Copernicus & Trans-Neptunian Objects



Culpeper Astronomy Club Meeting March 25, 2019

Overview

- Introductions
- Copernicus
- Pluto and Trans-Neptunian Objects (TNO)
- Constellations: Canis Major, Lepus, Monoceros
- Observing Session (Weather permitting)

Observing Sessions

- CAC Group Session: 23 March, 7:30-11 p.m.
 - Had a great evening under incredible skies!
 - ISS Pass at 7:55 p.m. lasted 6 minutes
 - 4 inch refractor (SV110ED/G11)
 - Mars, small (4.79") and reddish; Uranus, blue dot low in horizon
 - Open clusters: the Pleiades (M45) and the Beehive (M44) and M35, M36, M37, M38, M41, M46, M47, and M48
 - Several double stars were checked out in Cassiopeia, Taurus, Leo and Cancer...including 57 Cancri, an exceptionally close double at 1.5 arcsec
 - 30 inch dobsonian
 - Nebula (M42 and Owl)
 - Galaxies (M81 and 82); Leo

Geocentric Theory

- The geocentric model (also known as Geocentrism, or the Ptolemaic system) is a superseded description of the Universe with Earth at the center
- Under the geocentric model, the Sun, Moon, stars, and planets all orbited Earth
- The geocentric model served as the predominant description of the cosmos in many ancient civilizations, such as those of Aristotle and Ptolemy
- Two observations supported the idea that Earth was the center of the Universe:
 - First, from anywhere on Earth, the <u>Sun</u> appears to revolve around Earth once per day; while the <u>Moon and the planets</u> have their own motions, they also appear to revolve around Earth about once per day; the <u>stars</u> appeared to be fixed on a celestial sphere rotating once each day about an axis through the geographic poles of Earth
 - Second, Earth seems to be unmoving from the perspective of an earthbound observer; it feels solid, stable, and stationary

Copernicus – Founder of Modern Astronomy

- Nicholaus Copernicus (1473-1543) was a mathematician and astronomer during a time of artistic and scientific innovation called the Renaissance
- His model of the universe as revolving around the sun, called the Heliocentric theory, challenged the existing view of Earth as the center of the universe (Geocentric)
- Spent the most of his life performing church duties and practicing medicine, but developed an early interest in astronomy
 - Throughout his life he performed astronomical observations and calculations
- Copernicus made astronomical observations with the naked eye and it was half a century later that Galileo (1564-1642) became the first person to study the skies with a telescope
- For his revolutionary contribution in the field, Nicolaus Copernicus is regarded as the Founder of Modern Astronomy



Copernicus

- At the time of Copernicus, and even many years after his death, Ptolemy's geocentric model of the universe was widely accepted
- He put forward an early version of his revolutionary Heliocentric theory in his 1514 work Commentariolus (Little Commentary)
- His Heliocentric model put the Sun at the center of the Solar System with the Earth as one of the planet revolving around the fixed sun, once a year, and turning on its axis once a day
- Similar models had been put forward by a few astronomers, but his solar system was more detailed and provided a more accurate formula for calculating planetary positions





Trans-Neptunian Objects (TNO)

- A TNO is any minor planet orbiting the Sun in our solar system:
 - Beyond Neptune
 - At a distance which is more than Neptune's (on average)
- Known divisions of bodies beyond Neptune (which are still part of the solar system) are:
 - Kuiper belt
 - Scattered disk
 - Oort cloud



The Kuiper Belt

- In 1951, Dutch-American astronomer Gerard P. Kuiper first proposed the idea of the Kuiper Belt
- He believed there was an elliptic shape region that was filled with a swarm of icy, rock objects
 - A disk shaped region past the orbit of Neptune
 - Extends from 30 to 50/55 AU (2.5 to 4.5 billion miles) from the Sun
- Found the first KBO in 1992 using photography
 - Have since discovered thousands
- Wide range in size; many, especially the large ones have moons
- Short- period comets originate in the Kuiper belt

The "Scattered Disk" Objects (SDO)

- Another distant region beyond Neptune's orbit populated by a few, minor, icy objects; widely believed to be the place of origin for a majority of periodic comets
- The scattered disk is still poorly understood, although prevailing astronomical opinion suggests it was formed when Kuiper belt objects (KBOs) were "scattered" by gravitational interactions with the outer planets, principally Neptune, into highly eccentric and inclined orbits
- While the Kuiper belt is a relatively "round" and "flat" doughnut of space extending from about 30 AU to 55 AU with its member-objects locked in autonomously circular orbits (cubewanos) or mildly-elliptical resonant orbits (plutinos and twotinos), the scattered disc is by comparison is much more erratic
- SDOs can often, as in the case of Eris, travel almost as great a "vertical" distance as they do relative to what has come to be defined as "horizontal"
- Orbital simulations show SDO orbits may well be erratic and unstable and that the ultimate fate of these objects is to be permanently ejected from the core of the solar system into the Oort cloud or beyond

The Oort Cloud

- The Oort Cloud is a reserve of cometary nuclei that contain ices dating back to the origin of the solar system
- No one knows for sure how many objects exist in the Oort Cloud, but most estimates put it at around 2 trillion
- The Oort cloud comprises two regions. There is a spherical outer Oort cloud, and a disc shaped inner cloud called the Hills cloud
- Objects in the Oort Cloud are mostly composed of water ice, ammonia and methane
- A majority of objects in this region are believed to be from the scattered disk



Pluto – The Planet

- Suspected based on discrepancy in orbit of Uranus
- Percival Lowell made calculations about its location
- Clyde Tombaugh hired to do the research in 1929
 - Self taught, 23 year old astronomer
- Tombaugh spent about 7000 hours (3.5 working years) at the blink comparator before he found Pluto in 1930
- He found it after he had searched only a small part of the sky
 - Dumb luck that it was there
 - Predictions he used to guide his search were bogus



Pluto – The First 75 Years

- Was named for the Roman God of the underworld
 - Able to make himself disappear for long periods of time
 - Name suggested by 11 Year old British schoolgirl
 - First letters: PL = Percival Lowell
- Has a highly eccentric orbit; actually closer to Sun than Neptune for 20 years of its 248 year orbit
 - 30-49 AU Distant; 1473 miles in diameter
- First moon, Charon, discovered in 1978
 - About one-half diameter of Pluto
- In 2005, two additional moons, Nix and Hydra, were discovered

What Happened to Pluto the Planet?

- According to a new definition established in 2006 by the IAU, a fullfledged planet is an object that orbits the sun and is large enough to have become round due to the force of its own gravity
 - In addition, a planet has to dominate the neighborhood around its orbit
- Pluto was demoted because it does not dominate its neighborhood
 - Charon, its large "moon," is only about half the size of Pluto, while all the true planets are far larger than their moons
- In addition, bodies that dominate their neighborhoods, "sweep up" asteroids, comets, and other debris, clearing a path along their orbits
 - By contrast, Pluto's orbit is somewhat untidy



IAU Resolution 5a

- (1) A planet is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit.
- (2) A "dwarf planet" is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) has not cleared the neighbourhood around its orbit, and (d) is not a satellite.
- (3) All other objects, except satellites, orbiting the Sun shall be referred to collectively as "Small Solar System Bodies."

The Other Dwarf Planets

- Eris' discovery was a big reason astronomers demoted Pluto to dwarf planet status in 2006
 - Discovered by Mike Brown's Team
 - Spotted in 2003; confirmed in 2005
- Estimated to be about same size as Pluto
 - Orbital period of 557 Earth years
 - Orbital plane extends beyond the Kuiper Belt
 - Has a single moon, Dysnomia
- There could be anywhere from 200 to 10,000 Dwarf Planets on the belt



Haumae

- Discovered in 2004 by Mike Brown's Team at Caltech
- On Sep 17, 2008, it was recognized as a dwarf planet
 - Named after Haumea, the Hawaiian goddess of childbirth
- Haumea's mass is about one-third that of Pluto
- It has an eongated shape, rapid rotation, high density, and high reflectivity (from a surface of crystalline water ice)
 - Thought to be the consequences of a giant collision
 - Left it the largest member of a family that includes several large trans-Neptunian objects (TNOs) and its two known moons, Hi'iaka and Namaka
- Haumea rotates every 3.9 hours





Makemake

- Makemake was discovered in 2005
 - Named after the creator god from Easter Island mythology
- Estimate its size at 1,500 km diameter
 - No known moon
- Frozen nitrogen, frozen ethane and frozen methane have all been detected on the surface
- Along with Eris, its discovery was a major factor in making the IAU look at the definition of a planet





Ultima Thule

- Using observations made with Hubble on June 26, 2014, the science team discovered an object that New Horizons could reach with its available fuel
- The object was subsequently designated 2014 MU69 and nicknamed "Ultima Thule" (which means "beyond the known world")
- Ultima Thule was 6.5 billion kilometers (4 billion miles) from the Sun, making this the most distant planetary flyby in history
- Is a "contact binary," consisting of two connected spheres. End to end, the world measures 19 miles (31 kilometers) in length
- Latest image reveals topographic details along the terminator, near the top. These details include numerous small pits up to about 0.4 miles (0.7 kilometers) in diameter





Planet Nine

- Hypothetical large planet in the far outer Solar System posed by Mike Brown and Team
- Gravitational effects would explain improbable orbital configuration of trans-Neptunian objects (TNOs) that orbit mostly beyond the Kuiper belt
- Would follow a highly elliptical orbit around the Sun, with an orbital period of 10,000–20,000 years
- The planet is estimated to have 10 times the mass and two to four times the diameter of Earth
- Most likely an ejected ice giant, similar in composition to Uranus and Neptune
 - a mixture of rock and ice with a small envelope of gas



Constellations

- Orion still prominent but not for long
- Plan to explore three of its neighbors:
 - Canis Major, The Big Dog
 - Lepus, The Hare
 - Monoceros, The Unicorn



Canis Major – The Big Dog

- Larger of the the two hunting dogs used by Orion; chasing the Hare
- Within the constellation can be found Sirius, the brightest star in the night sky
 - Known as the "Dog Star"
 - Derived from the Greek word seirios which means "scorcher"
- Sirius Difficult Binary (50 yr period)
- M41 Open Star Cluster
 - Better viewed at low power
- Thor's Helmet Emission Nebula (30LY)
 - A nebula formed of ionized gases that emit light of various colors
 - Most common source of ionization is highenergy photons emitted from a nearby hot star
 - Wolf-Rayet star named HD 56925, an extremely hot giant, located in the center of the nebula and thought to be in a brief pre-supernova stage of evolution



Lepus – The Hare

- Depicted as a hare being chased by the mythical hunter Orion and his hunting dogs
- Hind's Crimson Star (R Leporis)
 - In the late stages of its life; has begun to churn up carbon from its core
 - Once in the star's atmosphere, the carbon blocks all but red and infrared wavelengths: gives the star its color
 - Variable star with period of 420 days
- M79 Globular Star Cluster
 - About 52 LY in diameter
 - Estimated to contain 150,000 stars



Monoceros - The Unicorn

- The constellation was created to fill the area between Orion and Hydra, where there weren't any constellations introduced in Greek times
 - No particular myth associated with it
- Beta Mon is a triple star system
- Messier 50 is an open cluster
 - Distinct for its heart-shaped figure
- The Rosette Nebula is a large emission nebula
- NGC 2264 is a New General Catalogue designation for two deep sky objects
 - Christmas Tree Cluster
 - Cone Nebula

