Part I: Humans and the sky

1: The Origins

- Civilizations self-regard as special → God put us at center of universe, celestials revolve around us
  - Universe: How large/created/How long/why exist? How significant are we? (Spatial/temporal)
  - We were there for a reason and everything else are there for our use or enjoyment/convenience
- If H.O. are simply for our convenience, why need to move complicated? Deeper meaning? Why here?
- Coincidences and regularity → Decode celestial transient event → Understand message of God
  - Human activities synced by the daily motion of the heavens (illumination)→ Patterns important
  - Practical (For agriculture, navigation)/Spiritual/Cyclic patterns VS Uncertainty in life/Connection

2. Universe Models

Pre-modern civilizations: **Flat earth** (square), celestial sphere above Earth, along axis in dir. of pole star)
Q: What happens to sun/stars after setting? → Motions continue after setting, make full circles

Arguments **against moving Earth**: Earth is different from the Heavens (bright lights vs mud/rock, Aether)
Against: We do not sense motion of the Earth, else a jumping man will land away from where he jumped

Ptolemy: Deferent-and-epicycle model; Cosmos contains no empty space, circles fill a spherical shell
X: Philosophically unappealing (equant), Moon apparent size varies greatly, Treat planets independently
Planet epicycle p: 1y, Dir. of CP always in dir. of Sun as seen from Earth, Epicycle center in sun dir. : sun?

Copernicus: Elimination of equant, heliocentric →1. Explain retrograde planets; 2. Period ∝ Sun dist.

- Uneven seasons → Uniform orbit of planet about an epicycle around the Sun, Double epicycle;
- Planets move in single dir; Size of orbits relative to Earth's orbit can be determined (elongation) → Order of planets come out naturally (Ptolemy: Not clear whether Mercury or Venus closer to Earth)
- Mathematically equivalent to geocentric epicycle system (Ptolemy), no improvement in accuracy
- More elegant, but not simpler (more epicycle than Ptolemy), no explanation to causes of motion
- Planets not on a sphere → Infinite universe? Earth is demoted to a planet; No up and down; X aether

3. Calendar Systems

- Month: Interval between sightings of crescent moon being first visible in W. horizon after sunset
- Tropical Year: Cycle of the seasons, interval between one vernal equinox and the next

Star calendar: Stars visible on the horizon few weeks earlier will move higher in sky as seasons progress

- Sirius: Brightest star in the sky; For part of the year, Sirius is close to the sun → Invisible
- One [before dawn], Sirius briefly appears in E. sky (Heliacal rising) ∝ Nile flooding → Egypt: summer

Lunar/solar calendar: Moon phases easily observable → Provided the basis for early calendars (Islamic)

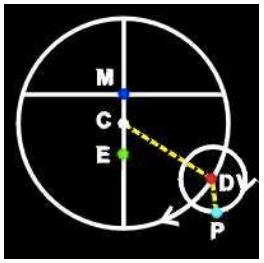
- Chinese: Months follow moon phases, Seasonal markers ∝ sun location [Solar cal.] (unevenly spread)
  - Alternating 29 and 30 days. Extra day (29.53) and extra month (365.35) added from time to time
- Iranian (Persian): Solar calendar, year begins on vernal equinox, different # days in 12 months
- Calendar reforms/Easter problem: 365.25 vs 365.2422 → 0.008 days longer → in 16th century, actual date of winter solstice was in early Dec. → Gregorian reform: Skip 10 days, new leap year rules (100)

4. Awakening of science

Pythagoras:	Morning & evening star the same (Venus)	Plato: Planets, moon, sun perfect shape (sph)

Aristotle: Based on everyday observe

- Universe: Fixed, motionless, everlasting, finite, Earth separated from heaven, have diff. laws (Aether); Earth immobile, ce_nter of universe
- H.O.: uniform and perfect (circular motion), 8 sph. shells for planets
- Planets retrograde motion govern variable events in the world
- 4 Basic elements (Earth, water, air, fire): Sub-lunar sphere, changing
- Not ideal: We observe that the sky is changing, not static
- Religious: Christians not concerned about science, all is god, flat E.



Eratosthenes: Circumference of Earth (Parallel rays → Measure distance/shadow) ; Ecliptic inclination
Measure noon altitude (angle) of Sun on SS & WS. Ecliptic inclination= angle difference/2

Aristarchus: Size of the moon using lunar eclipse (curvature) (angular size) → distance (eclipse time)
Distance to the sun: Correct theory, but not accurate enough measurement (20x)
Heliocentric: (Against: if we move, why stars don't appear to move? → dist. negligible)

Hipparchus:

Seasons are not equal: Sun orbits earth at uniform rate, with Earth offset from centre
"Transformation of Greek mathematical astronomy from a descriptive to a predictive science"

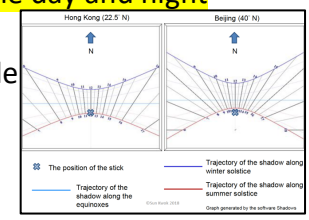
VE moves W along ecliptic by 1°/100yrs, tropical year shorter than sidereal by 20min → moving CP → Whole field of fixed stars revolve W about pole of ecliptic (50''/year → 28°/2000years (1 sign))
Tropic of Cancer: Zodiac constellation where the sun is on Summer Solstice (Capricorn → WS)

Part II: Motions of the Heavens

1. Motions of the Sun

Daily motion: Rises in the east horizon, goes up to certain altitude, descends to west horizon (meridian)

- Location, time of sunrise and sunset, length of day are different every day
  - Summer/Winter Solstice: Longest/Shortest day of the year; Equinox: Same day and night
  - Rises earlier and earlier, then later and later; Winter Day < Summer Day
- Shortest shadow vertical stick: Dir.= North; Time = Noon; Length → Sun Altitude
  - Length of noon shadow shortens as one goes south → Higher Sun Altitude
  - Inside tropics (HK): Noon shadow disappears (zenith passage) twice a year
  - Outside tropics (Beijing/Athens): Sun is never directly overhead
  - Tropic of Cancer: S. solstice; Tropic of Capricorn: W. Solstice; Equator: Fall and Spring Equinox
    - "Discrimination line of whether people in that location can see the Sun directly overhead"
- Length and direction of the shadow varies with time during the day and during the topical year
  - Longest at sunrise and sunset, pointed at roughly opp. dir.; Longer in winter (sol.) than summer



Annual motion: Sunrise swings N and S along the horizon during the year (NE →E→ SE, SE →E→ NE)

- Sunrise in the NE on Summer Solstice (21/6) → Exactly east on Fall (Autumnal) Equinox (22-23/9) → SE on Winter Solstice (21-22/12) → Exactly east on Spring (Vernal) Equinox (20-21/3)

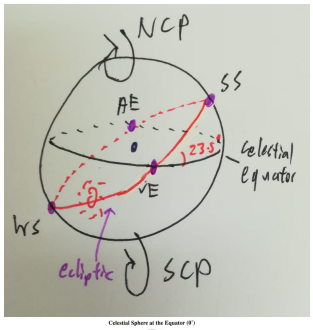
2. The Celestial Sphere

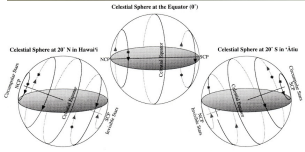
Axis of stellar rotation/solar path is tilted, *Inclined* diff. ∝ latitude → Diff. day duration/stars seen from diff. locations on same day → **ppl travel and communicate → diff. viewing ppv → earth X flat, round**

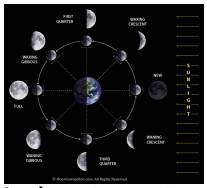
- Northern regions: Sun barely rises above horizon in Dec, never overhead; Tropics: Vertical Rise & Fall

2-sphere model: Sun & stars go below Earth → Earth is fixed, isolated in space

- Sun/Moon/Stars rise in E, set in W (circular path) → heavens are a sphere
- Stars on sphr. dome above Earth, rotate in axis dir. of pole star (fixed??)/CP
  - Sun btw Earth & stars; Diurnal rotation: Earth rotates W to E
  - Stars: Fixed relative positions, max altitude when crossing meridian
  - Star comes back to same place in 23h 56m (Sidereal vs Solar day (24hr))
- North Celestial Pole/Celestial Equator: Extend Earth's north pole/Eqtr.
- Sun stars turn around Earth once a day; sun craw along Ecliptic once a year
- Sun moves *through* the stars **(stars faster than sun)**, faster in winter
  - Ecliptic: Path of sun through stars, inclined by 23.5° from celestial eqtr.
  - Over a tropical year: Sun pass through 12 constellations (ecliptic)
  - Ecliptic and CE intersect at AE & [VE (moving W→ t.y. =sidereal y -20m)]
  - Uneven Seasons: Ecliptic/eqt inclined, shining mostly in N/S hemisphere







3. Moon Phases

Rises in the east and sets in the west; Rises later and later (≈ 1hr) each day

- Bright side of Moon always faces sun (reflect sunlight), always same face;
- Phase cycle: 29.53 dy (*synoptic* m.), move thr. stars 27⅓ dy. (*sidereal* m.) → New Moon move E. thr constellations (Moon & Sun move) (*prograde*); Short period → Near Earth
- Solar eclipse: Moon block sunlight reaching Earth; Lunar eclipse: Earth shadow on moon, spherical

Phase	Rise	Set
New	Sunrise	Sunset
First Quarter (b)	Noon	Midnight
Full	Sunset	Sunrise
Third Quarter (d)	Midnight	Noon

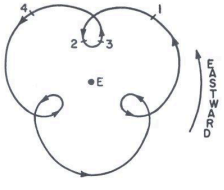
Pos. of Rise/Set	New	FQ	Full	TQ
Winter	SE/SW	E/W	NE/NW	E/W
Spring	E/W	NE/NW	E/W	SE/SW
Summer	NE/NW	E/W	SE/SW	E/W
Autumn	E/W	SE/SW	E/W	NE/NW

"New moon close to Sun (∠ < 90°), Full m. opp. sun" | "New moon rises at sunrise, Full m. rise at sunset"

4. Ptolemy's Planets

Planets move rel. to background stars, no fixed rel. positions; Move ≈ on ecliptic at diff. speeds, st. line
Generally **Prograde**: Slower < CS (W) (Sun)/ **Retrograde**: (Faster), rev. dir., [brighter (s.p.: closer to sun)]
Tropical period: Average amount of time taken to go once along ecliptic; **Synodic**: Period btw rg. motion

- Venus & Mercury: Limited Angular dist. (elongation); Evening (E)/Morning (W) stars; inferior planets
  - Path (of Venus) in sky (at sunset) diff. every day: Not seen every day, relative locations unclear
- Mars, Jupiter, Saturn: ∞ elongation; Rg: oppos., bright; Slow → Near f. stars, superior
- Epicycle: Planet on small circle (retrograde); Eccentric: Center of Deferent, not Earth
- Equant: Movement uniform about this point, **not center of circle** → X uniform speed
- Successful in accurately predicting motion of planets, but complex, no "explanation"



Chapter 7: Emergence of science and scientific method

Copernicus: Alternative mathematical model of planetary motion to Ptolemy's, not more accurate

- Heliocentric model removes coincidences that Mercury and Venus have tropical periods of one year, and the epicycles of Mars, Jupiter and Saturn all have periods of one year
- Accounted for retrograde motions in a most natural way, how planets were laid out in a very harmonic fashion, with respect to their spacing from the Sun and with respect to their periods
- Size of orbits of planets can be determined from observation
- Diurnal (daily) motions of the sun and stars are due to the self rotation of the Earth along N-S axis
- The annual motion of the sun is due to revolution of the Earth around the Sun
- Precession is the result of the wobble of the rotational axis of the Earth
- Ecliptic plane: Plane of revolution of the Earth, explanation of seasons same as before
- Rise of the Moon: Rotation of the Earth; Moon phases unchanged (relative position of Sun, Moon, Earth)

Difficulties of Heliocentric model:

- If the Earth goes around the sun, stars should appear to shit their positions
- Speed of rotation of the Earth at equator / Speed of revolution of Earth around sun fast, should feel it
- In two-sphere model, assume Earth is much smaller than celestial sphere, horizon is observed to bisect celestial sphere
- Relative dimensions of two spheres must be such that we cannot measure difference horizon and celestial sphere diameter
- Copernicus model: Assume Earth's orbit much smaller than celestial sphere → Size of celestial sphere larger
    - Why will god leave so much empty space?

Tycho Brahe: Accuracy and completeness

- Combine the geometrical benefits of the Copernican system with philosophical benefits of Ptolemaic system
- Observed new star brighter than Venus, unexpectedly appeared in constellation Cassiopeia, among fixed stars
    - Fixed stars, unlike planets, comets, or meteors, <u>do not move</u> other than as part of the daily motion
    - The idea of a new star is contrary to the Aristotelian view that the fixed stars were immutable from the day of creation to Eternity
    - Most viewers insisted it must be a comet, "human sins formed into a kind of gas ignited by anger of God"
- Destroyed the theory of celestial spheres with precision measurements that showed the celestial heavens were not immutable, new stars were not "atmospheric" tail=less comets but occurred above the atmosphere and moon
- Comets were also not atmospheric phenomena, and must pass through the celestial spheres (not sub-lunary)
    - Unable to detect parallax of comet, so comet was beyond the moon (6x)
    - Aristotle's celestial spheres aren't physical or the comets have crashed through them
        - If there are no crystal spheres, what keeps stars and planets in their places? → Gravity
- 1563 Aug 24 Conjunction of Saturn and Jupiter found that event occurred days away from prediction of Ptolemy
    - A need for more accurate measurements to make accurate predictions
    - Measured positions of 1000 stars and courses of planets over a period of 20 years
    - Data more than twice as accurate than those before: Relationship between technology and astronomy
- Knew that Copernicus' model more superior to Ptolemy's geocentric system, but he could not believe the Earth was not the focus of the universe.
- If the Earth orbited the Sun annually there should be an observable stellar parallax over any period of 6 months, during which the angular orientation of a given star would change. OR stellar sphere too much further away than previously conceived
- Advocated an alternative Ptolemaic geocentric system, a geo-heliocentric system now known as the Tychonic system. The Sun annually circles a central Earth (different from planes), while 5 planets orbit the sun
    - Identical to Copernicus, Just a matter of changing the definition of what is fixed: Sun or Earth
    - Same geometric consequences about retrograde motions, size of orbits elongations
    - No longer must accept the unintuitive, un-Aristotelian notion that Earth is moving
    - Different heavenly spheres now intersect each other: Further distances geometrical astronomy from the idea that the physical reality of the heavens is planets lying in crystalline shells of Aether

Johannes **Kepler**: Transform astronomy from applied geometry to dynamical physics: 3 Laws (empirical pattern, not explanation)

- Lived in an age where astronomy had been purely descriptive geography of the sky; Observe, describe and predict, not search causes
    - Believed in powerful concord between cosmos and individual, Rejected traditional details of astrology
- Distances to the planets provided by Copernicus serve as a basis for a cosmological model
- Geometric universe: 5 regular polyhedra, circumscribed with spheres positions closely approximate 5 spacing of planets
- Relationship between orbit and period: The planets are driven by the sun, Sun's influence decreases with distance
    - Center of Copernican system was the center of Earth's orbit, not the Sun. Sun was nearby, but played no physical role.
    - Kepler argued Sun's centrality was essential and the <u>Sun itself must supply the driving force to keep the planets in motion</u>
    - Results only approximate, but at least the important physical-mathematical step had been taken
        - First scientist to demand physical explanations for celestial phenomena
    - Aristotle: Assumption that spheres in the sky must rotate uniformly, Equant/Extra epicycles required to match the geometry with the observation that planet seemed to move fast sometimes/slow at others
        - Argued that for the sphere to change rotational speed, would require something act on it to slow down/speed up
- Orbit is an eclipse (<u>noncircular</u>): Circular orbits uncessful against Tycho's Mars data, within observational error of previous
    - Sun is located on one of two foci of eclipse orbit → Faster when planet closer to sun, slower when more distant
- Law of equal areas: a line joining a planet and the sun sweeps out equal areas in equal intervals of time
- Law of Harmonies: The square of a planet's sidereal period around the sun is directly proportional to cube of semimajor axis

Chapter 8: Unification of terrestrial and celestial motions

- Heavenly objects are not perfect, the celestial heavens are not unchangeable

Galileo Galilei: Laws of motions of terrestrial motions, use telescope to observe celestial objects; Popularizing of heliocentric model

- Publish book (easier to read than Copernicus and Kepler) about observations of Moon, star, moon of Jupiter, contradict Aristotle
- Observed that the line separating lunar day from night was irregular, seeming made up by craters and mountains
  - Deduced from the length of shadows the topography of moon, Contradict Aristotle heavenly bodies perfectly smooth
- Saw 10 times many stars with telescope than naked eye; Nebula/cloudy stars in Ptolemy's catalogue were actually multiple stars too close to be resolved into individual ones by naked eyes
  - There are stars beyond what the naked eye can see implies that stars were not created for men's pleasure
- Discovered 4 moons orbiting Jupiter, Earth is not the only planet with a moon
  - Earth is not the center around which ALL celestial objects revolve as in the views of Ptolemy and Aristotle
- Dark spots on surface of sun (sunspots), Sun is not perfect as Aristotelian cosmology would suggest
- Venus has phases like the moon, appear larger in crescent phase than almost full, as Venus is closer to Earth in crescent phase
  - Phase change cannot be explained in Ptolemy's model, can be explained in Tycho's Model
- Ordered not to support the Copernican theory: Interrogated, threatened with torture, recanted in 1633
  - Further consolidated reputation in history
- Reasonable to consider the planets as moving physical objects (Re: Kepler)
- Explanation of moving Earth: A stone at the top of a moving shop moves both downward (by gravity) and in the direction of motion of the ship (horizontal component along with gravity, to observer on ship seems stone just falls vertically to bottom)
- Discussion of terrestrial motion did not agree with Kepler's law, physics still separated heavens and Earth
- Modern evidence of Earth's self rotation: Pendulum plane of oscillation rotated during the day; Oblateness of the Earth

Newton: Universal gravitation, connecting terrestrial and celestial motions

- Inverse square law of gravity; Three laws of planetary motion of Kepler can be derived from Newtonian laws of motion, law of gravity, vector differential equations, Defined Kepler "there is a force in the sun" mathematically
  - Good scientific theory: ability to explain a wide range of phenomena (elegance)
- Did not explain the cause of gravity itself; Cannot explain *why* bodies with mass are attracted to each other
- Modern dogma:
  - Lights in the dark sky come from physical objects that can be studied and understood
  - Universe made up of ordinary matter governed by universal interactions
  - The world is rational, ordered, and understandable
  - There are laws behind every confusing phenomena (our body, our mind, our society)
  - All systems can be reduced to basic laws and structures

Chapter 9: Nature of science and exploration of the cosmos

- Way of reasoning before science (metaphysics): Start with assumptions about nature, fit the laws to meet those assumptions.
- Scientific method: Observations, (qualitative/quantitative), Formulation of patterns, Hypothesis to explain observed patterns, Deduction from hypothesis and prediction of new phenomena, testing of prediction with new observations, revision of hypothesis
- Theory: Explanation for a very general class of phenomena

- Universe at beginning of 18th century: The sun is center of universe, Earth is one of 6 planets revolving around Sun, Elliptical orbits of all planets can be explained by a physical model (laws of motion + gravitation), outside solar system is sphere of fixed stars
- Halley: Planet transit: When a planet moves in front of the sun (alignment of Earth, planet, sun) → Size of solar system
  - Comets: Members of the solar system
- Herschel: Discovery of Uranus → Deviations of orbital motions of Jupiter, Saturn and Uranus
- Discovery of Uranus: Mathematically predicted before first observation by a telescope

- Fixed stars moving in the sky: Relative positions will shift (e.g. Sirius), not just due to precession
  - Halley studied stellar positions that Ptolemy listed in Almagest 1800 years ago, compared them with contemporary obs.
- The sun is also a star: Giordano Bruno argued the sun is a star, universe is infinitely large, and there are many worlds → burnt alive
  - Sun demoted from a central position of the universe, just a regular star
    - Calculate true brightness of stars corrected from distance, about as bright as the sun
    - Most properties of the sun were also found to be similar as other stars, such as surface temp, chem composition
  - Stars are located at different distances, not all on the surface of a crystalline sphere in outer space
- Parallax: Apparent position of a nearby star changes against the background with Earth's orbit
  - Ancient astronomer's lack of ability to measure any such angle was a strong argument against heliocentrism

Chapter 13: Big History of Earth and Life

- Possible hypothesis the begin life on earth;1 pre-biotic molecules accumulated in ocean/2organic matter delivered
- From stars,provide ingredients for life/3self-sustaining reactions begin with the advent of stable& reproducible
- macromolecules sustaining metabolism 1839 Charles Darwin evolutionary theory-evol. Tre/support by DNA
- theory (all living organisms on Earth descended from a common ancestor.)photosynthesis 光合作用 release oxyge
- **4.6 billions years** →earth form→3.8 billions years: replicating molecules form→3.5 billion years: evolution to
- unicellular to form bacteria →555million years: multi-cellular organism formed and release oxygen released into
- atmosphere →420 million years: land plants evolve, changing landscape and creating different habitat→250
- million years→mammal are common→65million years: dinosaurs extinction→4million years: early hominid

Chapter 10: The grand scale of the universe

- From Galileo's observations with telescopes, it was realized that the Milky Way is made of stars
- Thomas Wright proposed that the observed collection of stars along the Milky Way was an indication that our sun and the other stars are part of a bigger system that has some particular structure
- Sun was just one of many stars orbiting about a common center point
- The orbiting motion can prevent stars from collapsing toward one another under gravity
- This model is consistent with observations that fixed stars in the sky actually are moving, though only by a tiny amount
- He concluded that the appearance of the Milky Way Galaxy is an optical effect
- Two shapes could account for appearance of Milk Way: Ring of stars, or Hollow Sphere

- Island universe model: New discovery of dim objects in the sky that appeared elliptical in shape; Ring of stars should actually be a continuous disk, which would appear elliptical at an angle
- Our star system is just one of many other disks of stars, pale patches are just universes (Milky Ways)
- A high count in a certain region in the sky was evidence of a greater distance to the border of Milky Way in that direction
- Herschel: The sun is the star near the center, shape of Galaxy inferred from star counts, cross section flat
- Nebulae in the sky: Fuzzy looking objects? Distant systems of stars? Planetary nebula?
- Technological development advance our understanding of nature: Nebulae; Rosse: M51 nebula to have a spiral shape (struct.)

- Shapley: Used Mount Wilson's 60 inch telescope to identify Cepheids in globular clusters dispersed around the Milky Way
- Astronomers earlier noticed a large fraction of these clusters were concentrated in the direction of the constellation Sagittarius
- Shapley determined the distances to 69 globular clusters and mapped their distribution in space using Cepheids
- If globular clusters were uniformly distributed in the Milky way, then his data would have suggested Sun is off to one side in flat disk
- Not widely accepted, Ignored important effects of gas and dust, which obscured star light and altered distance estimates
- Distribution of gas and dust in the Milky Way is highly non-uniform and concentrated on the disk
- Distr. of globular cluster is indeed fairly uniform in the Milky Way; Most clusters observed were outside the disk so gas dust less imp.
- Stars are circulating within the Milky Way around a point situated in constellation Sagittarius, suggested to be the center
- The sun rotates around the center of Milky way at 200km/s, takes 200-240 million years for one revolution

- The great debate: All nebulae were members of the milky way vs Island universe, nebulae are galaxies beyond our milky way
- Difference between scientific method and process of science; Making progress is science is not like following a recipe
- Even given the same set of data, scientists may have different conclusions → affected by background knowledge, what want to see

Chapter 11: Contents of the Universe (Ingredients, energy generation inside stars, generation for all energies used on Earth)

- Spectroscopy: Same dark lines in the spectra of Moon, planets and sun → Planetary bodies do not emit light, reflect light from sun
- For different chemical elements, different characteristic pattern of bright colored lines can be identified through spectroscope
- Analyze sunlight → Sun & stars made up of same chemical elements as on Earth, not made of ether; Discovery of Helium
- Assumption: Light emitted by atoms from objects in the sky have same spectral "fingerprints" as atoms in laboratory
    - Universality of physics and chemistry
- We are all made up of stellar material: Chemical elements are made by stars; These atomic nuclei are ejected into interstellar space and form interstellar clouds, condense to form stars and solar systems; Tiny pieces of solid materials aggregate to become planets

Chapter 12: Big History of the Earth and the Universe

- Age of Earth: Radioactive dating, C14
- Earth's relation with its surrounding: Originally seen as an isolated body; Bombarded by meteorites, not a closed system
- Age of the solar system: Dating on meteorite, 4.567B years, Sun and solar system formed from same rotating disk of gas
- Speed of light: Very fast but finite, as we look at distant objects, we are looking at the history of universe
- General relativity: Study evolution of the entire universe
- Hubble: Identify Cepheid variables in M31 and measure their brightness in great details, found to be almost 1M ly away
    - Support island universe hypothesis, human position is further demoted
- No evidence suggests to scientists that we should question the static and finite nature of the universe
- Doppler effect, Hubble's law: Universe is expanding, father the galaxy, faster it is moving away from us
- Beginning of the universe: Big Bang; Remnant of the big bang: Microwave noise observed everywhere in the sky
- Universe was denser and hotter the further back in time, matter were in form of basic particles (quark-gulon mixture)

- ***The goal of course*****㊗下面：**
- **(1.)**Understand the **scientific method** and techniques of quantitative reasoning;→*find Neptune*
- Observation→question→hypothesis→prediction→testing→yes(additional prediction),no(adjust hypothesis)
- Discovery of Neptune→ Johanne Gottfried Galle: mathematically predicted before observation by telescope
- **(2)**Learn about the *method of solving problems through examples of* **previous work**→*Kepler find the orbit of eclipse*
- *based on tycho's data* ***(3)***Develop bold, independent, and creative **thinkin**g→*geocentric-helicentric*
- ***(4)***Acquire the ability to make **rational judgmen**t, rise above ignorance and prejudice.-->*flat earth-round earth*
- **Difference between science method and daily usage of world:** →trust our eyes and perception, common sense,
- Things are intuitively obvious e.g revival of flat earth
- **Importance of scientific method:** *understand the nature of universe/applied all studies/science is about explain the*
- *Known, predicting the unknown, synthesizing apparently different phenomenon*