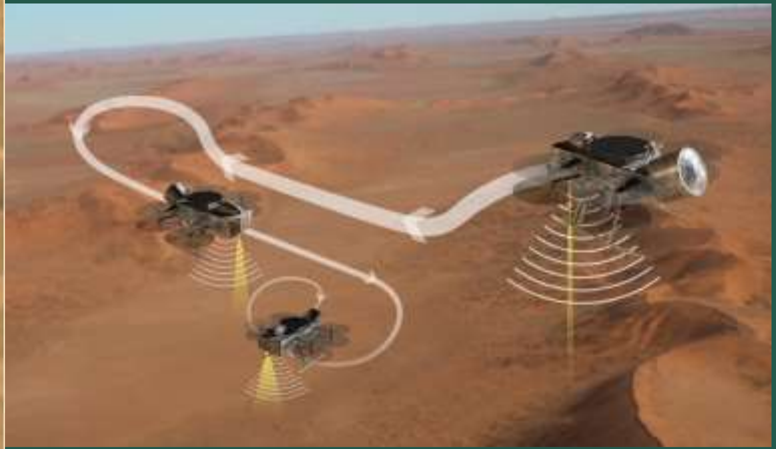


Solar Eclipse

- On July 2, parts of Chile and Argentina caught glimpse of total solar eclipse
- Some regions in South America saw a partial solar eclipse, including other areas in Chile and Argentina, as well as Ecuador, Peru, Bolivia, Paraguay, and Uruguay
- First total solar eclipse since "Great American Eclipse" in August 2017
- The next one won't take place until December 2020; again through South America

Dragonfly Mission to Titan

- NASA's next destination in the solar system is Saturn's largest moon – Titan
- Titan is our solar system's only moon to have a dense atmosphere and clouds; mostly methane and nitrogen
- First visited by Cassini/Huygens in 2005
- Dragonfly mission will:
  - Will launch in 2026 and arrive in 2034
  - Will fly multiple sorties to sample and examine sites around Saturn's icy moon
- First time NASA will fly a multi-rotor vehicle on another planet
  - Has eight rotors; flies like a large drone
  - Takes advantage of Titan's dense atmosphere – 4x's denser than Earth's
  - Will fly science payload to new places for access to surface materials



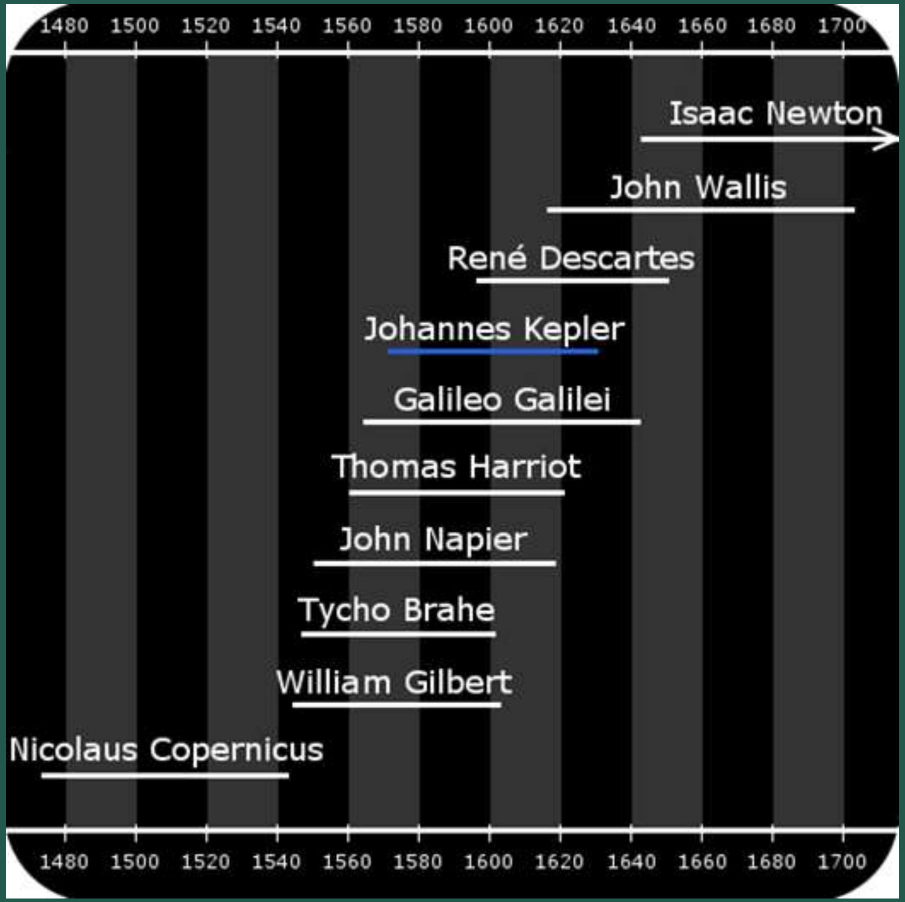
Sir Isaac Newton

Sir Isaac Newton - Contributions

- First person to adequately form a theory that encompassed the movement of bodies through space, including the principles of inertia, action-reaction, and acceleration
  - Displayed through theoretical mathematics that the motion of objects could be effectively predicted
- First to describe the force of gravity, noting that all objects attracted all other objects in space and that the planets orbited the Sun by way of an invisible force
- In his most important publication, "Principia," Newton basically explained for the first time why things moved the way they do
- Newton also made a large contribution to the engineering of telescopic lenses.
  - Prior to Newton, the glass lenses that made up most telescopes of the day produced fuzzy images at the edges of bright objects
  - Newton discovered that utilizing mirrors in his telescope would eliminate the fuzziness, and his telescope could outperform larger telescopes with lenses

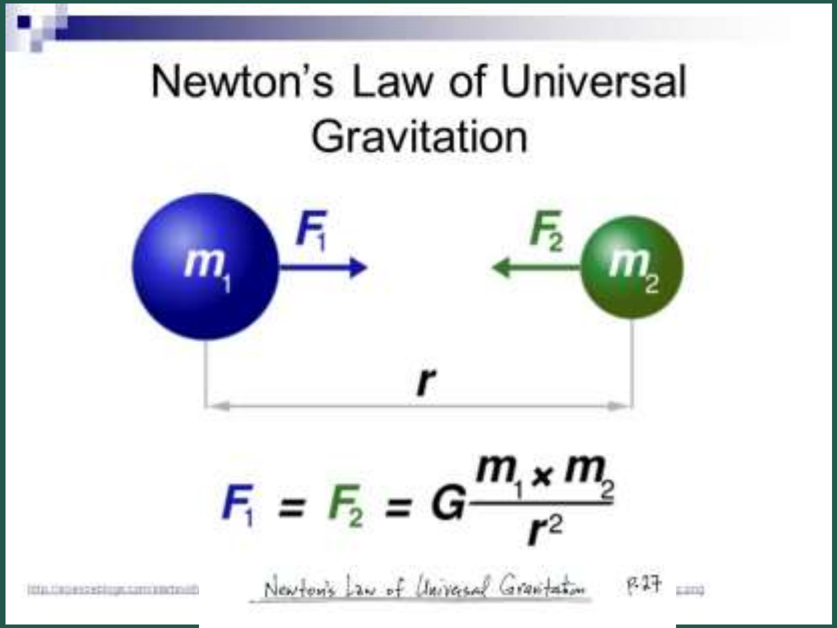
Sir Isaac Newton - Bio

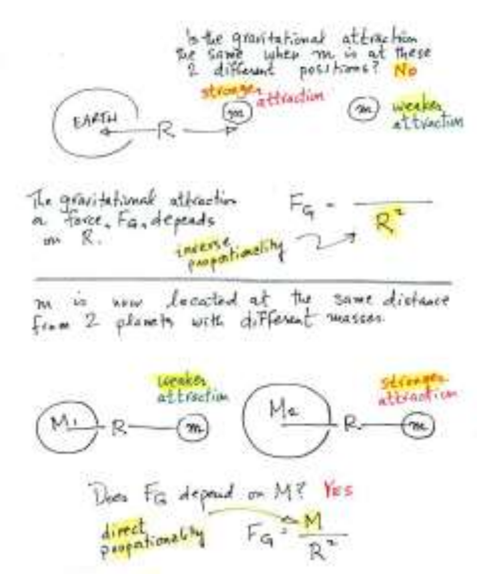
- Isaac Newton was born in Woolsthorpe, England in 1642
- Went away to the Grammar School in Grantham, where he lived with the local apothecary, and was fascinated by the chemicals
- The plan was that at age seventeen he would come home and look after the farm; he turned out to be a total failure as a farmer
- His mother was persuaded it would be better for Isaac to go to university, so in 1661 he went up to Trinity College, Cambridge
- In 1664, he was elected a scholar, guaranteeing four years of financial support; unfortunately the plague was spreading across Europe, and reached Cambridge in the Summer of 1665.
- The university closed, and Newton returned home, where he spent two years concentrating on problems in mathematics and physics
- He wrote later that during this time he first understood the theory of gravitation and the theory of optics (he was the first to realize that white light is made up of the colors of the rainbow), and advanced mathematics (both integral and differential calculus)



Isaac Newton – Gravitational Force

- Newton's law of universal gravitation states that every particle attracts every other particle in the universe
- With a force which is:
  - Directly proportional to the product of their masses
  - Inversely proportional to the square of the distance between their centers





Newton’s Laws of Motion

- First Law: Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it

- Second Law: The relationship between an object's mass m, its acceleration a, and the applied force F is F = ma; acceleration and force are vectors; in this law the direction of the force vector is the same as the direction of the acceleration vector

- Third Law: For every action there is an equal and opposite reaction

Isaac Newton - Contributions

- First major scientific achievement was the invention, design, and construction of a reflecting telescope
- He ground the mirror, built the tube, and even made his own tools for the job; real advance in telescope technology, and ensured his election to membership in the Royal Society
- The mirror gave a sharper image than was possible with a large lens because a lens focuses different colors at slightly different distances (chromatic aberration)
- This problem is minimized nowadays by using compound lenses, two lenses of different kinds of glass stuck together, that err in opposite directions, and thus tend to cancel each other's shortcomings, but mirrors are still used in large telescopes

Big Bang Theory

Big Bang – Its Beginnings

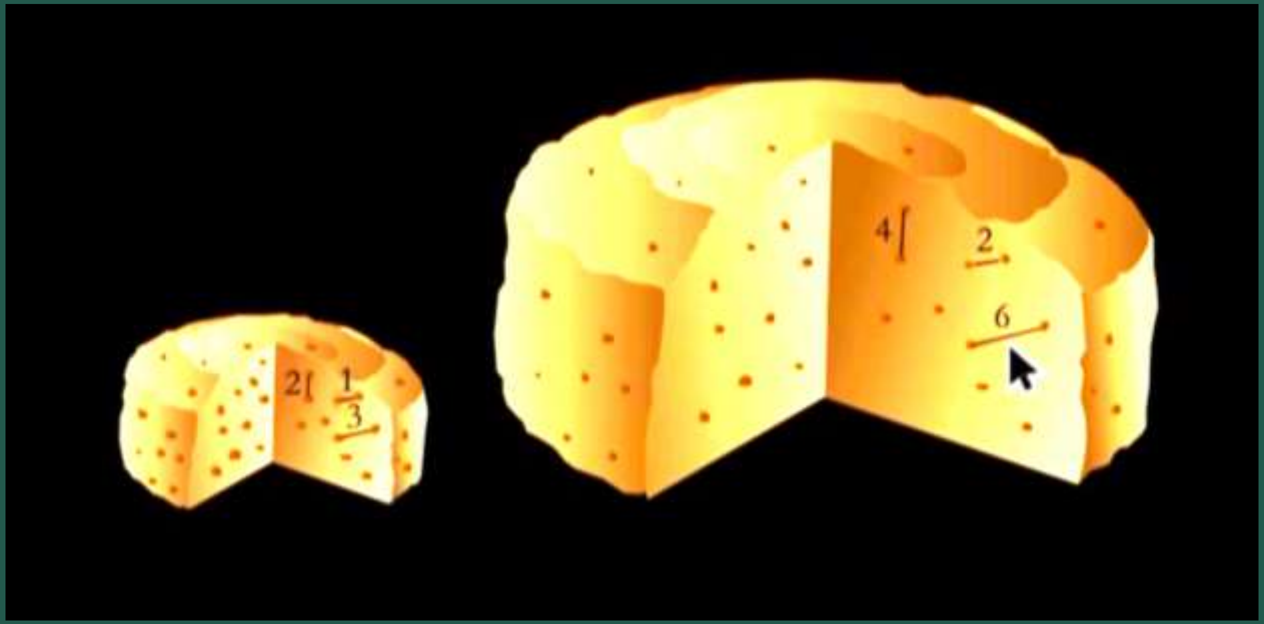
- The “Big Bang Theory” describes the development of the universe from the time just after it came into existence up to today
  - It doesn't attempt to explain what initiated the creation of the universe, or what came before the big bang or even what lies outside the universe

- It's one of several scientific models that attempts to explain why the universe is the way it is
  - The theory makes several predictions, many of which have been proven through observational data
  - As a result, it's the most popular and accepted theory regarding our universe's development

- The most important concept to get across when talking about the Big Bang is expansion.
  - Many people think that it is about a moment in which all the matter and energy in the universe was concentrated in a tiny point
  - Then this point exploded, shooting matter across space, and the universe was born
  - In fact, the Big Bang explains the expansion of space itself, which in turn means everything contained within space is spreading apart from everything else

Big Bang – Its Beginnings

- A preferred analogy for the universe's expansion is the "dough and raisins" analogy
- In this analogy, we picture the universe as a gigantic blob of dough which is placed in an oven and begins to expand.
- Embedded throughout the dough are a bunch of raisins, each of which represents a galaxy (including one for our galaxy, the Milky Way).
- As the dough expands, the distances within it all stretch proportionally, and the raisins move away from each other IN ALL THREE DIRECTIONS

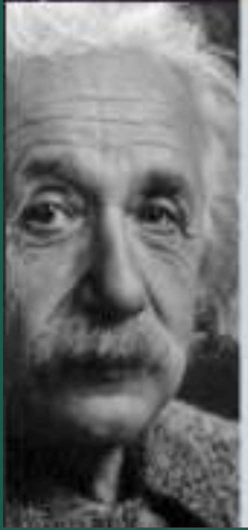


EVIDENCE FOR A BIG BANG

ABOVE: TEXTURE OF THE COSMIC MICROWAVE BACKGROUND RADIATION

Astronomers make three assumptions about the universe based on theory and observation:

- The **laws of physics are universal** and don't change with time or location in space.
- The universe is homogeneous, or **roughly the same in every direction** (though not necessarily for all of time).
- **Humans do not observe the universe from a privileged location** such as at its very center.

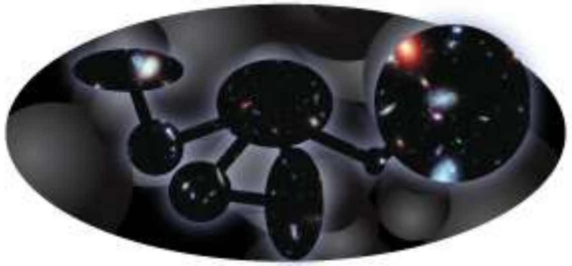


When these assumptions are applied to Einstein's equations, they indicate that the universe has these properties:

- The universe **expands** (astronomers see light from the universe's distant regions shifted toward the red end of the spectrum by the expansion of the space between).
- The universe emerged from a **hot, dense state** at some finite time in the past.
- The **lightest elements**, hydrogen and helium, were created in the first moments of time.
- A **background of microwave radiation** fills the entire universe, a relic of the phase transition that occurred when the hot, early universe cooled enough for atoms to form.

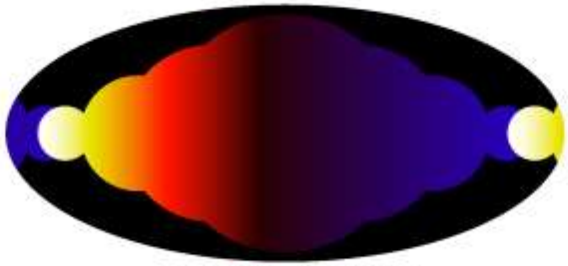
STEADY-STATE UNIVERSE

An early rival to the Big Bang theory, Steady State posits **continuous creation of matter** throughout the universe to explain its apparent expansion. This type of universe would be infinite, with no beginning or end. However, a mountain of evidence found since the mid-1960s indicates that this theory is not correct.



ETERNAL INFLATION (LEVEL II MULTIVERSE)

After the Big Bang, the universe expanded rapidly during a brief period called inflation. The Eternal Inflation theory posits that **inflation never stopped**, and has been going on for an infinite length of time. Somewhere, even now, new universes are coming into existence in a vast complex called the **multiverse**. Those many universes could have different physical laws.



OSCILLATING UNIVERSE

Originally, the **cyclic model** of the universe involved an endless series of Big Bangs, followed by Big Crunches that restarted the cycle, endlessly. The modern cyclic model involves colliding **"branes"** (a "membrane" within a higher-dimensional volume called the "bulk").

OTHER THEORIES

Implications found in quantum gravity and string theory tantalizingly suggest a universe that is in reality nothing like how it appears to human observers. It may actually be a **flat hologram** projected onto the surface of a sphere, for example. Or it could be a completely **digital simulation** running in a vast computer.

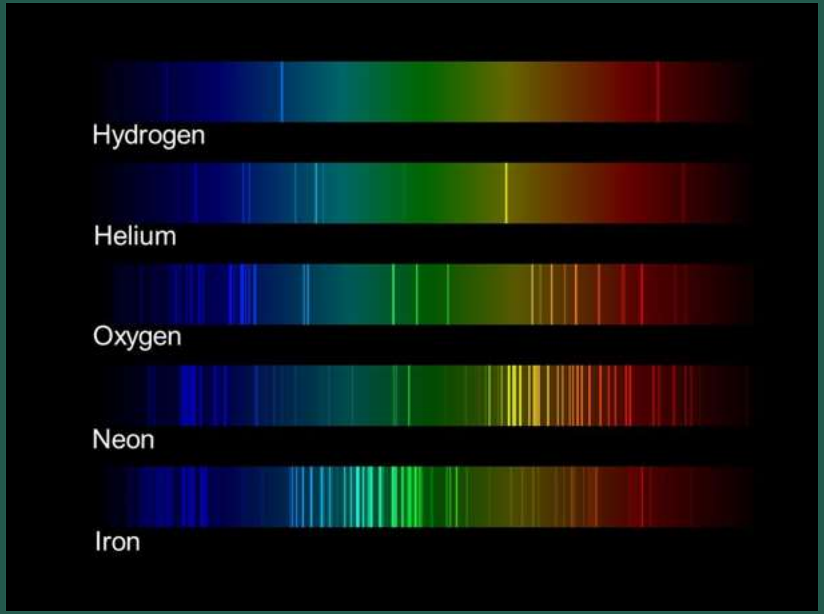
Big Bang – Its Beginnings (Continued)

- Today, when we look at the night sky, we see galaxies separated by what appears to be huge expanses of empty space
- At the earliest moments of the Big Bang, all of the matter, energy and space we could observe was compressed to an area of zero volume and infinite density; Cosmologists call this a "singularity"
- What was the universe like at the beginning of the big bang?
  - According to the theory, it was extremely dense and extremely hot.
  - There was so much energy in the universe during those first few moments that matter as we know it couldn't form.
  - But the universe expanded rapidly, which means it became less dense and cooled down
  - As it expanded, matter began to form and radiation began to lose energy
  - In only a few seconds, the universe formed out of a singularity that stretched across space

Big Bang – Its Beginnings

- The Big Bang Theory is the result of two different approaches to studying the universe: astronomy and cosmology
  - Astronomers use instruments to observe stars and other celestial bodies
  - Cosmologists study the astrophysical properties of the universe

- In the 1800s, astronomers began to experiment with spectroscopes (also known as spectrographs).
  - A spectroscope divides light into a spectrum of its component wavelengths
  - Spectroscopes showed that the light from a specific material, such as a glowing tube of hydrogen, always produced the same distribution of wavelengths unique to that material
  - By looking at the wavelength distribution from a spectrograph, you could figure out what kind of elements were in a light source

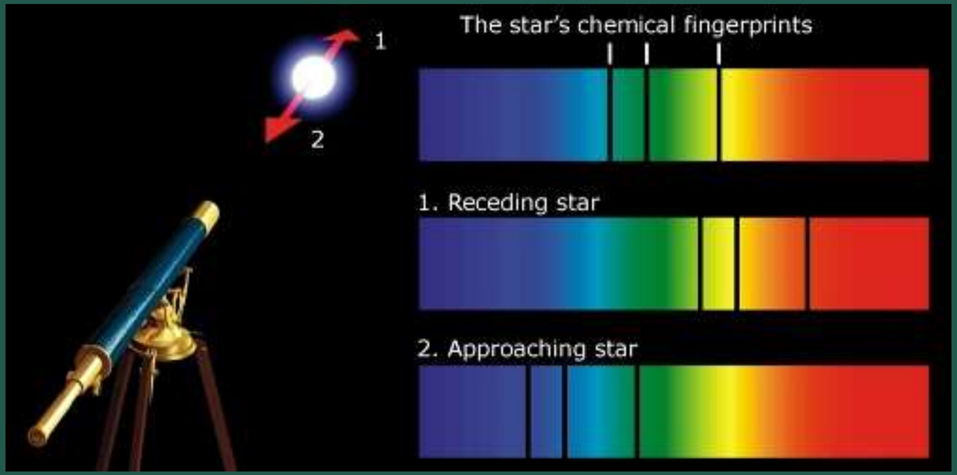


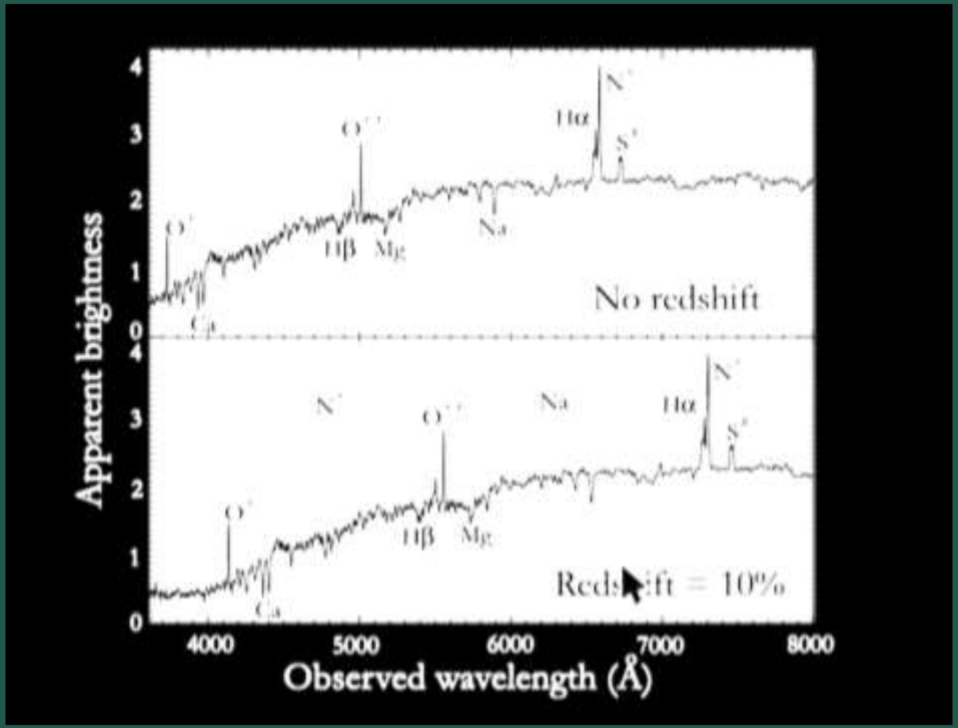
Big Bang – Doppler Shift

- Austrian physicist Christian Doppler: frequency of a sound wave depended upon the relative position of the source of the sound
    - As a noisy object approaches you, the sound waves it generates compress
    - This changes the frequency of the sound, and so you perceive the sound as a different pitch
    - When the object moves away from you, the sound waves stretch and the pitch goes down; it's called the Doppler effect.

- Light travels in waves too, and astronomers discovered that some stars had more light falling into the red side of the spectrum than they expected.
    - They theorized that this meant the stars were moving away from Earth.
    - As the stars move away, the wavelengths from the light they emit stretch.
    - They shift to the red end of the spectrum because that end has longer wavelengths.

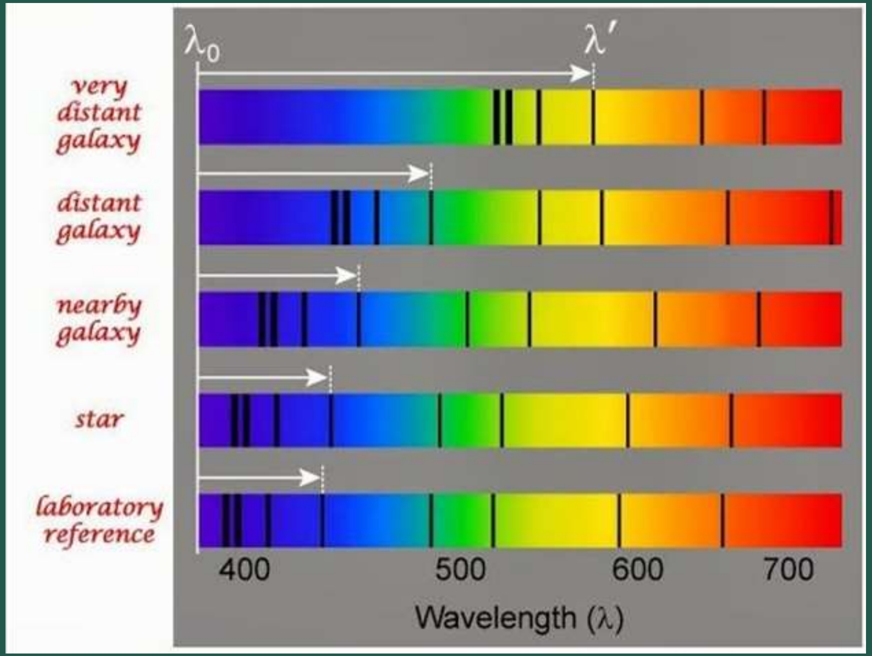
- Cosmologists call this phenomenon the redshift. A star's redshift is an indication of how quickly it is moving away from Earth. The further toward the red end of the spectrum the light shifts, the faster the star is moving away.

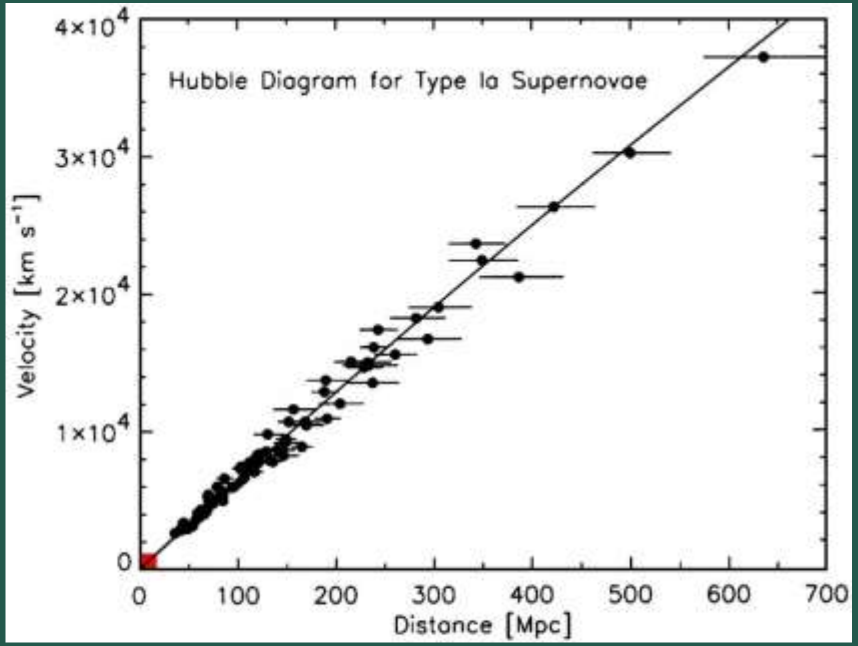


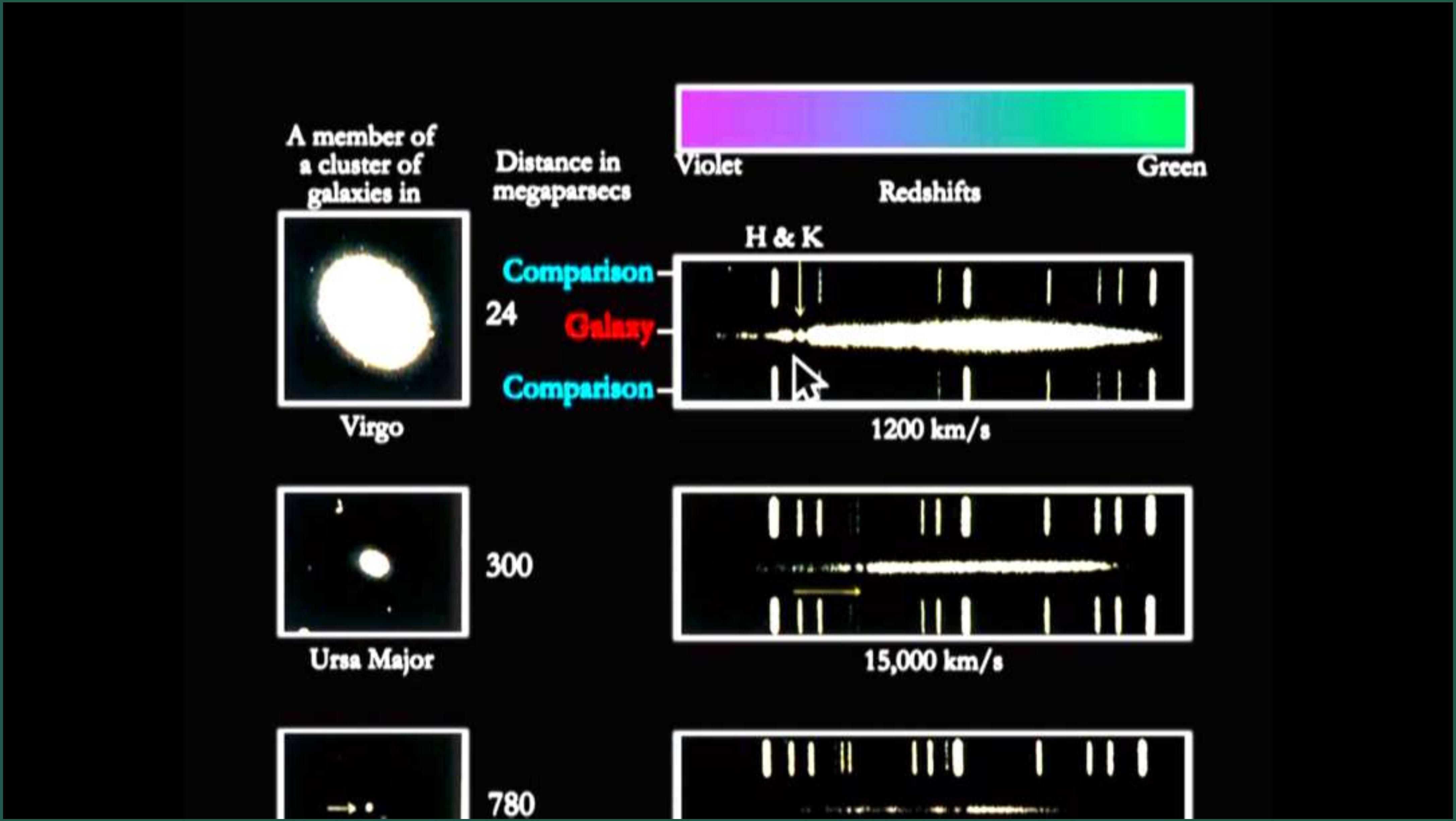


Hubble's Constant

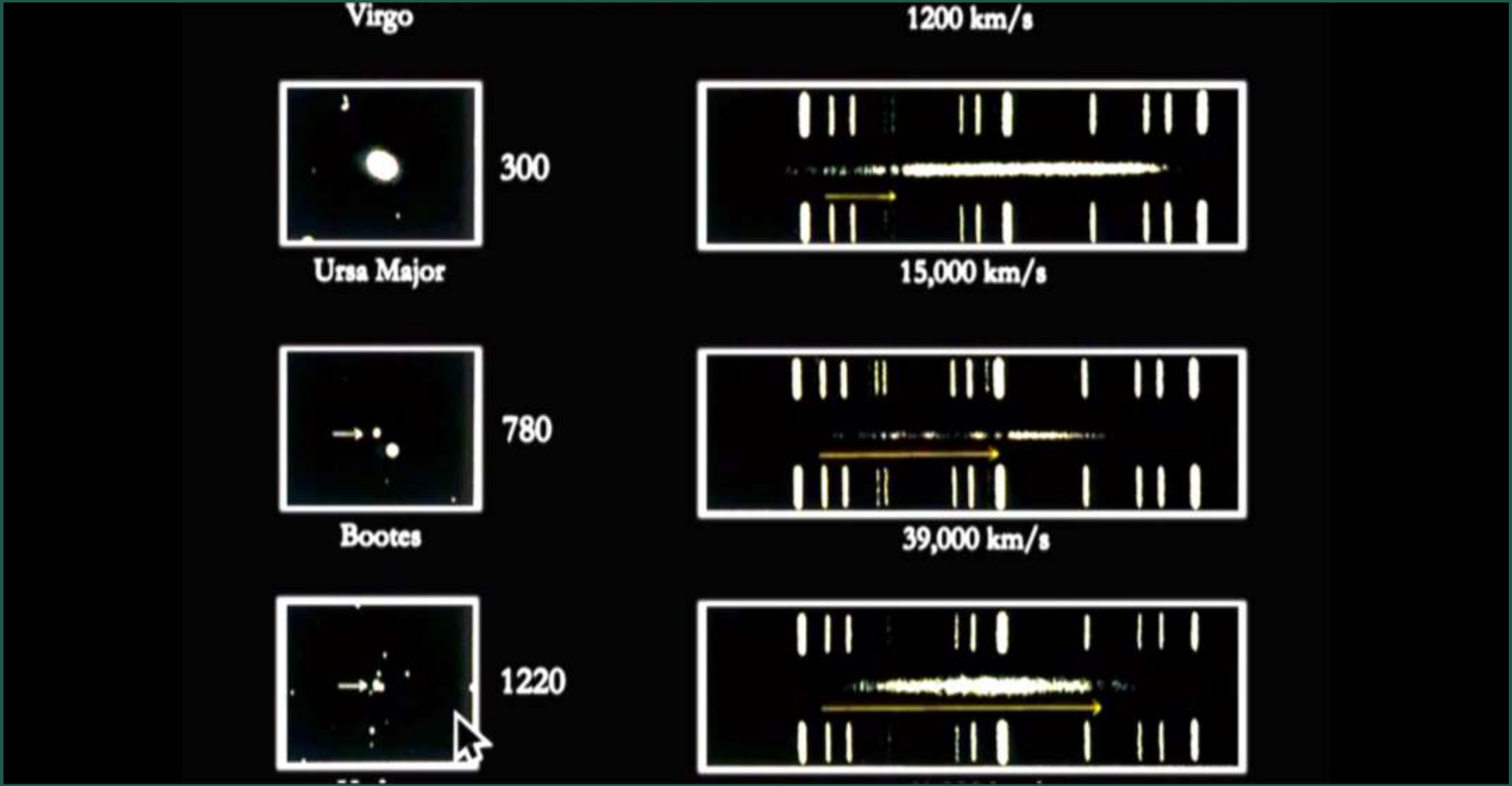
- Edwin Hubble (in 1929) noticed the velocity of a star proportional to its distance from the Earth
  - The farther away a star was from Earth, the faster it appeared to move away from us
  - Hubble theorized that this meant the universe itself was expanding.
- Hubble's discovery resulted in a lengthy debate that still rages today
  - Cosmologists call this relationship the "Hubble Constant"
  - Disagreement on that relationship







A member of a cluster of galaxies in
Distance in megaparsecs
Violet
Green
Redshifts
H & K
Comparison
Galaxy
Comparison
24
Virgo
1200 km/s
300
Ursa Major
15,000 km/s
780


Virgo
1200 km/s
300
Ursa Major
15,000 km/s
780
Bootes
39,000 km/s
1220

Age Of The Universe

- If we agree that Hubble's Law tells us that the universe is expanding, it also implies that in the past the universe was much smaller than it is today
-
- If we assume that the expansion's apparent velocity (that is, how fast the galaxies appear to be moving apart) has been constant over the history of the universe, we can calculate how long ago the galaxies began their separation
-
- This should tell us the time that the expansion began, which should give us an estimate of the age of the universe

So, the time it has taken for the galaxies to reach their current separations is t=D/v

But, from Hubble's Law, we know that v=H0D

So, t=D/v=D/(H0×D)=1/H0 . So, you can take 1/H0 as an estimate for the age of the Universe

The best estimate for H0=73km/s/Mpc; to turn this into an age, we'll have to do a unit conversion

Since 1Mpc=3.08×1019km, H0 = (73 km/s/Mpc) x (1 Mpc/3.08 x 1019 km) = 2.37 x 10−18 1/s

So, the age of the Universe is t = 1/H0 = 1 / 2.37 x 10−18 1/s = 4.22 x 1017 s = 13.4 billion years

Constellations

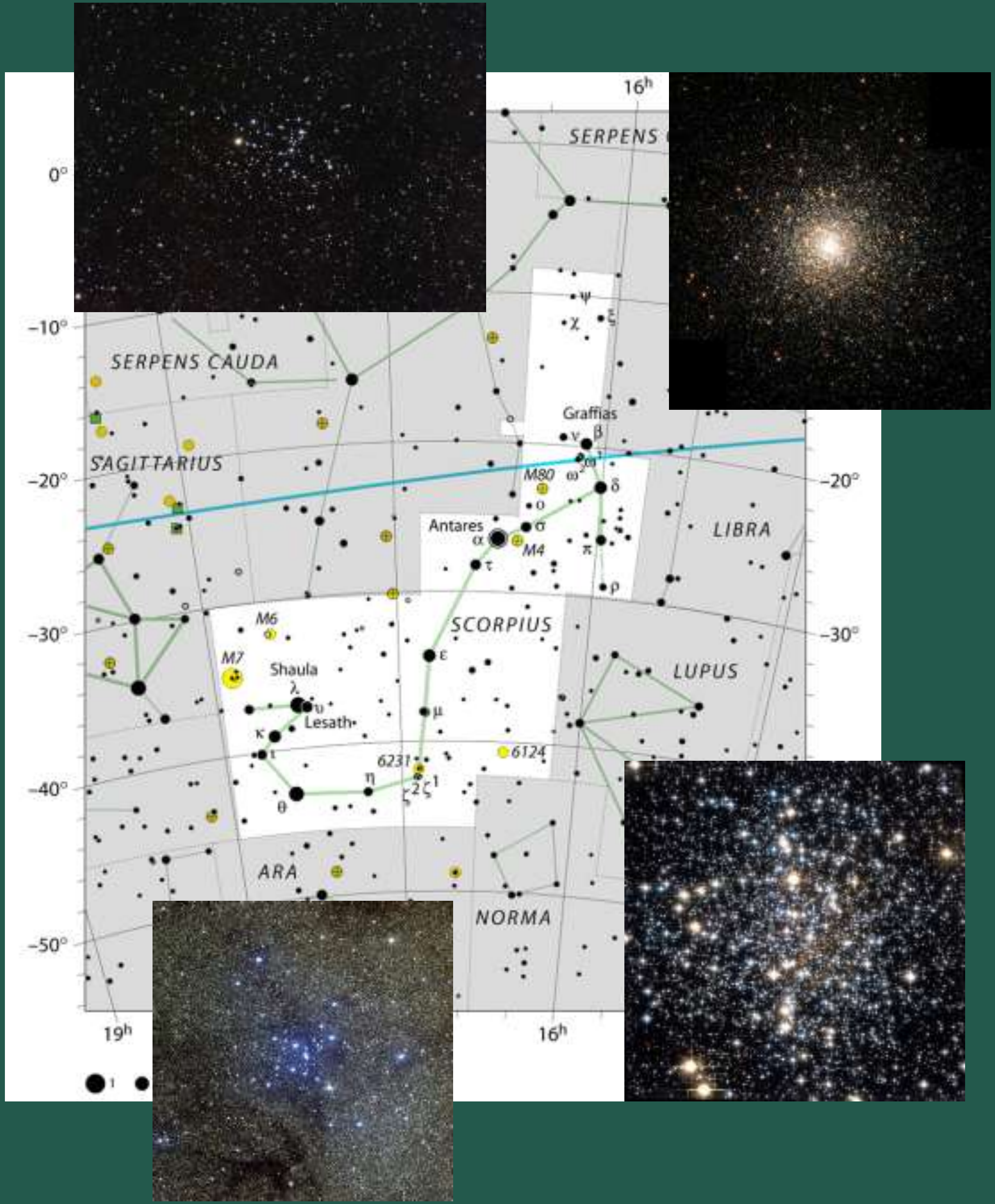
- Scorpius: The Scorpion
- Draco: The Dragon
- Ophiuchus: Serpent Bearer

Scorpius- “The Scorpion”

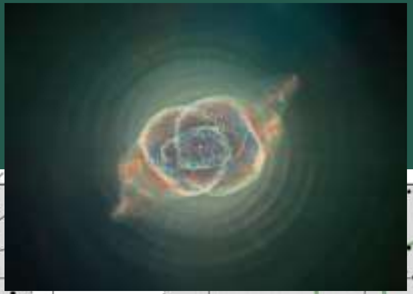
- In Greek mythology, the constellation Scorpius was identified with the scorpion that killed Orion, the mythical hunter

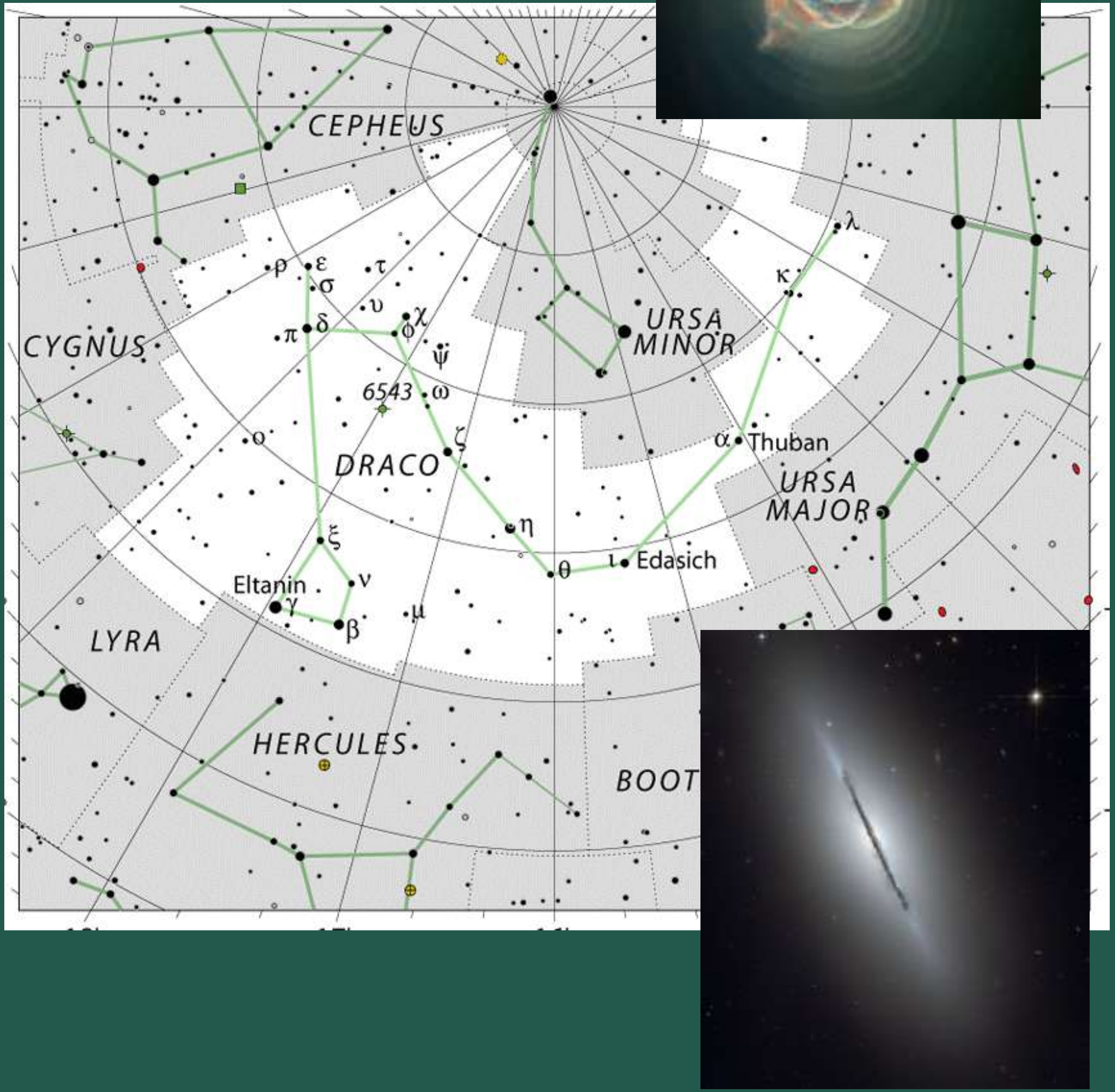
- Beta Scorpii is a binary star separated by 13.5 arc sec
  - Primary is binary star with an orbital period of 610 years and its own brighter component is a spectroscopic binary, with components separated by only 1.42 miliarcsec and orbiting each other every 6.82 days
- Pi Scorpii is a triple star system with a combined visual magnitude of 2.9; 590 light years distant

- Deep Sky Objects include:
  - Two Clusters (M6 and M7), and two Globular Cluster (M4, and M80)



Draco – “The Dragon”





- Draco represents Ladon, the dragon that guarded the gardens of the Hesperides in Greek mythology

- Double Stars:
  - Nu Dra: two white stars; 62” sep
  - 39 Dra: Triple star; white-white-blue; 90”, 3.7” sep

- Deep Sky Objects:
  - NGC 6543 (Catseye Nebula): a planetary nebula 3300 light years distant; visual magnitude of 9.8

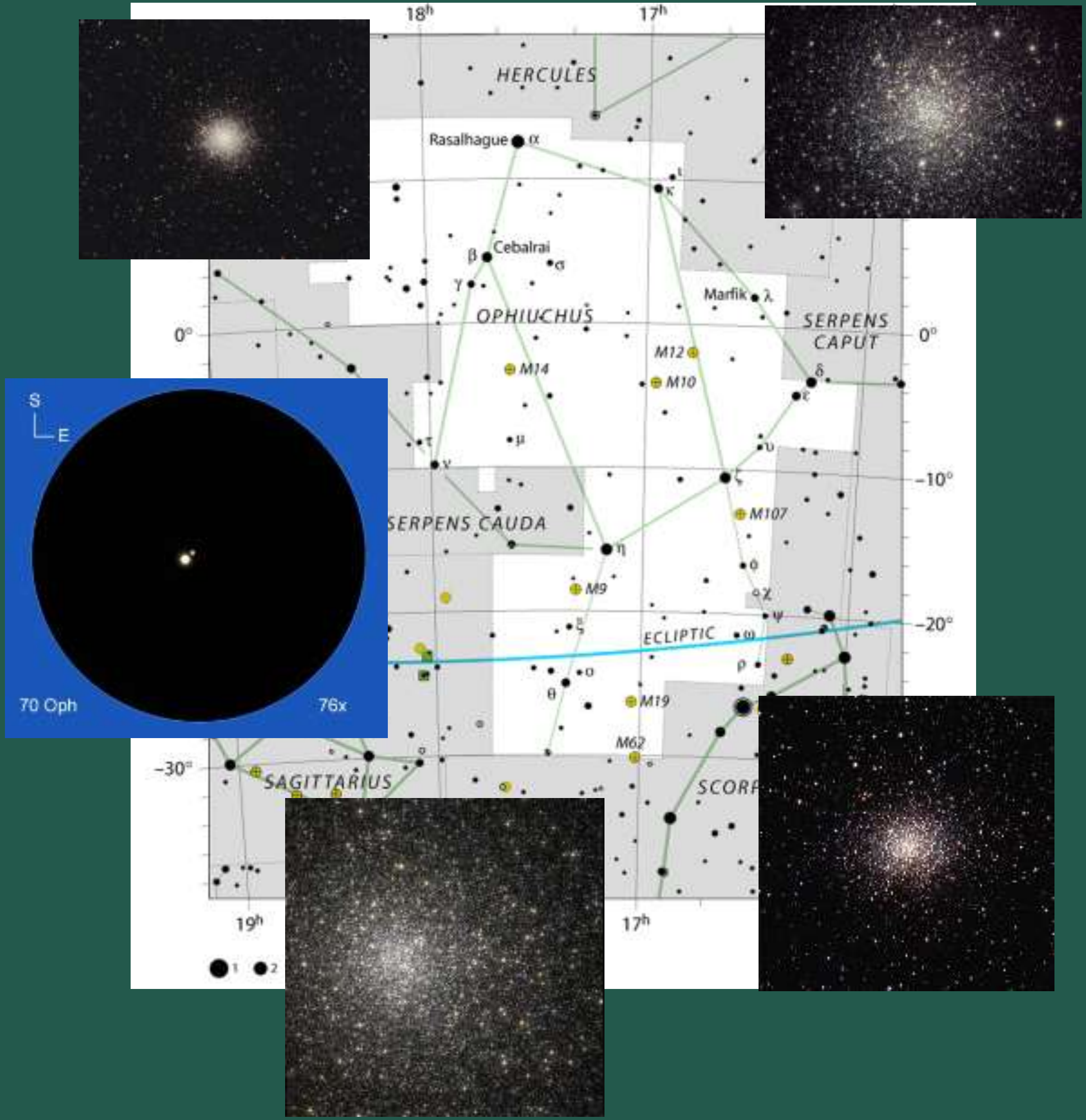
  - M102 (Spindle Galaxy): a spiral or lenticular galaxy; apparent magnitude of 10.7; 50M light years distant

Ophiuchus – "Serpent Bearer"

- Ophiuchus is generally depicted as a man holding a snake, represented by the neighboring constellation Serpens

- Interesting Stars:
  - 70 Ophiuchi (Binary Star, 15LY Distant)
  - Two orange Dwarf Stars

- Ophiuchus contains seven Messier objects:
  - M9, M10, M12, M14, M19, M62, and M107 (All Globular Clusters)
  - Many other NGC globulars



Upcoming Events

- Next Meeting: August 26, at 7-8:30 p.m.
    - Topic: TBD
- Perseid Meteor Shower: August 11-14

Resources

- Sky and Telescope website: http://www.skyandtelescope.com/
- Stellarium software application: www.Stellarium.org
- Suggested books: