Medieval Islamic Astronomy and Its Influence on Renaissance Europe

April 2018

Khalid Baheyeldin

Who Am I?

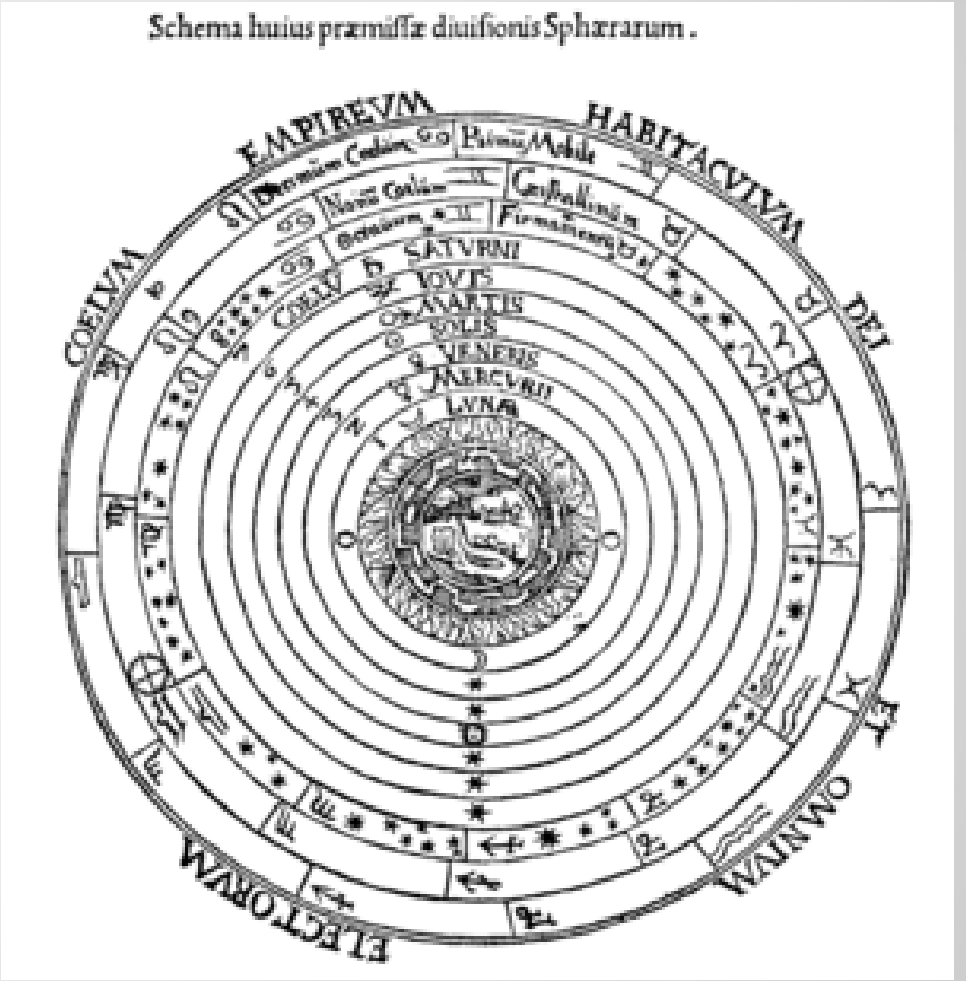
2bits

- Khalid (“ ... ed” not “ ... eeeeed”)
- Pharmacist by education
- Open Source Software Development and Consulting by experience (32 years)
- One of the developers of Drupal, a Web Content Management System
  - The Economist, Foreign Policy, Harvard, UW
  - NASA, RASC, Cosmos @ Swinburne
- Amateur Astronomy, and Astrophotography

Aristotle

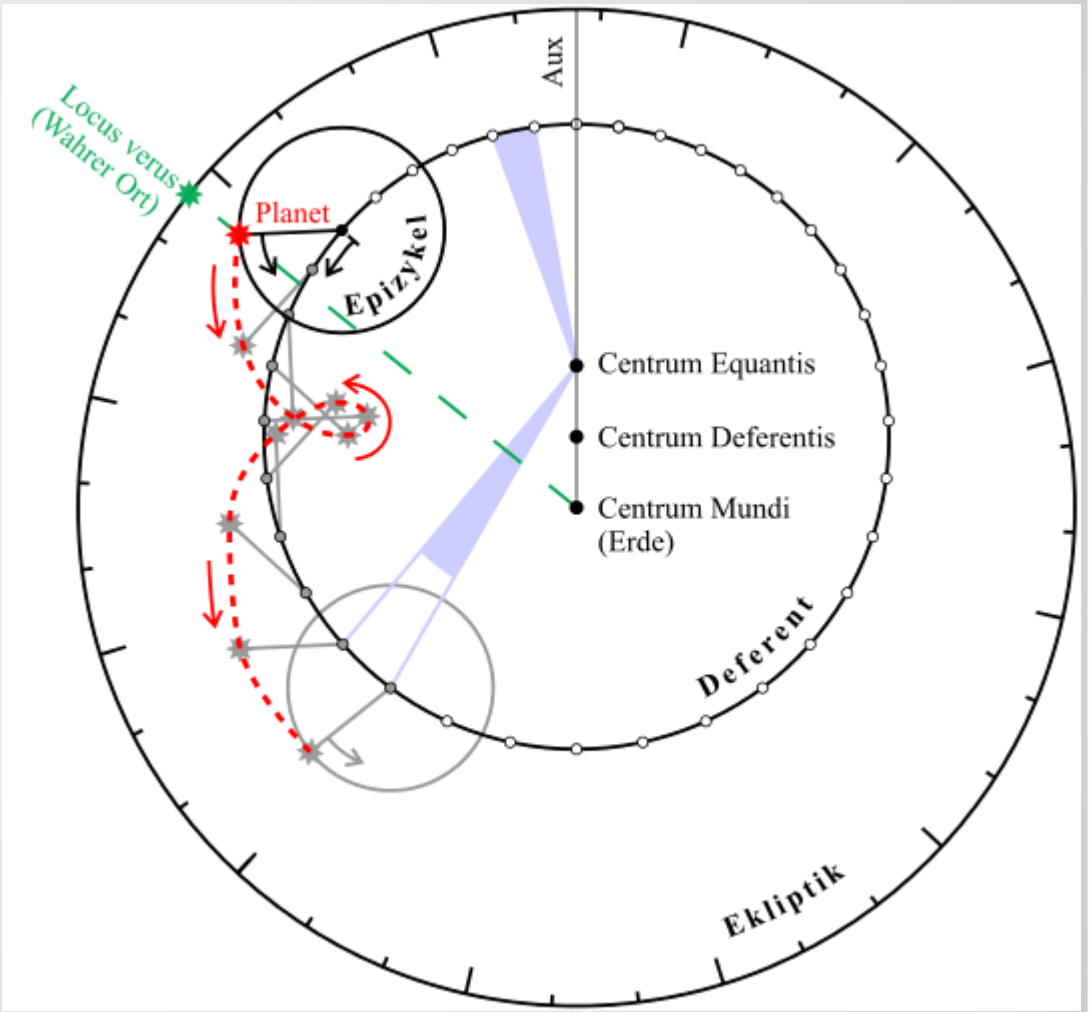
2bits

- Greek philosopher, d. 322 B.C.E
- Universe is concentric spheres, with unmovable earth at the centre
- Moon, Mercury, Venus, Sun, Mars, Jupiter, Saturn, Fixed stars
- Perfect, unchangeable universe
- Anything irregular will be in our atmosphere, below the moon's orbit
- Aristotle's philosophical works extremely influential in Islamic World, and in the West



Claudius Ptolmey

- Alexandria ~ 150 C.E.
- Almagest, Tetrabiblos (Astrology), translated to Arabic (800s), then from Arabic to Latin in (1100s)
- 48 Constellations, 1025 stars, catalog and magnitudes from Hipparchus
- Geocentric model: equant, deferant, epicyles, until mid 1600s.




Where In The World?
2bits
Belgium
Prague
Paris
Czechia
Vienna
Slovakia
Ukraine
Austria
Moldova
France
Hungary
Romania
Croatia
Serbia
Black Sea
Italy
Barcelona
Rome
Bulgaria
Georgia
Caspian Sea
Uzbekistan
Kyrgyzstan
Portugal
Madrid
Tyrrhenian Sea
Istanbul
Azerbaijan
Greece
Turkey
Turkmenistan
Tajikistan
Kazakhstan
Syria
Tunisia
Mediterranean Sea
Iraq
Afghanistan
Morocco
Israel
Jordan
Iran
Pakistan
New Delhi
Algeria
Libya
Egypt
Nepal
Persian Gulf
Riyadh
Western Sahara
United Arab Emirates
Saudi Arabia
India
Mauritania
Red Sea
Oman
Mumbai
Mali
Niger
Sudan
Eritrea
Yemen
Chad
Senegal
Bengaluru
Burkina Faso
Gulf of Aden
Arabian Sea
Djibouti
Guinea
Benin
Nigeria
Sierra Leone
Togo
Ethiopia
Côte d'Ivoire
Ghana
Sri Lanka
Liberia
Lagos
Central African Republic
South South Sudan
Cameroon
Laccadive Sea
Gulf of Guinea

Culture and Language

2bits

- Islamic and/or Arabic Science
- The Islamic Empire was very diverse,
  - Ethnically (Berber, Arabs, Persians, Turkic),
  - Linguistically
  - Even religiously (Jews, Zoroastrians, Mandeans, various Christian sects all produced scholars in various disciplines)
- Arabic became the language of the state (for several centuries), correspondence, liturgy, literature, and science, regardless of the native languages

Arabic Language

2bits

- Most of classical and medieval Arabic is intelligible to ~ 350 million native speakers
- Domain specific challenges (terminology of discipline, e.g. philosophy, logic)
- Drift in some areas
  - Hout: ‘Fish’, now ‘Whale’
  - Kawkab: ‘Star’, now ‘Planet’

Arab Folk Astronomy

2bits

- Pre-Islamic (before 622 C.E.)
- Southern Iraq, Syria, and all of Arabia
- Preserved in poetry, and handed down in stories and proverbs
- Not the Greek signs of the zodiac
- Various asterisms

Moon Stations

- Manazil (plural of: Manzil, *house*)
- The 28 places where the moon appears every night (when visible)
- Include some well known stars/objects (Aldebaran, Pleiades)
- The Saads (more later)
- Corresponds to Anwaa (rain or wind, more later)
- India and China have analogous systems

Anwaa Tradition

- Rising and setting of certain stars (e.g. Sirius, Canopus, Pleiades, ...etc)
- Timing of important annual events: wind, rain, livestock giving birth, availability of pasture, ...
- First documented and collected by Abu Hanifa Al-Dinawari, in his book: *Al-Anwaa*
- His work is lost, but almost all of it is incorporated in other works (including Ibn Qutaybah, and Al-Sufi, who critiqued his lack of scientific method)
- In present day Alexandria, an annual list of *Nawwa* is issued for days with wind and rain

Religious Needs

- Daily Prayer times
  - Dawn, Sunrise, Noon, Mid-Afternoon, Sunset, Dark
- Direction of Makkah (Mecca)
  - Geography, distance, ...etc.
  - East Africa archeology showed changes in where mosques faced, as navigation improves

Religious Needs

- Islamic Calendar (Anno Hegirae AH)
  - Pure lunar (Year 1 = 622 C.E)
  - 29 or 30 days per month
- Determines:
  - Start and End of the Month of Fasting
  - Pilgrimage
- Traditionalist view stresses actual sighting of the crescent new moon
  - No central pan-Islamic authority
  - Each country has its own body

Trade and Commerce

- Navigation for sea trade
  - Indian Ocean, Red Sea, and Mediterranean
- Measuring distances
- Navigation aids (stars, other ...)

Astrology

- Forbidden by Islam as mere superstition
- Refuted by some scientists (Avicenna, Alhazen, Farabi, Biruni, Averroes...)
- Yet remained very popular among rulers
- Founding of cities, consulting astrologers
  - Baghdad
  - Cairo (originally: Al-Zahira, Al-Qahirah)

Astrology

- Astronomy was a tool for astrology
  - *Ahkam Al Nujum* vs. *ilm al-Falak*
- Famous Astrologers
  - Albumasar (Abu Ma'shar Al-Balkhi)
  - Mashallah
  - Zael (Sahl Ibn Bishr Al-Isra'ili)
  - Haly/Hali, Abenragel (Ali Ibn Abi Al-Rijal)
  - Abu Maslama Al-Majriti
- Most of their works made it to Europe translated to Latin

Islamic Sciences

2bits

- Mathematics and related disciplines
  - Geometry (Iqlidis = Euclid)
  - Astronomy
  - Algebra, Algorithms (by Al-Khwarizmi)
- Medicine
- Philosophy
  - Including Logic and Rhetoric
- Others (Botany, Gems, Alchemy)

Arab Astronomy

2bits

- Started by translation from Sanskrit sources (India)
- Then from Greek (Ptolmey's Almagest)
- House of Wisdom
  - Established by Caliph Al-Mamun, in Iraq
  - Translation of scientific works: geometry, medicine, philosophy
  - Also a research institute (more later)
- Successive observations and corrections (e.g. to the value of precession, circumference of earth)

Zij

2bits

- Persian: *astronomical handbook*, tables and formulas
- *Zij-i Shariyar* from Persian Pahlavi sources
- *Arkand* and *Sind-hind* from Indian sources
- *Mumtahan*, for Caliph Al-Mamun, Iraq, early 800s
- *Sabi*, by Al-Battani, Iraq, late 800s
- *Hakemi*, for Al-Hakim, ruler of Egypt, late 900s
- *Ilkhani*, by Tusi for Hulegu, Maragheh, late 1200s
- *Sultani* commissioned by Ulugh Beg, Samarkand, 1400s
- Others

Islamic Astronomers

2bits

- Those with Moon Craters named after them

- Al-Battani (Albategnius)
- Al-Sufi (Azophi)
- Al-Zarqali (Arzachel)
- Al-Bitruji (Alpetragius)
- Al-Buzjani (Abul Wafa)
- Al-Ma’mun (Almanon)
- Al-Biruni
- Al-Firghani (Alfraganus)
- Ibn Al-Haytham (Alhazen)
- Ibn Aflah (Geber)
- Al-Khwarizmi
- Al-Marrakushi
- Ibn Yunus

Thabit Ibn Qurra

2bits

- Not a Muslim, Sabian (modern Mandaean)
- Northern Iraq, d. 901 C.E.
- Calculated that precession was not linear, rather oscillating periodically
- Book: *On The Motion Of The Eighth Sphere*

Al-Battani

- Iraq, d. 929 C.E, of Sabian ancestry, though Muslim
- Calculated earth's inclination more accurately
  - 23d 35' vs. Ptolemy's 23d 51'
- Also a more accurate calculation for the eccentricity of the sun
- New instruments (mural quadrant, new sundial, armillary sphere, ...)
- First in history to propose **annular solar eclipses**, based on varying size of moon
- Zij Al-Sabi

Book Of Fixed Stars

2bits

- By Al-Sufi, epoch 1 October 964 C.E.
- Adopted precession of 1 degree every 66 years, based on Zij of Al-Battani, compiled earlier
- Almagest longitudes + 12 degrees and 42'
- First pictorial star/constellation atlas
  - Brocchi's Cluster (Coat Hanger)
  - Andromeda Galaxy
  - LMC and SMC

Translations

- Persian
- Latin
- Italian
- French

Mirror Images

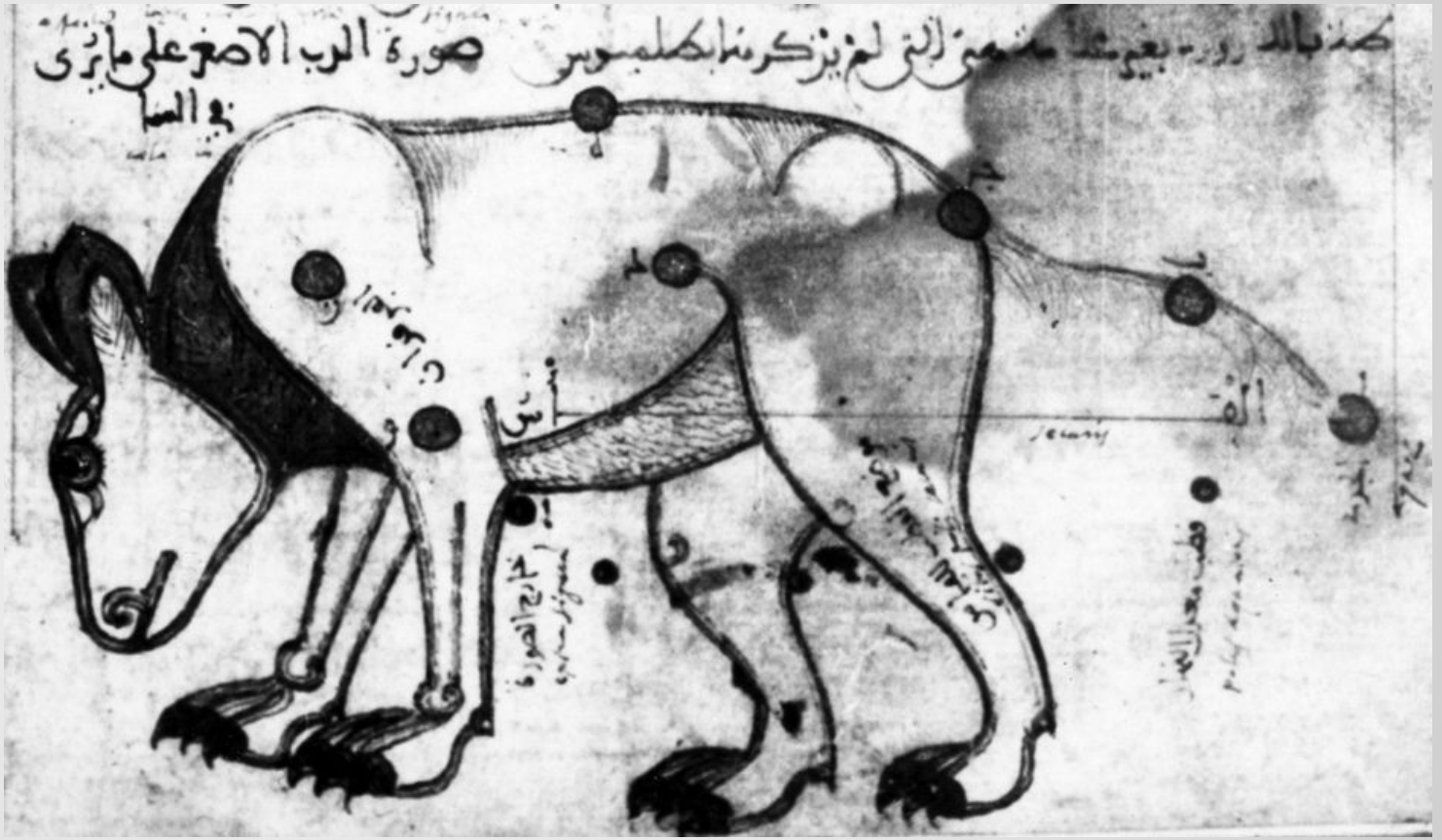
- One as seen in the sky
- Another as seen on a celestial sphere
- Distinction between ‘inside the image’, and ‘outside the image’

Star List - Cancer

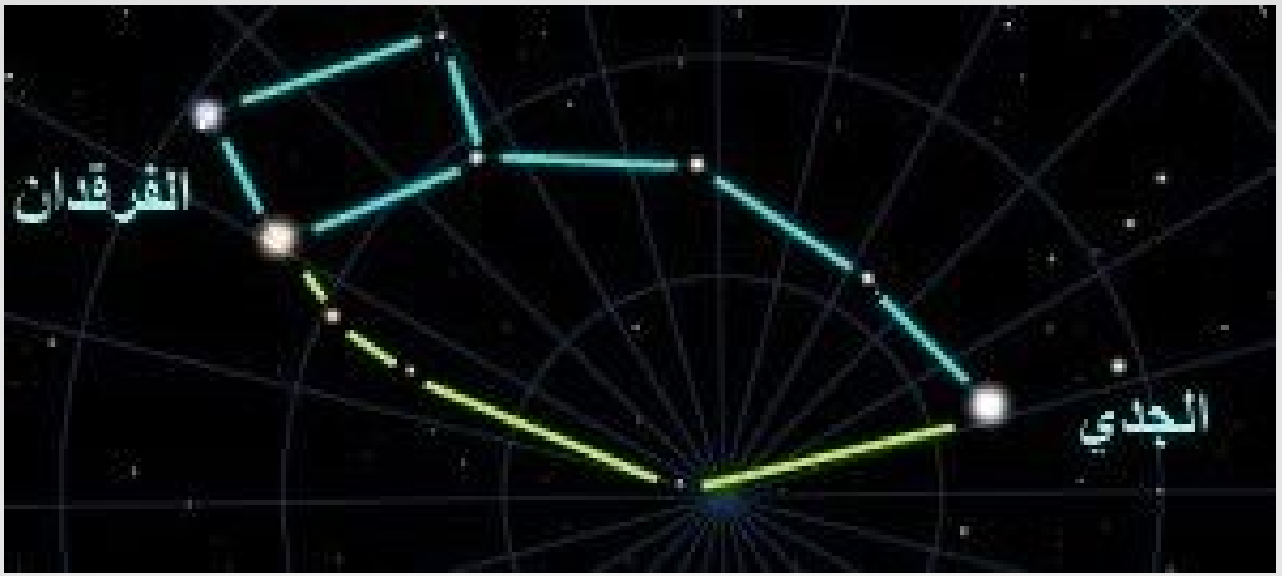
- First star listed as ‘cloudy’
- Two sections, inside the image, and outside
- Summary by magnitude after each section

Ursa Minor

- Vatican, Morocco 1224 C.E.
- Andalusian script
- “millstone rig”
- Marking for ‘pole’
- قطب معدل النهار



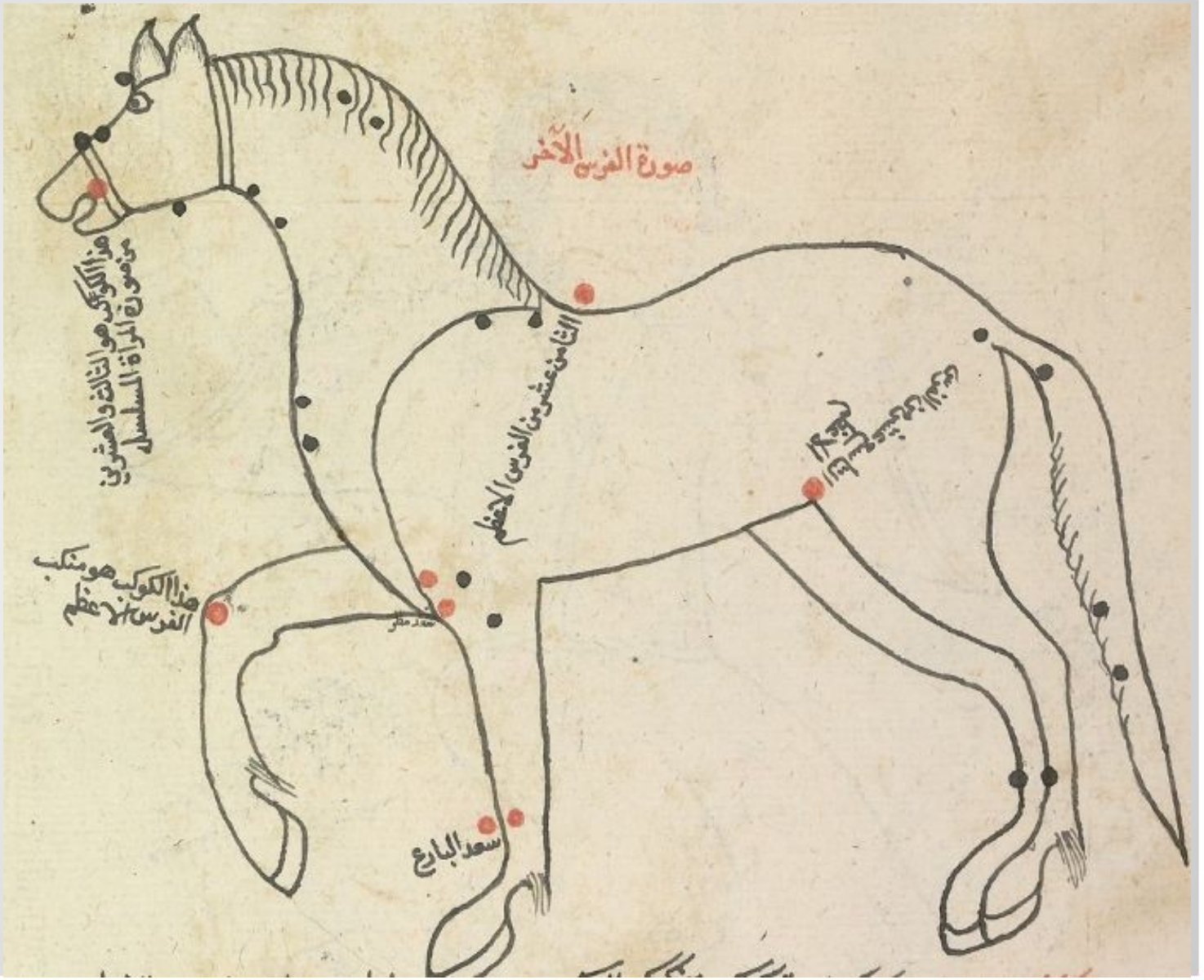
NCP ~ 960 C.E.



- Reconstruction of north celestial pole in 960 C.E.
- Sufi's text says it is at the bend connecting the two Pharkads [Pharkad and Kochab] and Algedi [Polaris]
- Scribe misinterpreted Sufi's analogy of millstone rig, shaped like the body of a fish

The Other/Full Horse

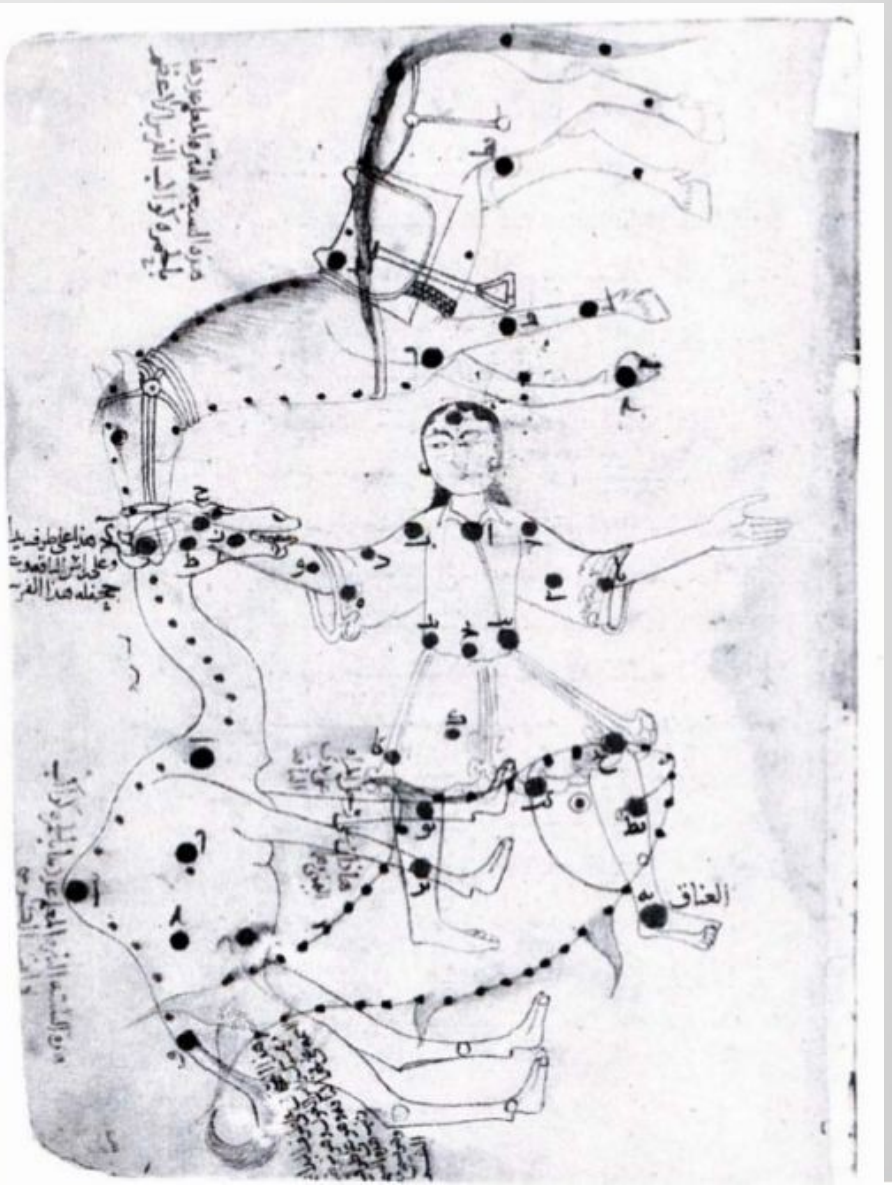
- From Arab Star Lore
- Called ‘The Other Horse’
- Also, “The ‘full’ Horse”



Andromeda + Other Fish

- Andromeda, with yet another Fish (Arab Star Lore)
- Note the Double Cluster on the fish's tail

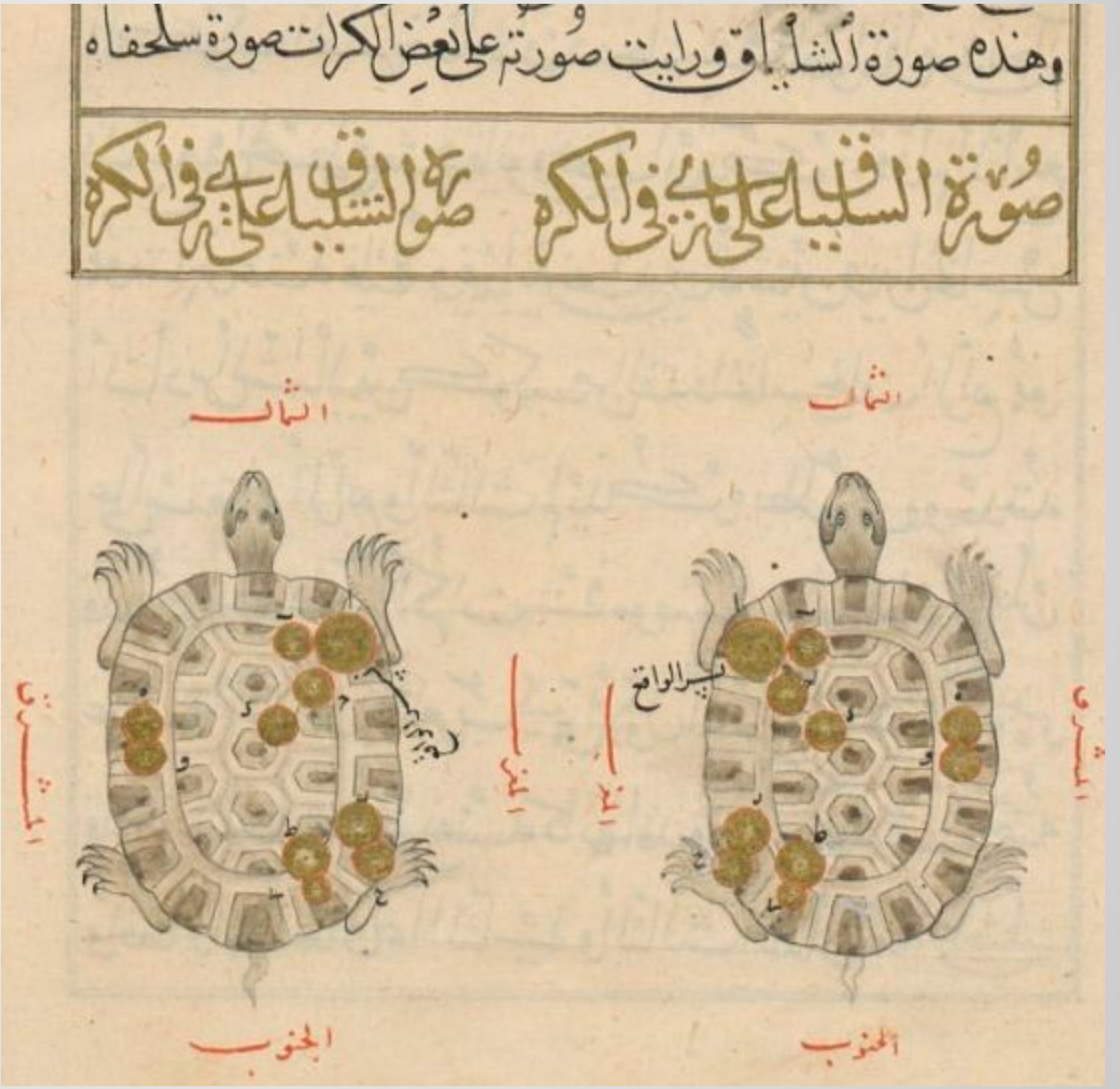
Horse, Fish, She Camel



Horse, Fish, She Camel

Lyra, Tortoise

- “Saw its image on some spheres as a tortoise’
- This is where Sulaphat comes from
- Sheliyak as well (not Arabic)



Father and Son

Al-Biruni

2bits

- Iran and Afghanistan, d. 1048 C.E.
- Polymath, astronomer, mathematician, ethnographer, indologist
- Books on astrolabe, astronomy, spherical trignometry, India
- Qanun Mas'udi, 11 treatises, 3 vol, 1482 pages
- Collaborated in 994 C.E. (while in Khwarizm) with Abul Wafa al-Buzjani (then in Baghdad) for both to simultaneously observe a lunar eclipse

Avempace

2bits

- Ibn Bajjah, d. 1138 C.E.
- Zaragoza, Iberia
- Polymath, philosopher, astronomer, mathematician, physician, botanist
- Proposed a system without epicycles
- Said Milky Way is a light of many stars
  - vs. Ignition of fiery exhalation by stars, per Aristotle
- Observed “two planets as dark spots on the sun” (Mercury and a sunspot?)

Instruments

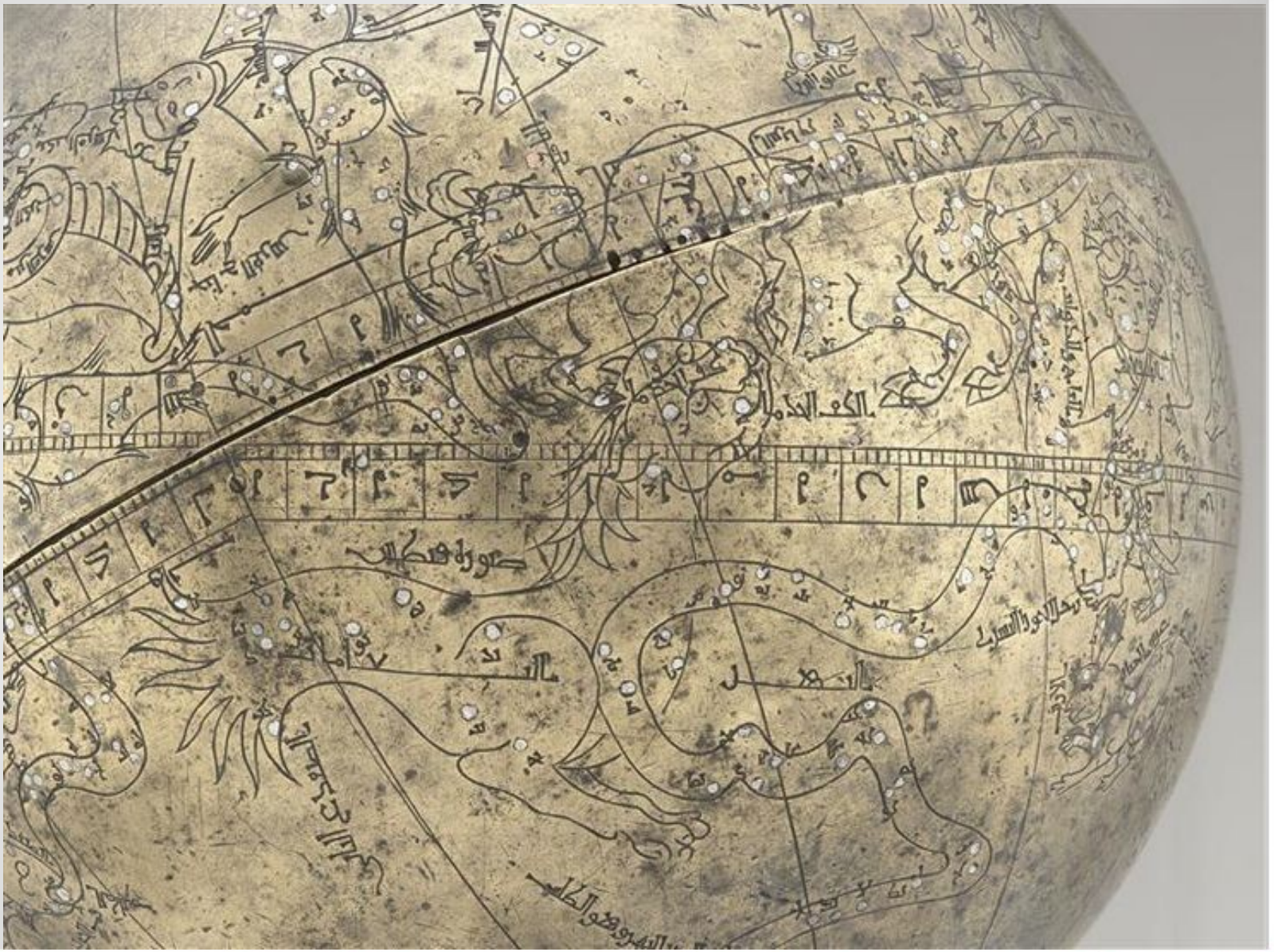
- Parallax Ruler
- Celestial Sphere
- Astrolabe
  - Various designs
- Sextant
- Quadrant
  - Portable vs. Mural
- Mechanical clocks (later)

Celestial Sphere

- ‘Not mentioned by Potelmy’

Celestial Sphere

- Ostriches
- River
- Second Toad

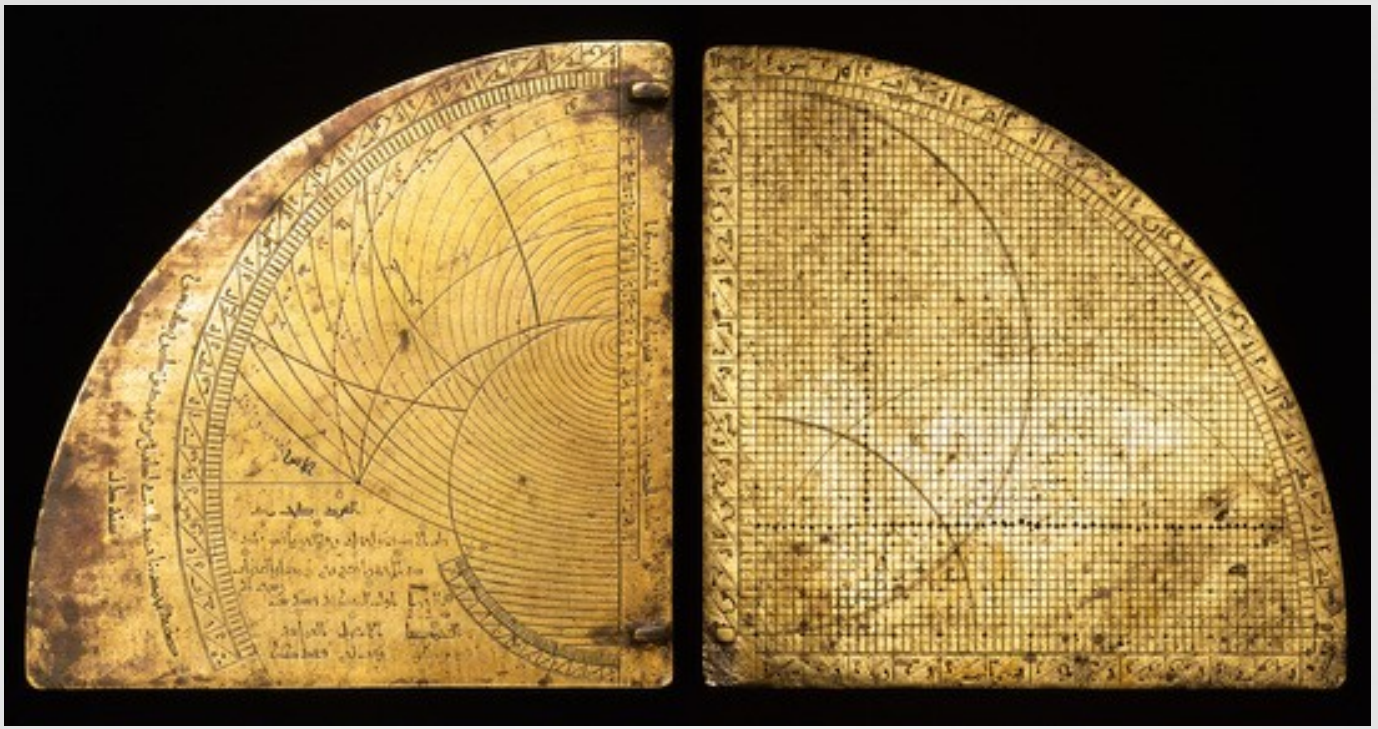


Celestial Sphere

Quadrant

- Variants
  - Sine Quadrant
    - Invented by Al-Khwarizmi, 800s C.E
  - Astrolabic Quadrant
    - Almucantar (?)
  - Trignometric
  - Universal

Sine Quadrant



- Made for the Mu’aqit (Time Keeper) of the Great Mosque in Damascus, Syria, ~ 1330 C.E
- By Muhammad Ibn Ahmad Al-Mizzi, author of several treatises on astronomy
- David Museum, Copenhagen

Sine Quadrant

- Measuring the sun's altitude (to determine noon)
- Plumb line
- Sun through holes, on index finger
- For stars, would look through the holes

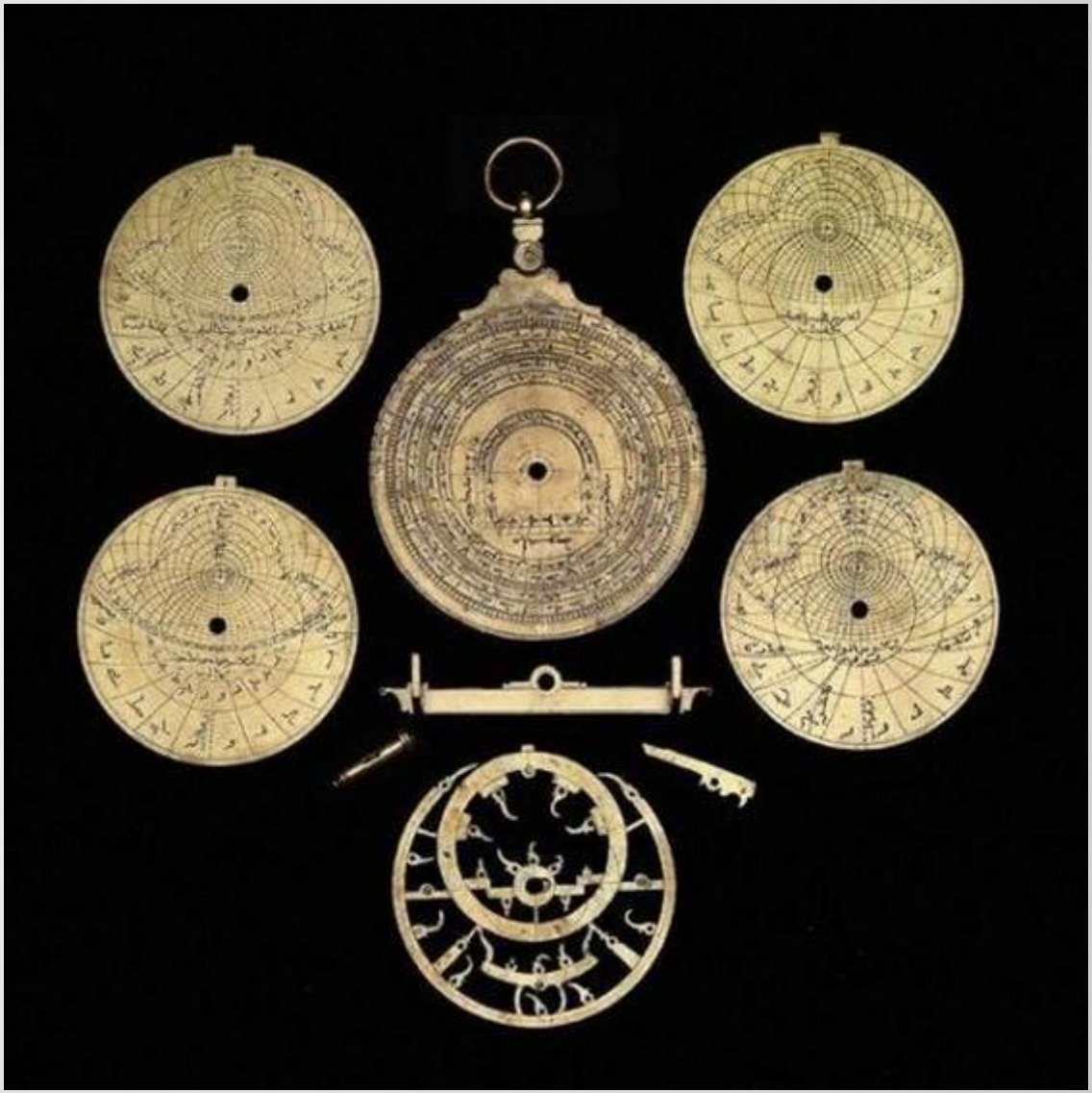
Astrolabes

2bits

- Invented by the Greeks, advanced by Muslim scientists
- Popular instrument in the Islamic world, from the 700s C.E. onwards
- Various books written about its theory and construction
- Several original ones from 10th C.E. onwards
- Early European versions copied exact inscriptions (even maker name, and year!)
- Web sites on how to make them, and simulator

Astrolabe Parts

- *Mater:* Lat. Mother, Base Plate
- *Rete*: Lat. Net, Ara. ‘Spider’
- *Alidade:* Arabic
- *Tympanum*: Lat. Drum, Ara. *Safihah* Plate
- Different plates for various latitudes



Astrolabe

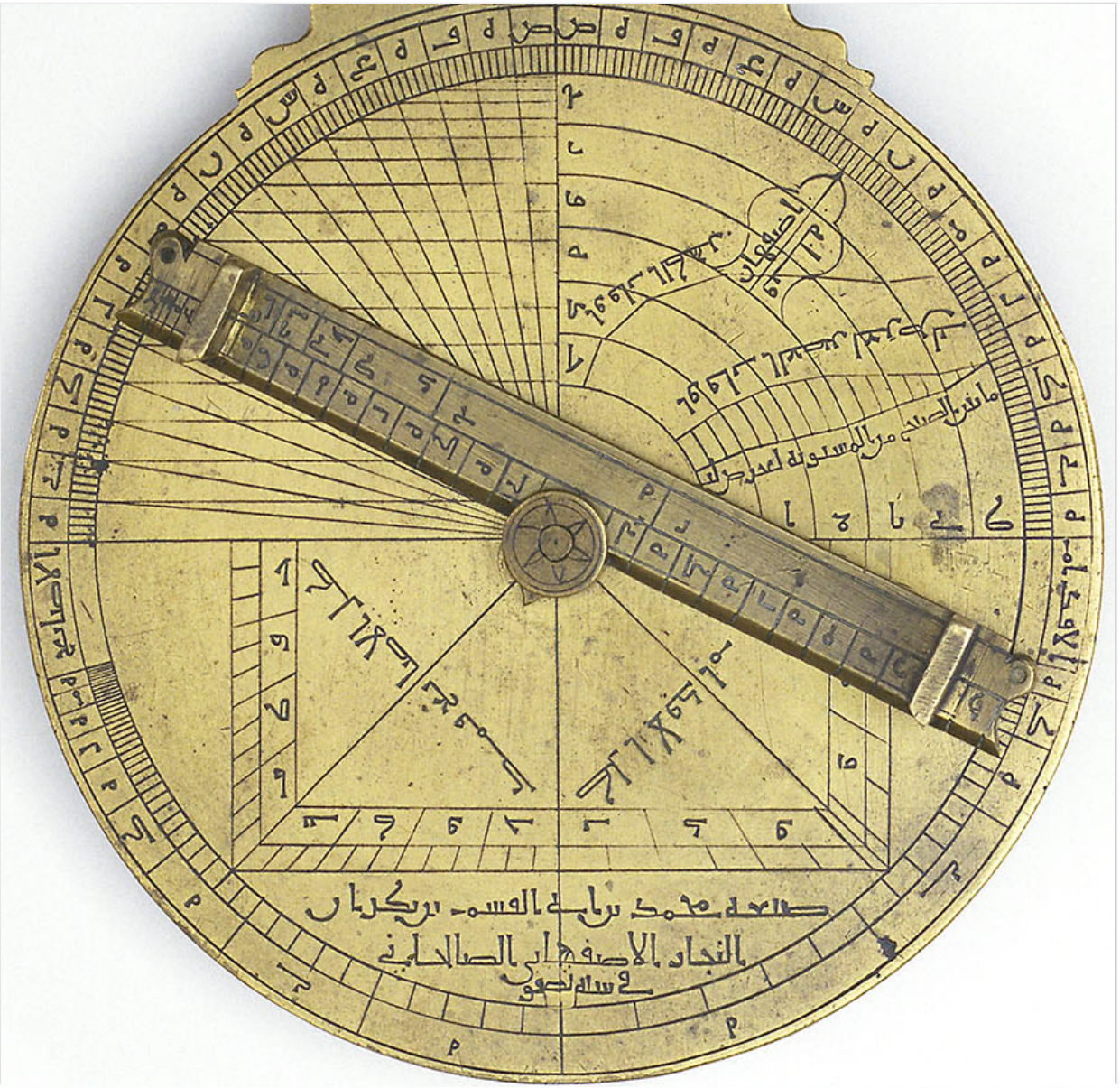
- Museo Galileo
- 900s C.E
- Astrolabium Arabirum ex Hispania ... Alfonsus Rex 1252
- Two tympani (30/33 and 36/4
  Lat)
- Yad Al Jawzaa
- Rijil Al Jawzaa
- Jinah Al-Ghorab

Astrolabe

- Museo Galileo
- Made 1103 C.E.
- Muhammad Ibn Abi-l Qasim Ibn Bakran [Al-Najjad Al-Isfahani Al-Salhani]

Astrolabe

- Qibla (Makkah direction) for prayers
- For Isfahan, Iran
- Curves for various prayer times
- Feet and fingers (??)



Astrolabe

- Museo Galileo
- 1300s
- Arabic made
- Maker unknown (could read: Othman Ibn Abdallah Al-Saffar)
- Latin Zodiac
- Pointer stars still in Arabic!

Astrolabes

- 1217 C.E.
- By Abu Bakr Ben Yusuf
- Toulouse Museum

Astrolabes

2bits

- 1505 C.E., Turkey
- For Sultan Bayezid (d. 1512 C.E.)
- By Al-Ahmar Al-Nujumi Al-Rumi (The Red One, Astronmer, European)
- Regulus, Rigel, Sirius, Procyon, Aldebaran, ...
- Sothebys

Universal Astrolabe

- Latitude independant astrolabe
- Invented by Al-Zarqali (Arzachel), d 1087 C.E.
- Toledo, then Cordoba, in then Muslim Iberia
- Copied in Europe later
- Saphea Arzachelis
  - Safeehah of al-Zirqali
  - Safeehah = ‘plate’

Clocks

- Clepsydra
- Water clock
- Known since Greek times
- No gears or pulleys

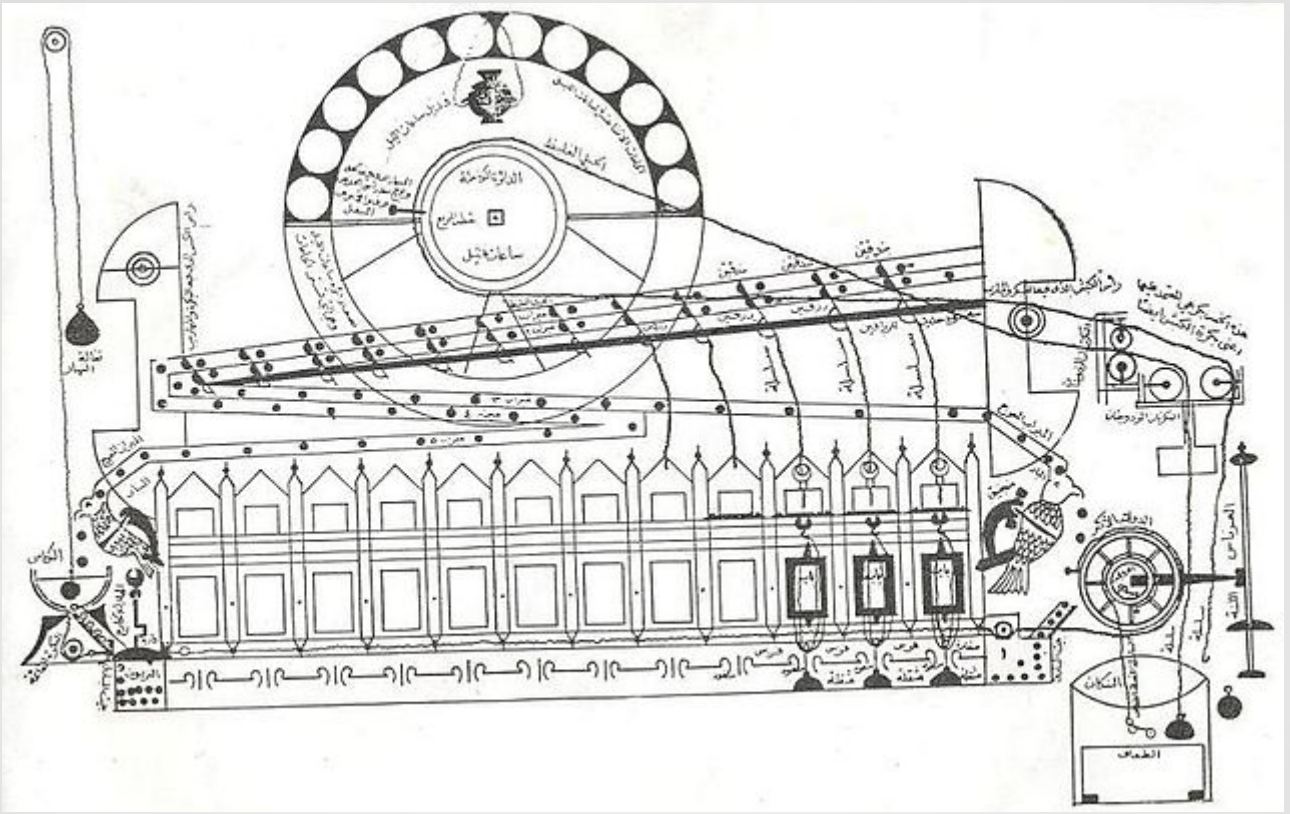
Clocks

2bits

- In 797 C.E., Caliph Harun Al-Rashid sent gifts to Charlmagne, including a water clock
- Pope Sylvester II, who was educated in Muslim Spain, introduced clocks to Europe, as well as Arabic numerals

Jayrun Water Clock

2bits



- Damascus, Syria, 1203 C.E.
- Water + Mechanical
- Counter weights

Elephant Clock

- Water Clock
- With mechanical parts
- By Al-Jazari (d. 1206 C.E.)
- "*Book of Knowledge of Ingenious Mechanical Device*"
- Replicas built in malls, museums

Castle Clock

- Also by Al-Jazari (d. 1206 C.E.)
- Water Clock
- With mechanical parts
- 12 Doors for hours
- Zodiac
- Solar and Lunar orbits

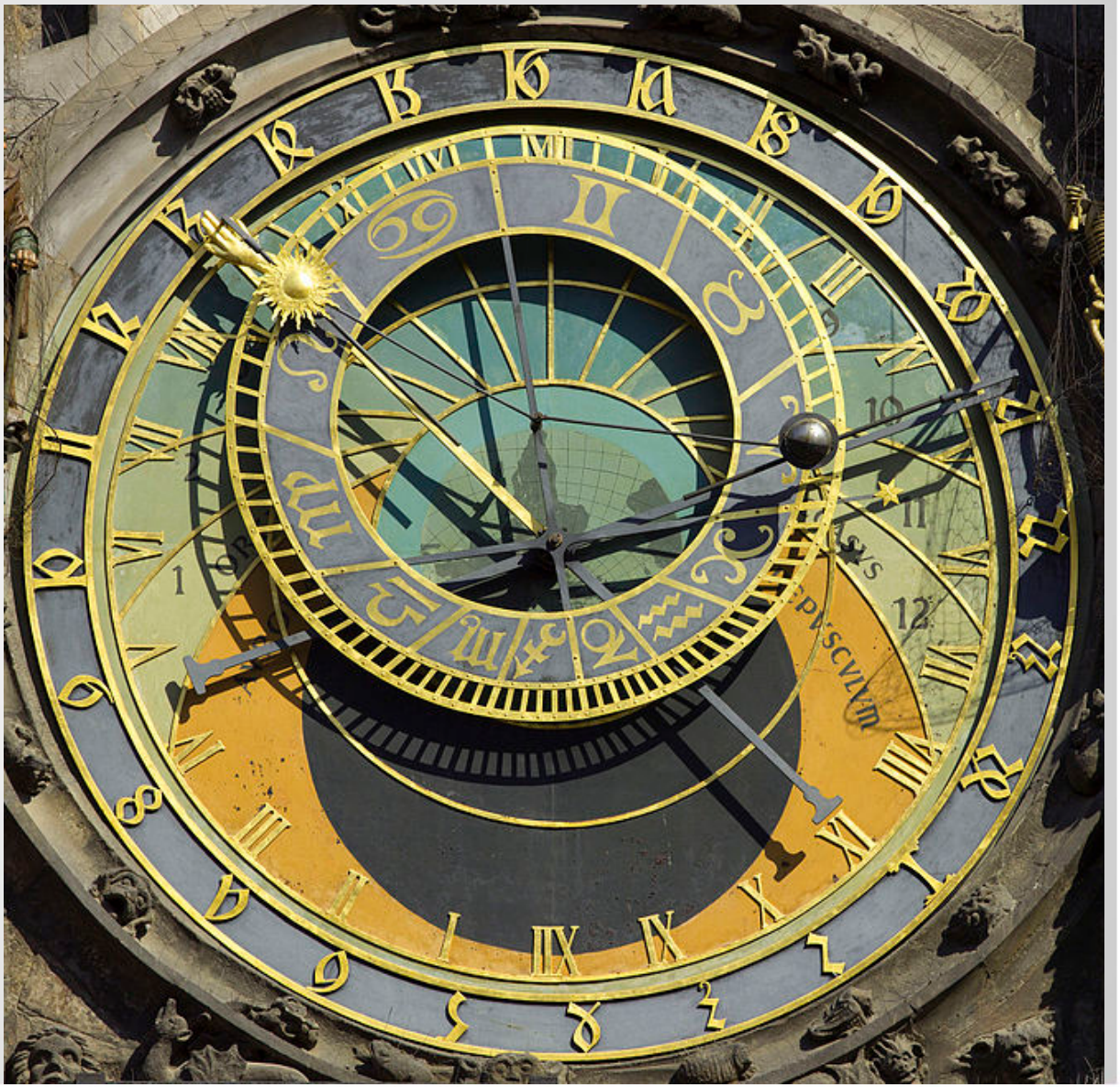
Dar Al Muwaqqit

- “Room of the Time Keeper”
- Al-Karaouine Mosque, Fez, Morocco
- By Al-Lajai
- Installed 1361 C.E.
- Water powered

Prague Orloj

2bits

- Astronomical Clock
- Prague, 1410 C.E.
- Moon phase
- Zodiac
- Sunrise, sunset, daybreak, Dark
- Sidereal time



Antikythera ‘Computer’

- Example of lost science and technology
- **Antikythera** Mechanism
- 70 B.C.E
- 30 meshing gears
- Eclipses, Planet positions, Olympic cycle
- No written record of it, or its theory of operation

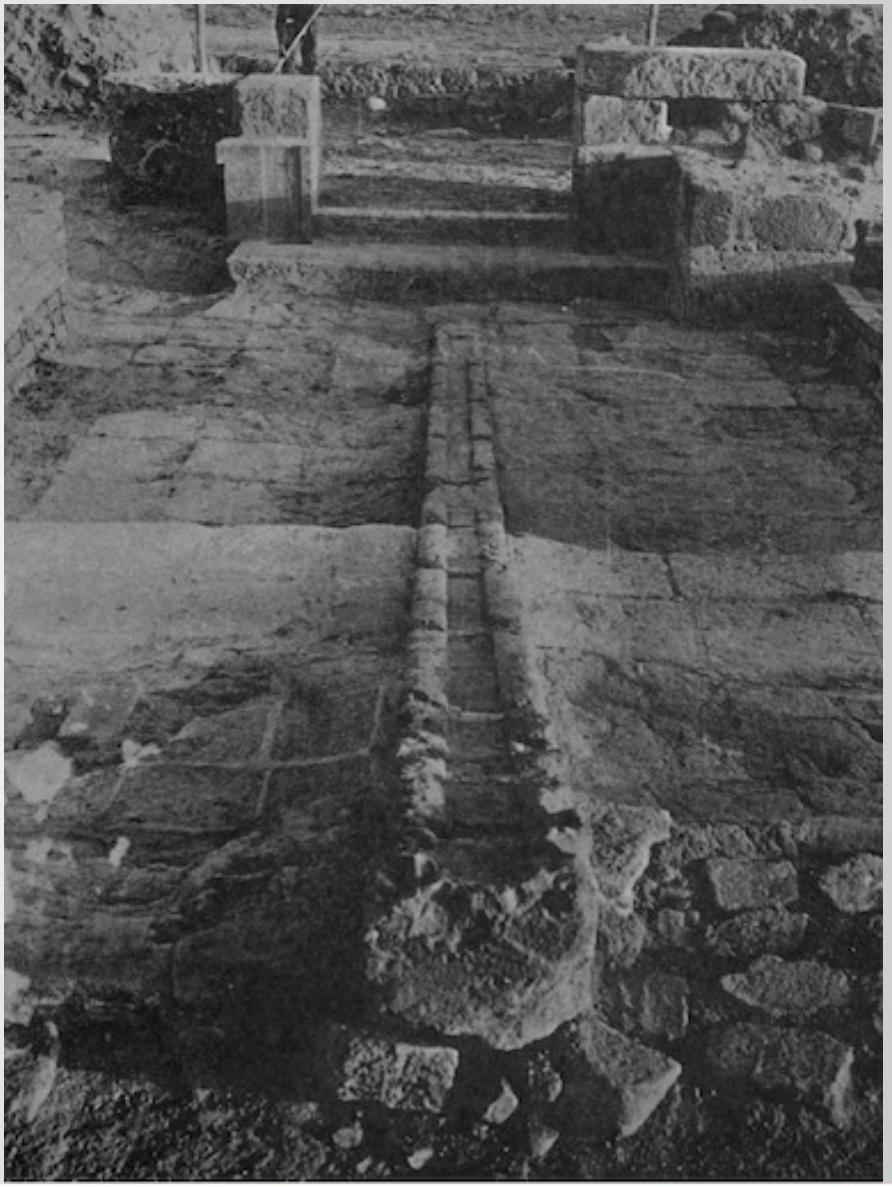
Nasireddin Tusi

- 1201 - 1274 C.E.
- Polymath: Mathematician, Philosopher, Physician, Astronomer
- Criticized Ptolemy's proof that the earth was at rest (though did not advocate it was moving)
- Tusi Couplet
  - Replacing Ptolmey's equant (more later)
- Measured precession to 51 arc seconds per year
  - Modern value is 50.2

Maragheh Observatory

2bits

- Founded 1259 C.E.
- UNESCO World Heritage
- Employed many famed astronomers
- Research Institute, extensive library
- Mural Quadrant 40 m radius
- Solsticial armilla
- Armillary sphere 160 cm radius
- Calculation of the precession
- Zij Ilkhani
- Model for later observatories

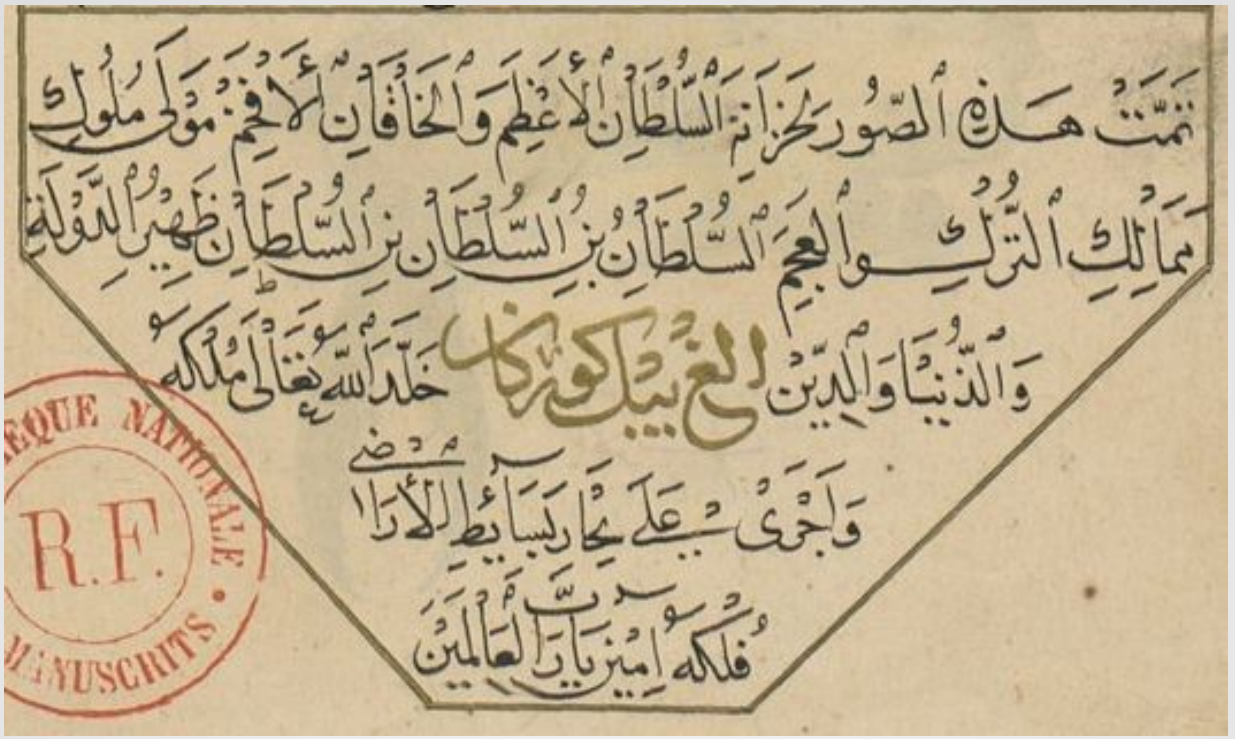


Ulugh Beg

2bits

- 1393 - 1449 C.E.
- Grandson of Tamerlane (Tatar conqueror) and Sultan
- Great nephews ruled India 1500s to 1700s (Taj Mahal)
- Employed famed astronomers
- Re-Observed positions of 992 stars
- Correction to the length of sidereal year
  - Error of only 25 seconds
- Zij Sultani, printed in Latin, Oxford 1655 C.E.
- His own son ordered his killing

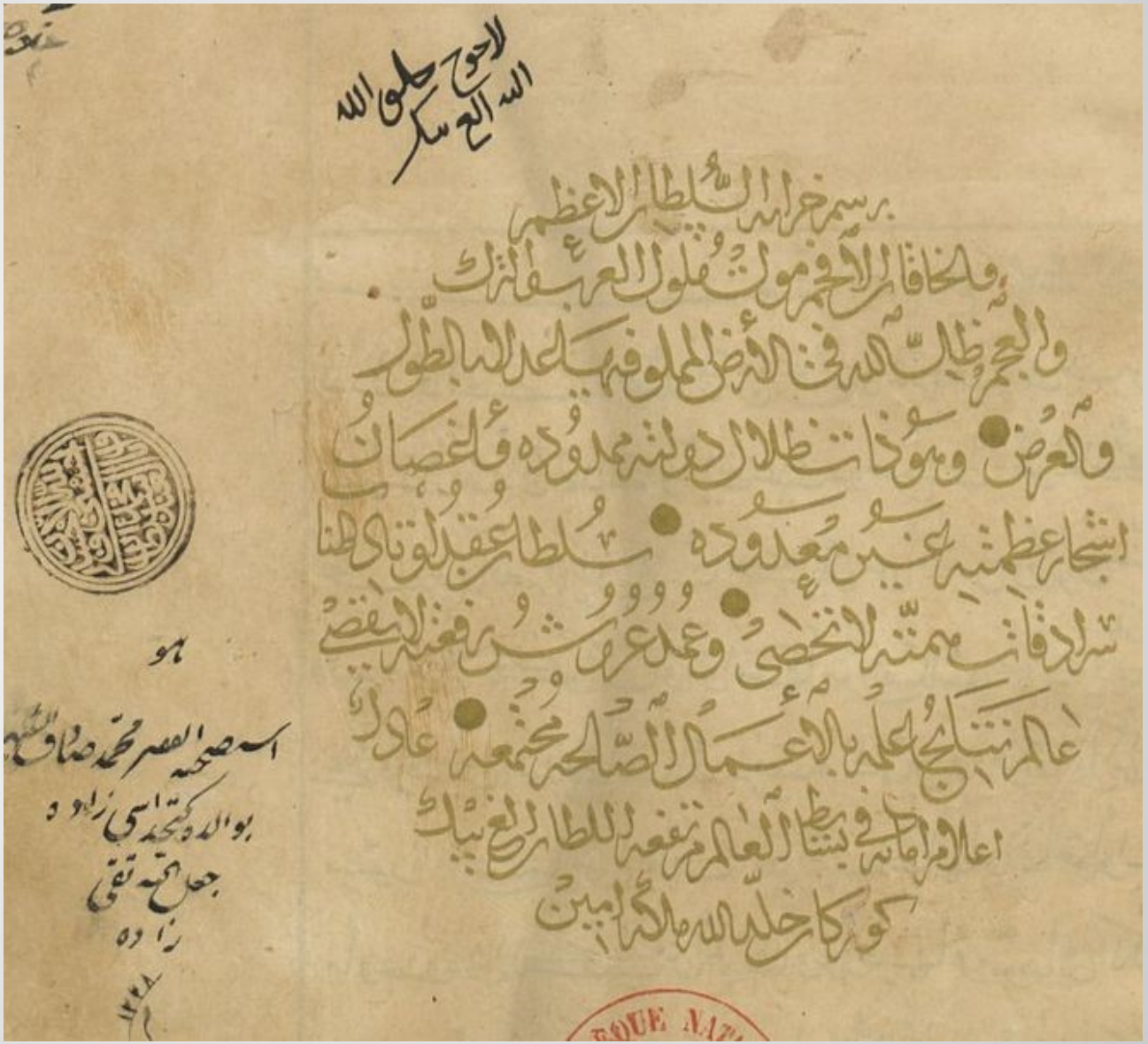
Manuscripts – Ulugh Beg



“Completed for the library of the Grand Sultan, King of Kings, of Turks and Persians, the Sultan Son of Sultan, Dhahir Al-Dawla Ulugh Beg Korkan may his domain be preserved by Allah ...”

Manuscripts – Ulugh Beg

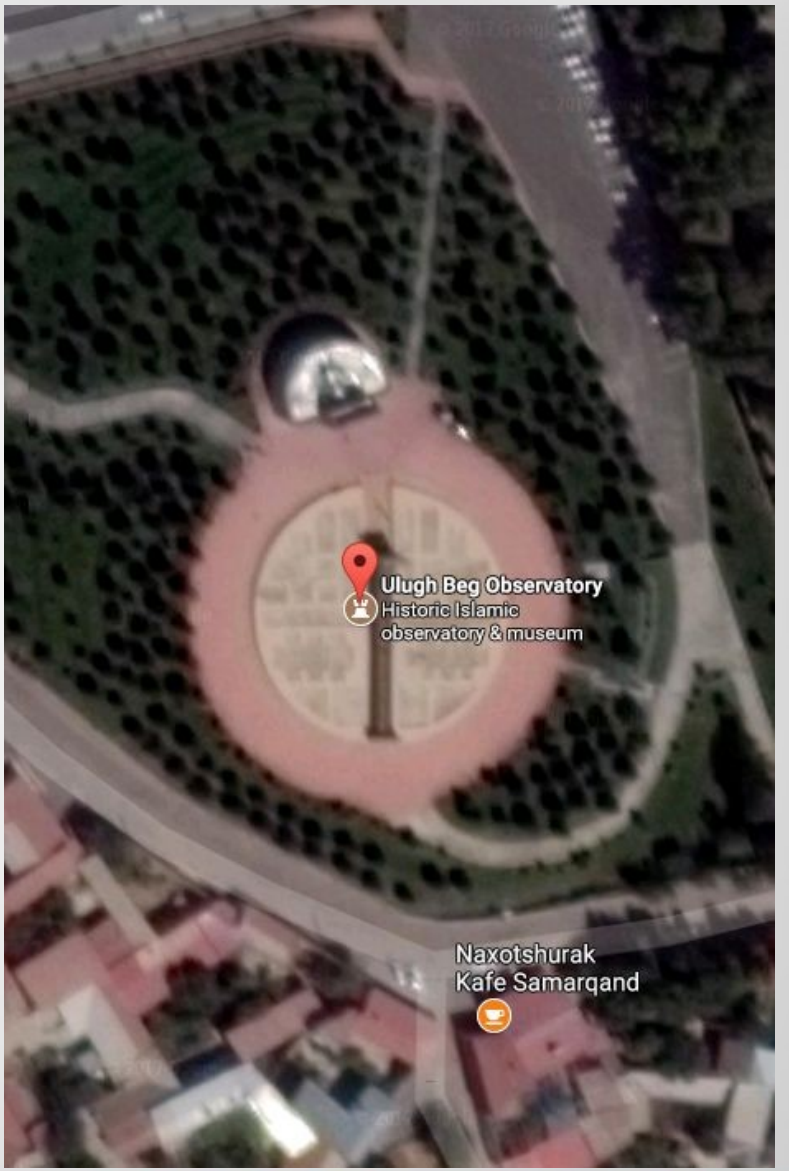
- Gold leaf praise and prayers for him
- Ulug Beg's own scribble (with humility)
- Seal and scribble of subsequent owners



Ulugh Beg Observatory

- Samarkand, Uzbekistan
- Observatory + Madrassa (college)
- UNESCO World Heritage site

Ulugh Beg Observatory



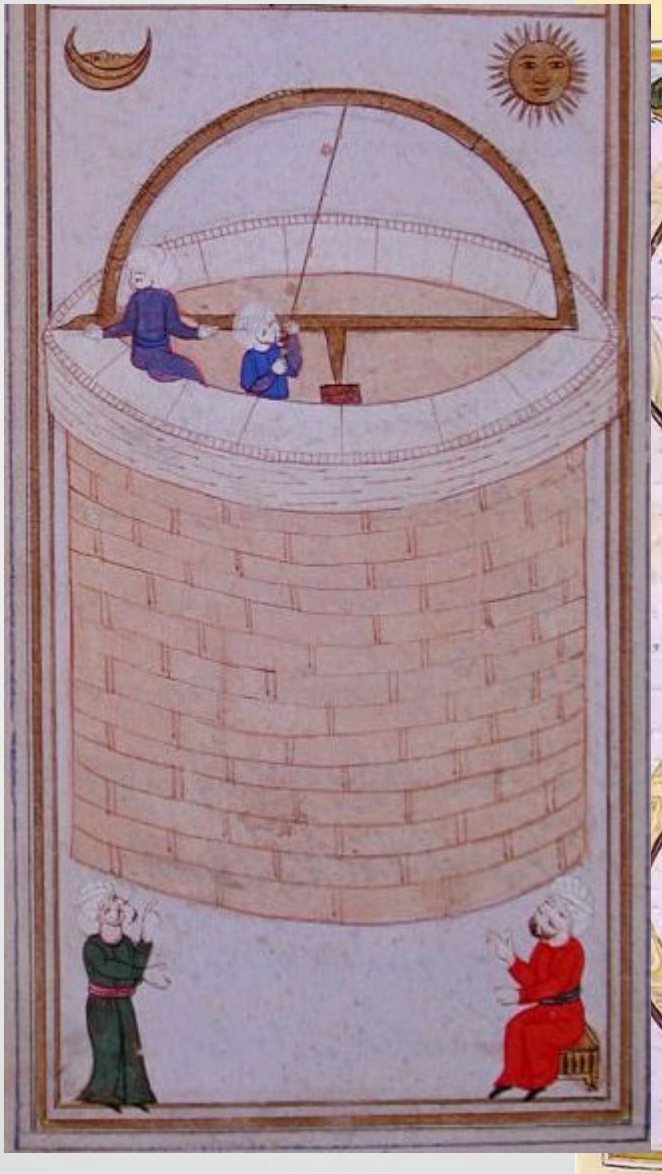
Istanbul Observatory

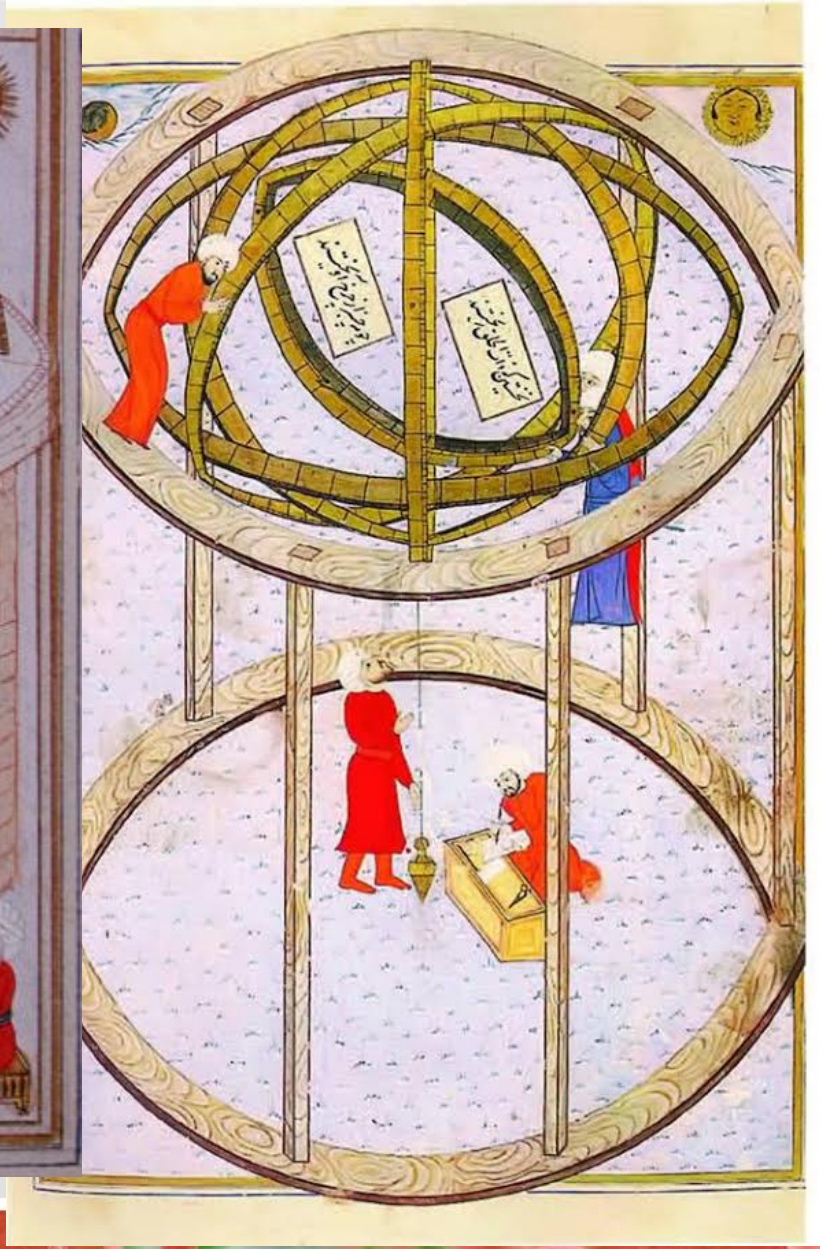
- Taqi al-Din, astronomer for the Ottoman Sultan Murad III
- Observatory in Istanbul, 1574 C.E., modelled after Ulugh Beg's
- Various instruments, including mechanical clock
- Employed 15 astronomers
- Great Comet of 1577 C.E, predicted Ottoman victory over Persia
- Plague broke out, many dignitaries died
- Observatory ordered demolished in 1580, as it 'caused' these disasters

Istanbul Observatory

2bits

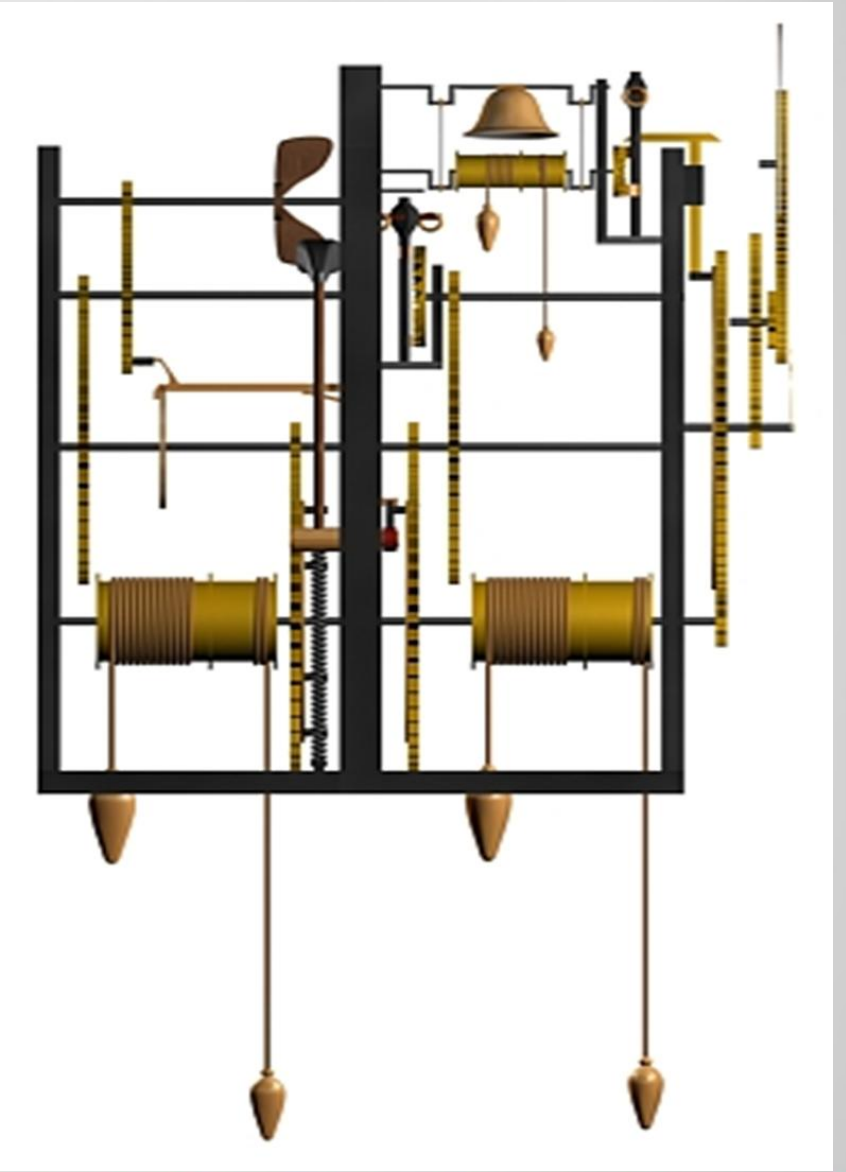
- Big Instruments!





Taqi al-Din Clock

- Taqi al-Din Astronomical Mechanical Clock
- Virtual reconstruction



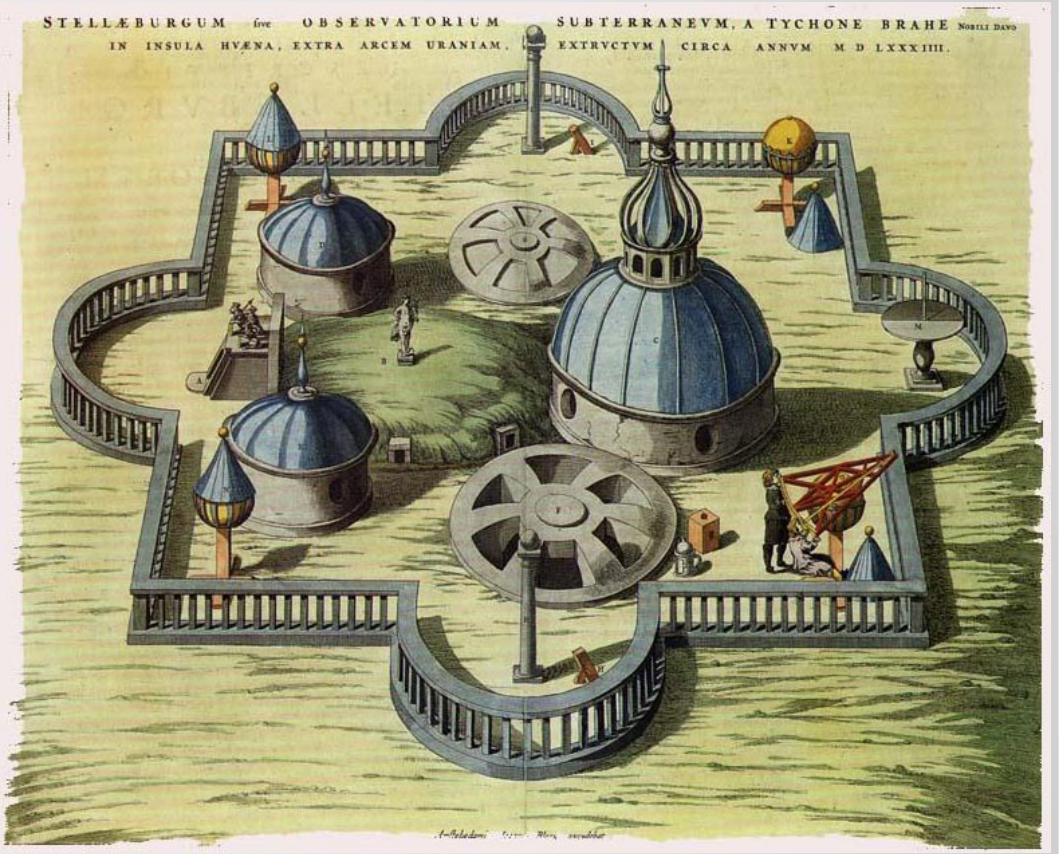
Tycho Brahe

2bits

- Danish noble, 1546 - 1601
- Solar eclipse 1560 predicted with one day error
- Court Astrologer: annual predictions, birth charts
- Built **Uraniborg** in 1576
- Supernova of 1572
- Comet of 1577
- **Tychonic model**, breaking away from Ptolmey

Stjerneborg

- Lots of detailed observations recorded, to 2 arc min accuracy
- Loss of sponsor
- Exiled and died in Prague
- Uraniborg demolished
- **Johannes Kepler** , Tycho's assistant, relied on Brahe's observations for his laws



Earth Circumference

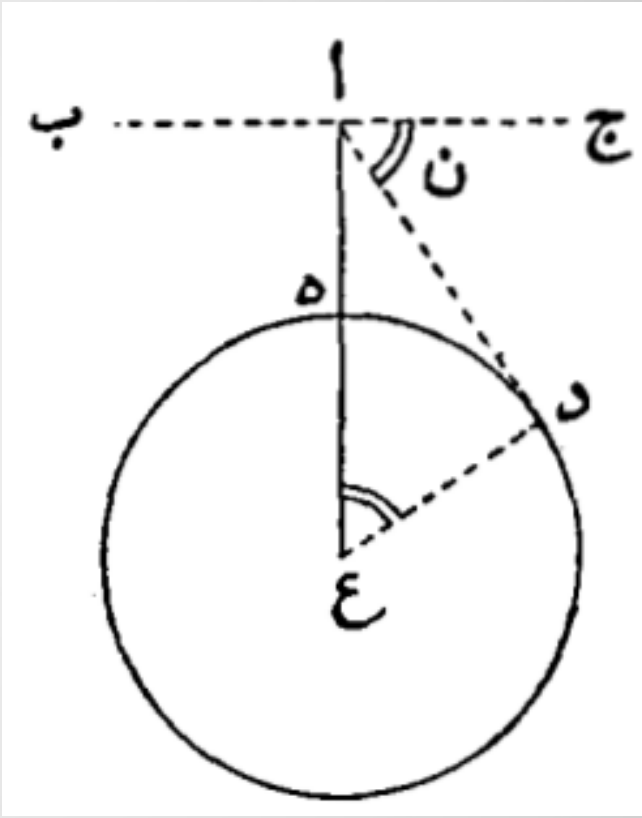
2bits

- Commissioned by Al-Ma'mun (r. 813-833 C.E)
- 1 degree = 56.667 'miles' (56.25 to 57 'miles')
- Carlo Nallino, Italian professor in Cairo University in early 1900s.
  - 1 Arab mile = 4,000 cubits
  - 1 cubit = 49.33 cm
  - 1 Arab mile = 1,973.2 metres
  - 1 degree = 111,815 meter
- Circumference = 40,253 km (actual 40,075 km)
- Not exact, but close

Earth Circumference

2bits

- Al-Biruni method
- Theorized, in his book on astrolabe, how to measure earth circumference, on a mountain near the sea
- In another book, recorded how he actually measured it in India
- Approx 57 Arab miles, close to Al-Ma’mun’s measure



Christopher Columbus

2bits

- Arab ‘miles per degree’ measurement was translated into Latin, erroneously assumed Arab mile = Roman miles
- Roman mile is 1,480 meters, yet Arab mile is 1,973.2 meters
- Hence, earth circumference is:
  - 360 deg x 56.667 x 1,480 m = **30,192 km**
  - 360 deg x 56.667 x 1,973.2 m = **40,250 km**
- So: ‘India is close’, hence ‘reachable by ship’ ...

Next Measurement

2bits

- Jean Francois Fernel, Physician, d. 1558 C.E.
- Measured distance between Paris and Amiens in 1525 C.E (on the same meridian)
- By counting the revolutions of his carriage's wheel
- 110,602 meters

Earth's Rotation

2bits

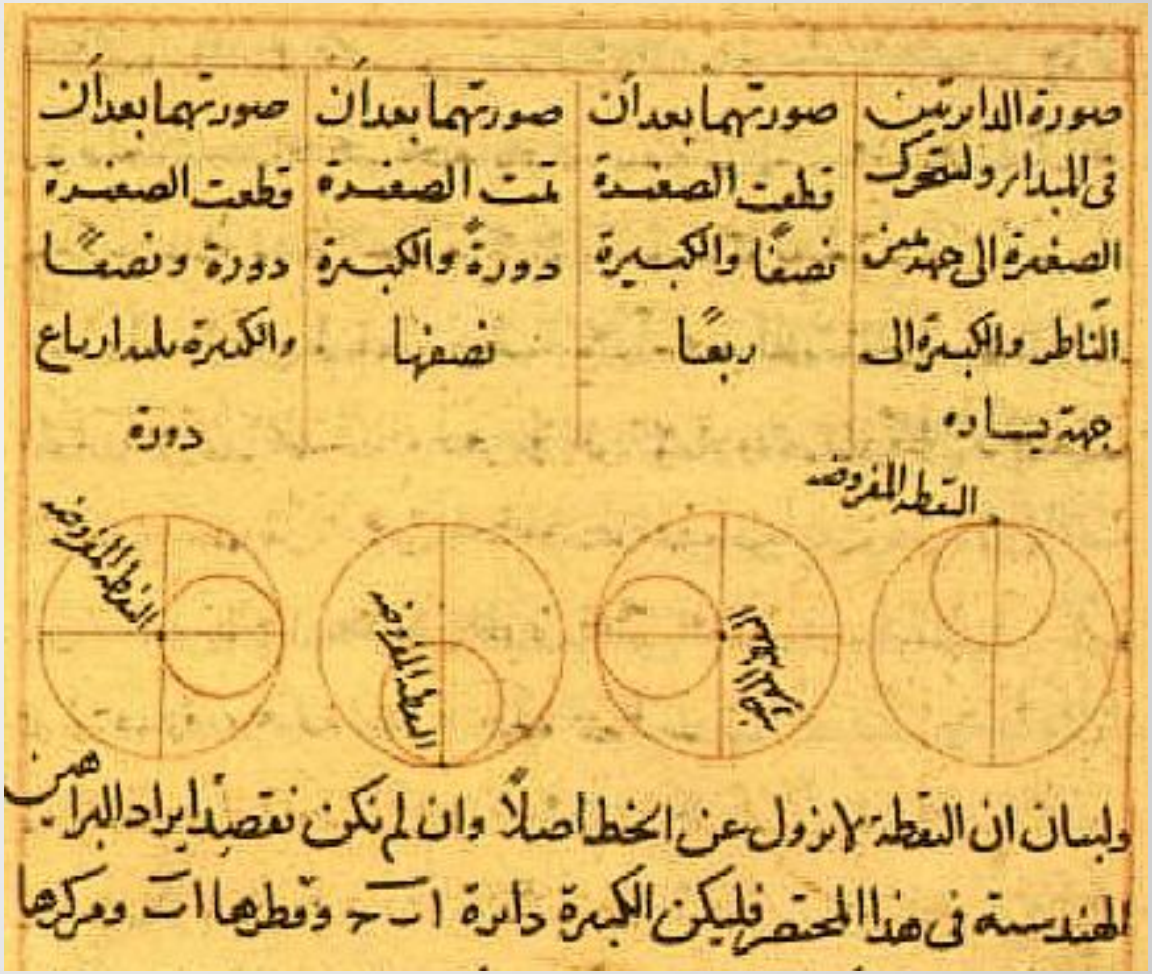
- Tusi criticized Ptolmey's proofs that earth does not move (though did not dispute his conclusion)
- Al-Sijizi (d. 1020 C.E.) proposed and accepted that earth rotates on its axis
  - Invented a version of the Astrolabe (Zuraqi) based on that principle
- Al-Biruni (d. 1048 C.E.) admitted that such a rotation would explain a lot of things
  - Yet, he would not accept it as fact, nor subsequent scientists

Correcting Ptolmey

- Ibn Al Haytham (*Alhazen*, d. 1040 C.E.)
- Book on Optics
- Camera Obscura
- Authored a book:
  - ‘Doubts *[Shukuk]* Against Ptolmey’
- *Shukuk* became a recurring theme from then onwards

Correcting Ptolemy

- Tusi Couple
- Linear motion from the movement of two circles
- Mentioned in a work in 1247 C.E,
- Formal mathematical proof in another work in 1261 C.E
- Knew, and stated, that he was introducing a new theorem



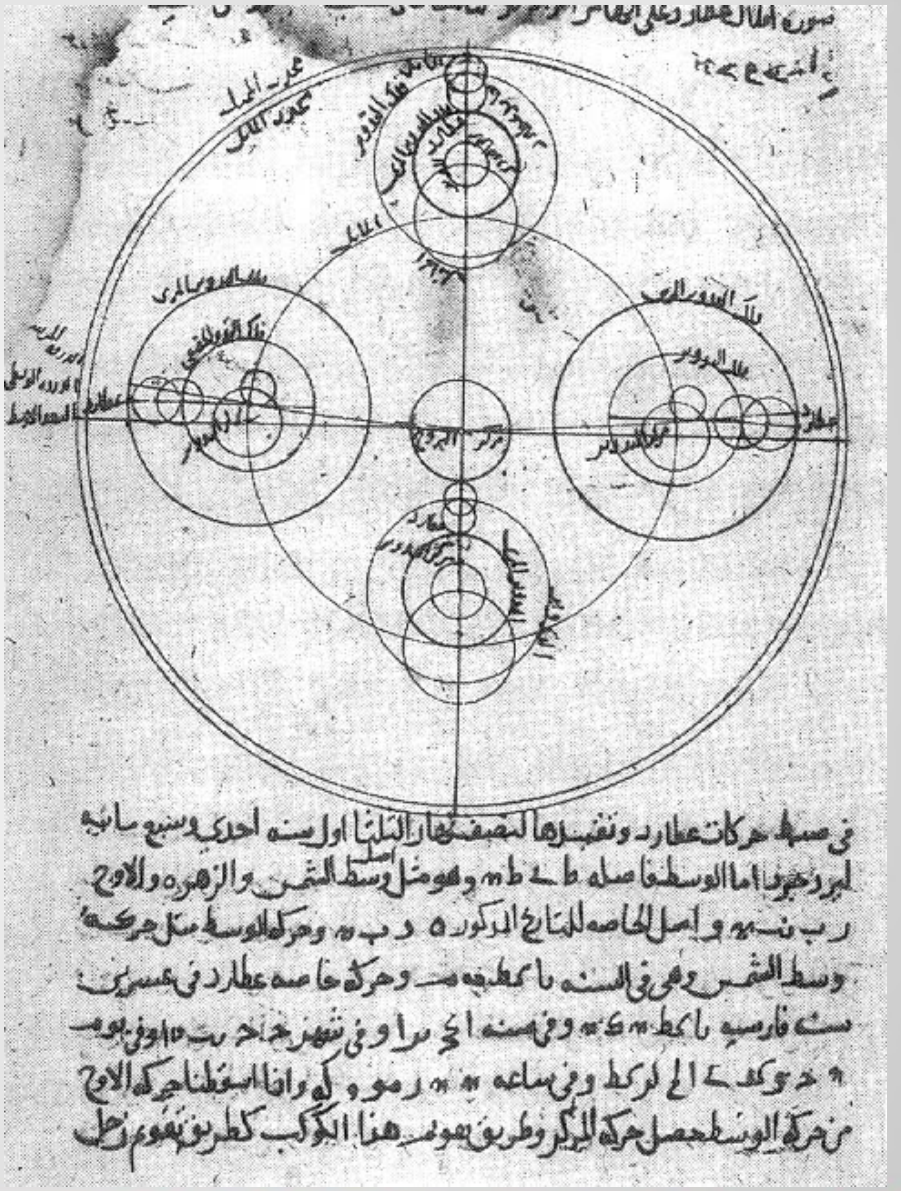
Ibn Al-Shatir

2bits

- Time Keeper in Damascus, d. 1375 C.E
- Zij Al Jadid (New Astronomical handbook)
- Instrument Maker
  - *Al-'Ala Al Jami'a* (Universal Instrument)
  - "In the wall inside his house, runs without water"
  - Sundial at Umayyad Mosque, Damascus
  - Another boxed one in Aleppo
- Calculated earth's inclination to 23d 31'

Correcting Ptolemy

- Drastically changed Ptolemy's model
- Eliminated 'eccentric' nor 'equant'
- Added extra epicycles, based on Tusi's Couple
- Similar calculations as Copernicus
- Mercury in 701 A.H.



Correcting Ptolemy

- **Urdi's Lemma**
- Mu'ayyad al-Din Al-Urdi was a colleague of Tusi in the Maragheh Observatory
- Ibn Al-Shatir incorporated the Lemma in his work

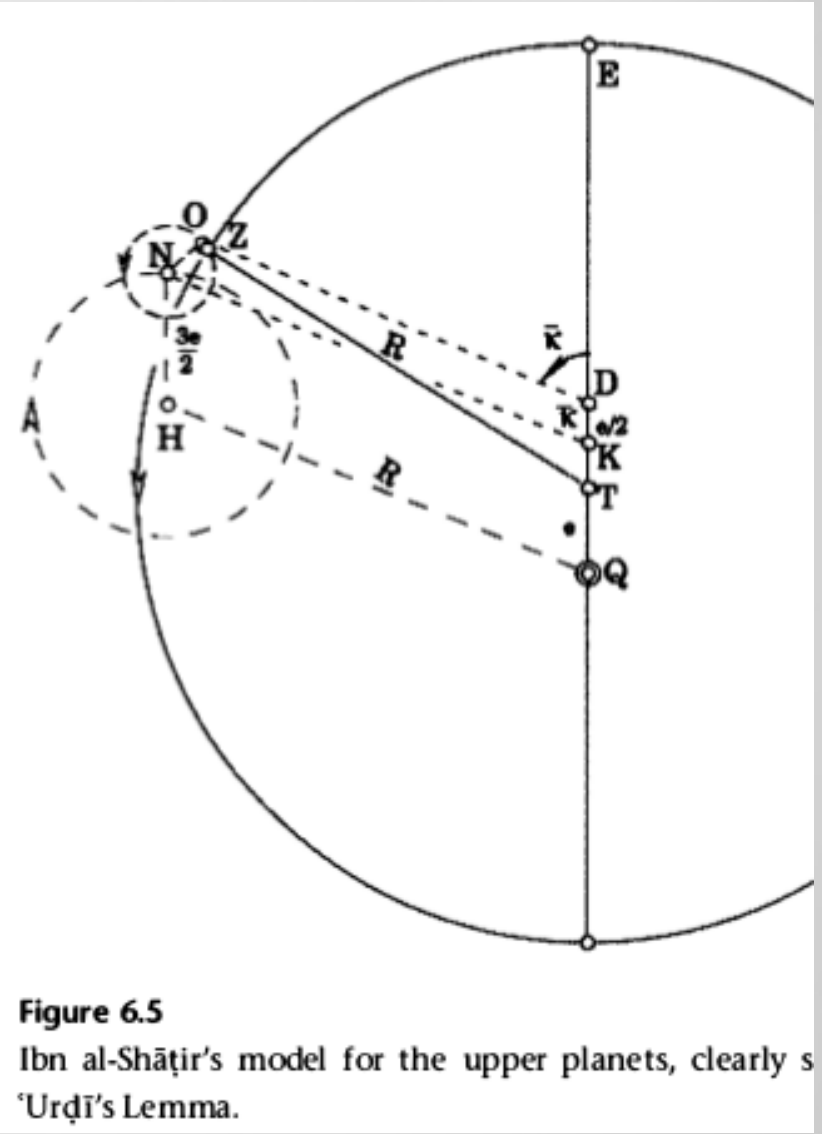


Figure 6.5
Ibn al-Shāṭir's model for the upper planets, clearly s
'Urḍī's Lemma.

Copernican Connection

- Copernicus model for the moon, was identical to Ibn Al-Shatir's
- Discovered accidentally by Edward Kennedy at Bodleian Library in Oxford (then professor of mathematics, and history of science at American University of Beirut, fluent in Arabic)
- He brought it to the attention of Otto Neugebauer in 1957
- Victor Roberts, Kennedy student: "The Solar and Lunar Theory of Ibn al-Shatir: A pre-Copernican Copernican model"

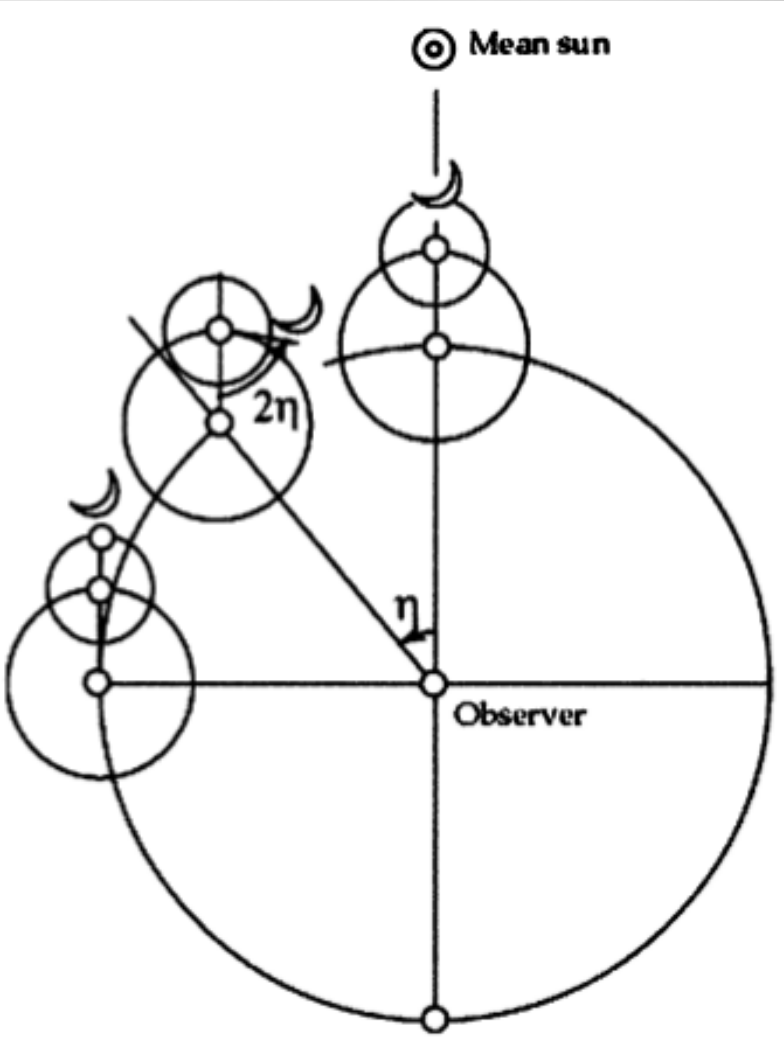


Figure 6.1
The lunar model of Ibn al-Shāṭir and Copernicus.

Copernican Connection

- Willy Hartner, historian of science
- Noticed in 1973 Copernicus used the same phonetic letters for his proof, as Tusi
- Arabic Alphabet:
  A B G D H W Z
- Latin Alphabet
  A B C D E F G H

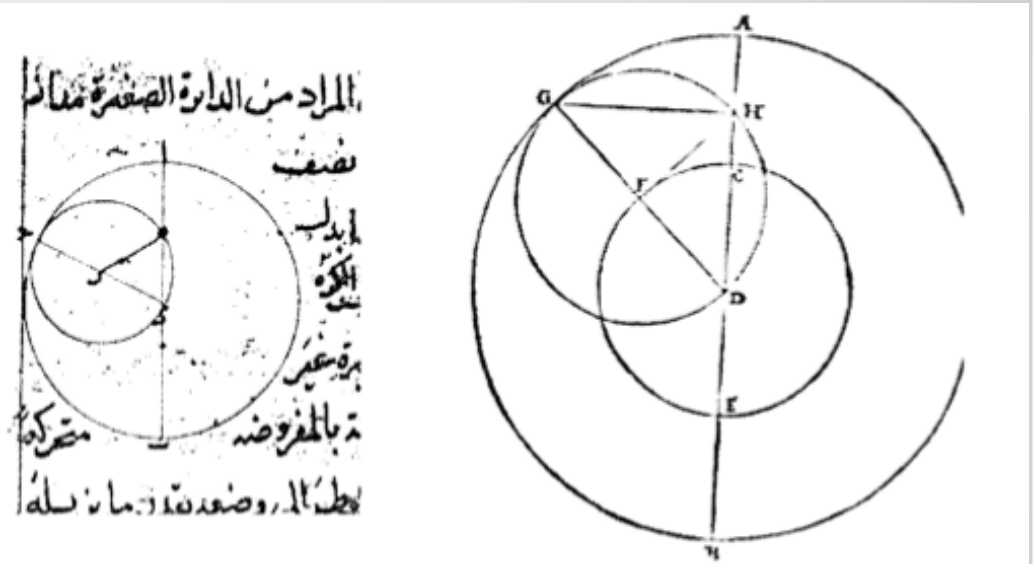
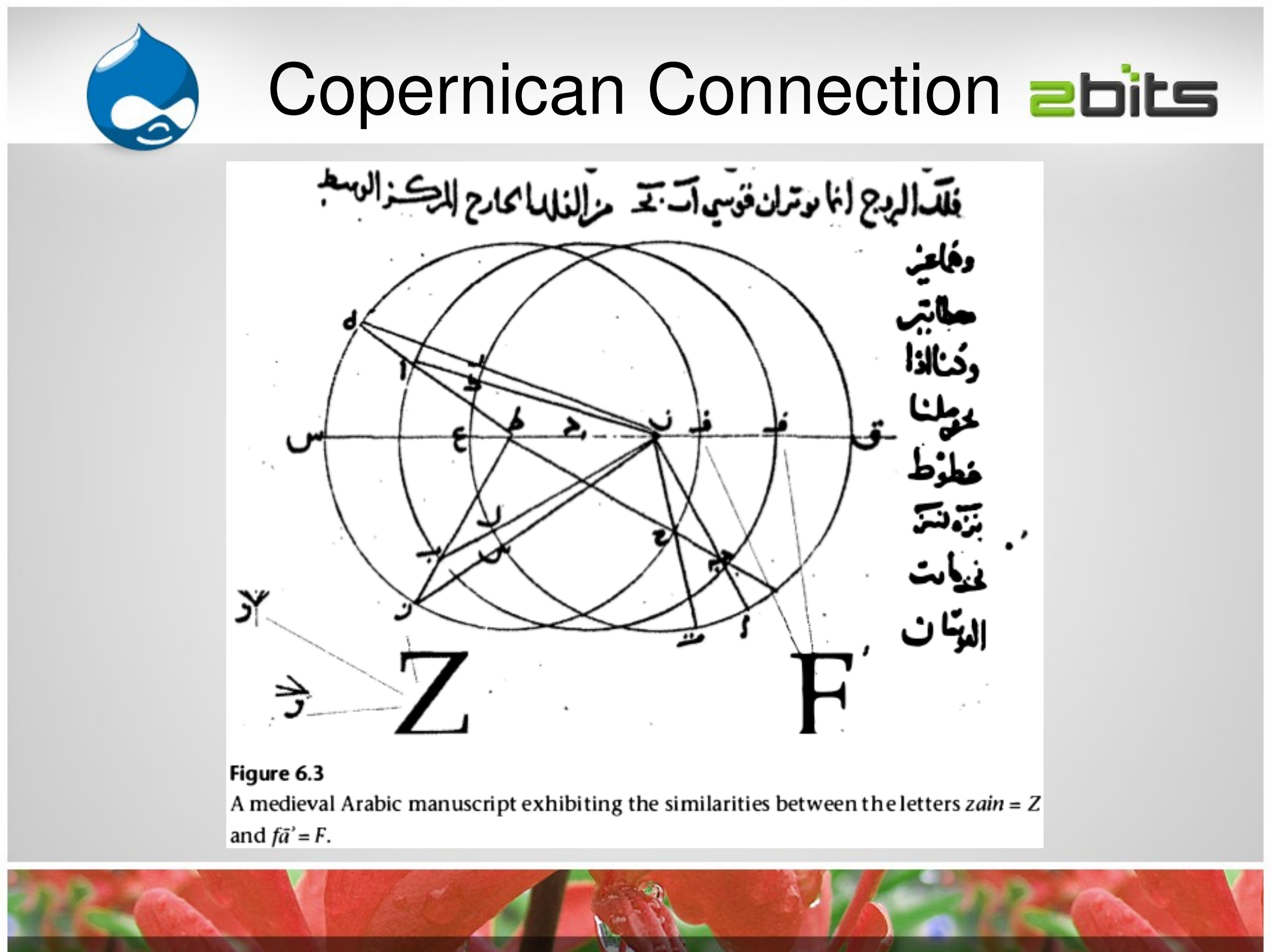


Figure 6.2
Proofs of the Ṭūsī Couple from the works of Ṭūsī (left) and Copernicus (right), showing the identity of the lettering of the diagrams. Wherever Ṭūsī had *alif* Copernicus had *A*, and wherever Ṭūsī had *bā* Copernicus had *B*, and so on, except that where Ṭūsī had *zain* for the center of the smaller sphere Copernicus had *F*. See figure 6.3.

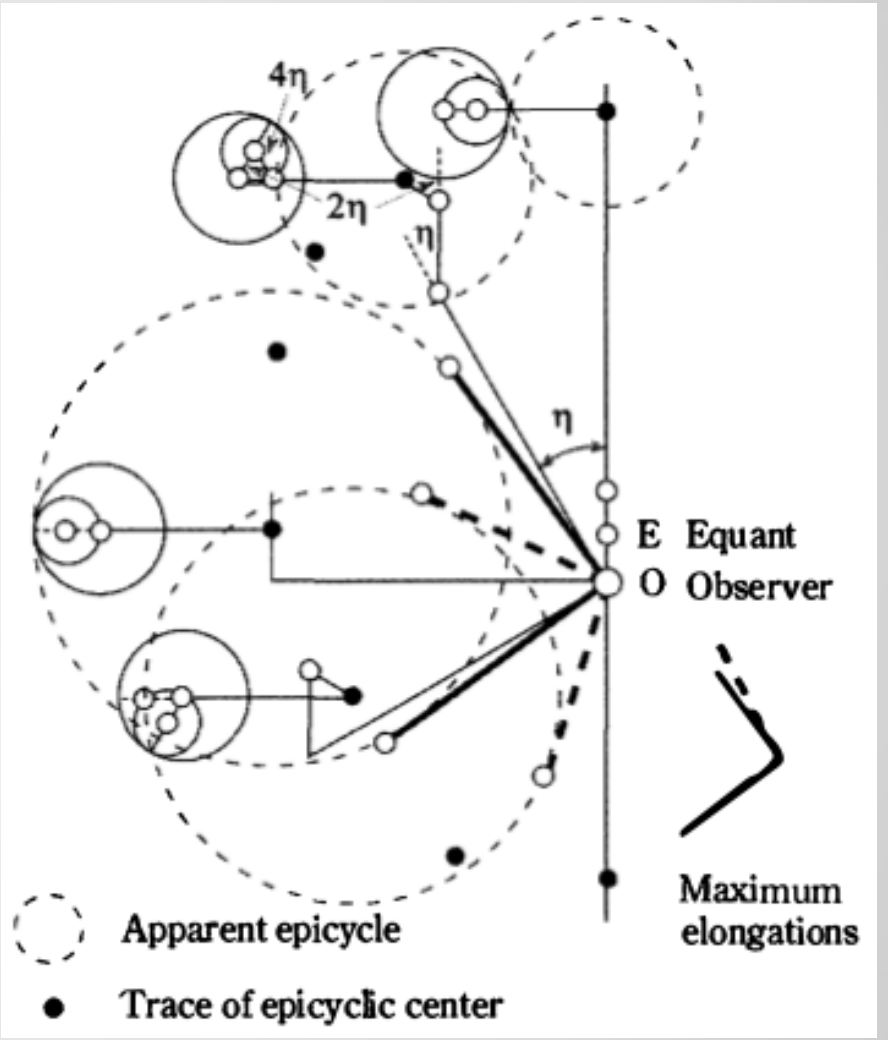


Copernican Connection

Figure 6.3
A medieval Arabic manuscript exhibiting the similarities between the letters *zain* = *Z* and *fā'* = *F*.

Copernican Connection

- George Saliba: *“Copernicus adopted [Ibn Al-Shatir’s] model without fully realizing the manner in which it functioned. Copernicus [didn’t] realize that the apparent size of an object depended on the size of the object and [it's] distance.*



Copernican Connection

2bits

- George Saliba: *“Therefore, not only did Copernicus apparently seek to solve the same problem of the Greek astronomical tradition by adopting the same approach ... he also used a theorem that had been invented by Tusi about 300 years earlier, and supplied a proof that was very similar to the one supplied by Tusi, with a slight modification in protocol, but still adhered to the same geometric points that were used by Tusi in the original proof. All of this cannot be mere coincidence, as some people still like to think.”*

Later Works

- Al-Tizini, Damascus 1534 C.E.
  - Muwaqitt (Time Keeper)
  - Calendarium
- Al-Achsasi al-Muwaqitt
  - Also Time Keeper at the Great Mosque (Al-Azhar) in Cairo
  - Calendarium and Star Catalog, circa 1650 C.E.
  - Used Right Ascension and Declination (cf. John Flamsteed first in Europe to use RA in 1712 C.E.)

Jantar Mantar 1734

Navigation

2bits

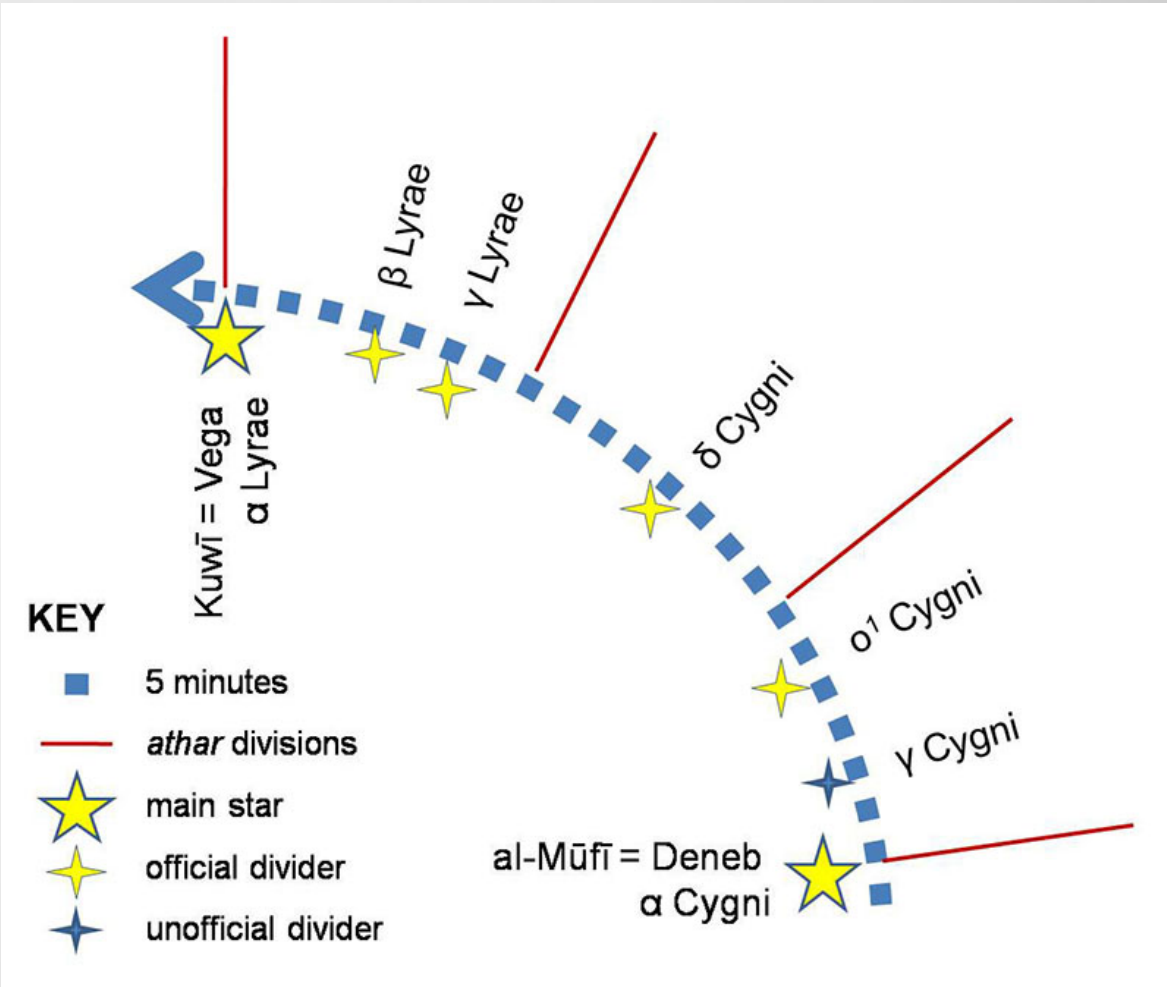
- Arab Sidereal Compass Rose
  - 32 stars for Red Sea/Indian Ocean
  - N=Polaris, NE=Capella, E=Altair, SE=Antares, S=Crux
  - Others for intermediate (NbE, NNE, NEbN, ...)
- Ibn Majid
  - Zanzibar/Oman
  - Several books on navigation
  - Used by Vasco da Gama for circumnavigating Africa

Irrigation

- Aflaj (sing. Falaj)
- Oman, UAE
- Redirecting spring, rain or other water to arable land
- Using canals, and gravity
- UNESCO World Heritage

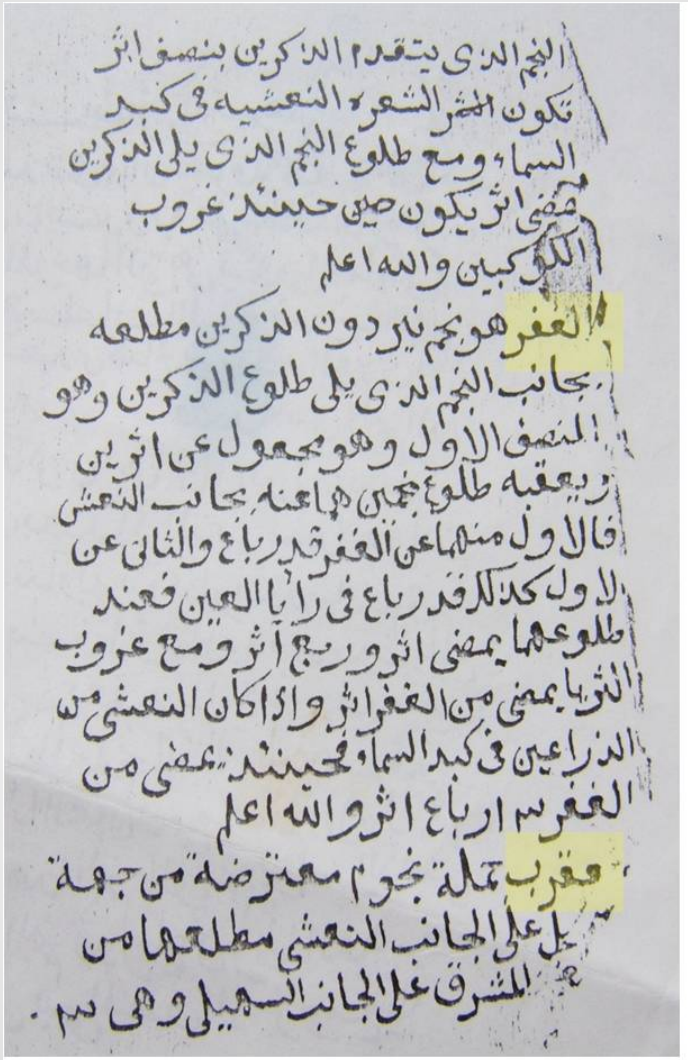
Sidereal Clock

- Still in use today!
- Astronomical Timing of irrigation
- Different villages use one or more technique: sundials, markings on walls, rising of stars
- Example: Vega to Deneb
- My timing: 1 hr 35 mins



Oman's Aflaj

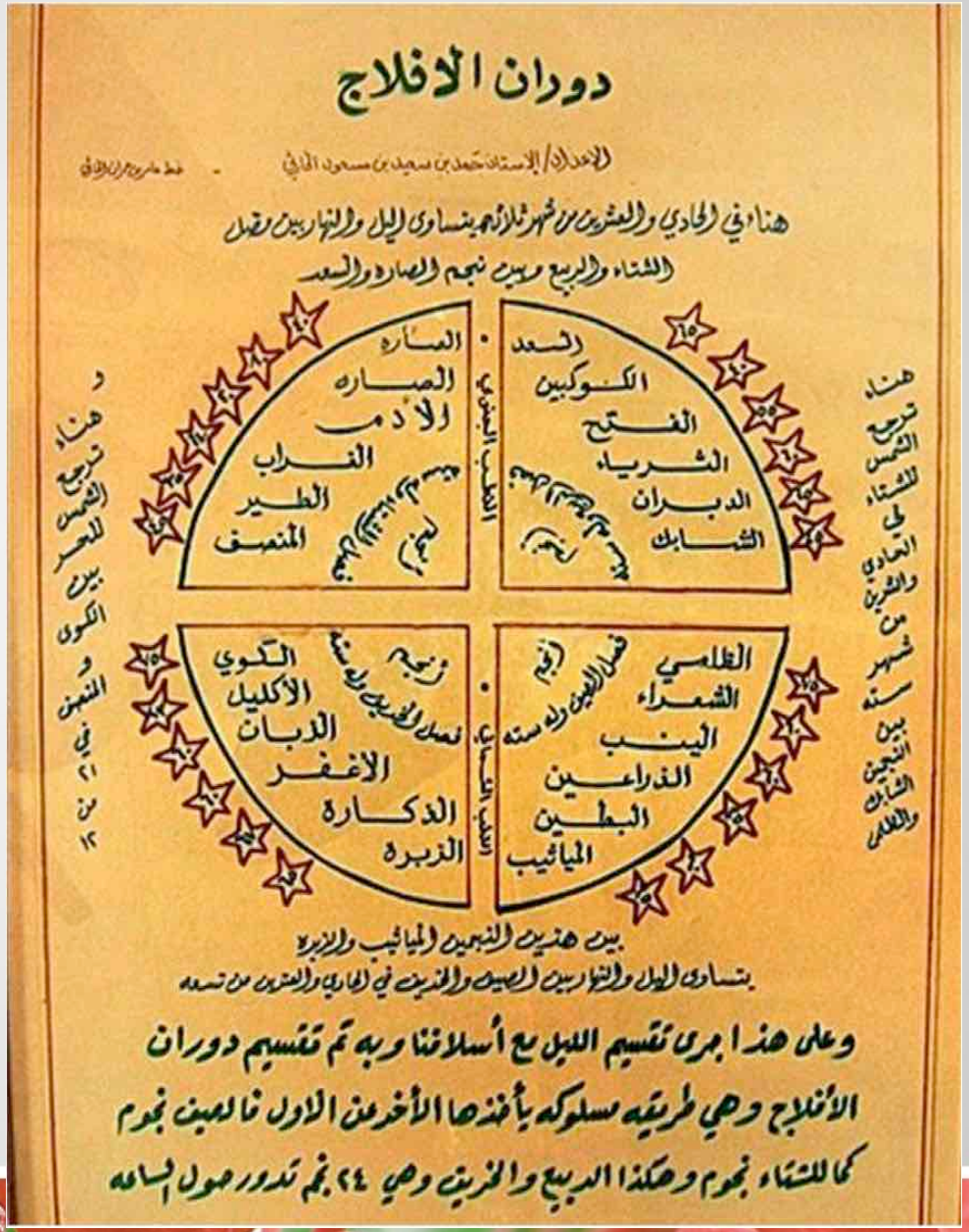
- Oral tradition
- Committed to writing recently
- 1921 C.E



Originator: Sheikh Saᶜīd b. Sāleh al-ᶜAbrī d. 1921
Copyist: Muḥammad b. ᶜĀmar al-ᶜAbrī c. 1941

Oman's Aflaj

- 1986 C.E.
- Seasons of the year
- Six stars per season, including:
- Pleiades, Aldebaran, Sirius, Alphecca, Vega, Altair, Algorab
- Other star names, unrecognized in ancient traditions



Arabic Terms

2bits

- Algebra
- Algorithm
- Cipher
- Azimuth
  - Singular: *as-Samt = Direction*
  - Plural: *as-Sumut*)
- Zenith
  - *Samt Ar-Ras* ~ samt ~ cenit ~ zenith
- Nadir
  - *Natheer = Counterpart*

Decline

- Up to mid 1600s, Islamic world was on par with Europe
- Ottomans banned the printing press
  - 1400s in Europe, early 1800s in Egypt
- Alternative Trade Routes (e.g. circumnavigation of Africa)
  - No longer part of India/China trade
  - No more cultural exchange
- New World = vast amount of riches
- Colonialism (mid 1800s to mid 1900s)
- Followed by native dictatorships, that are still there

Conclusions

- Golden Age was not only 800s to 1,100s C.E
- It continued well into the 1600s
- Had a major impact on Western science (astronomy, geometry, trignometry, navigation)
- Arabs were *not* merely transmitters (observers, theorists and improvers of science). Colonial view.
- 1620s changed everything (Galileo, Kepler)

Further Reading

2bits

- Carlo Alfonso Nallino (d. 1938 C.E.)
  - Various works on Arab Astronomy, Al-Battani
- George Saliba, professor at Columbia University
  - Islamic Science and the Making of the European Renaissance, 2007
  - A History of Arabic Astronomy: Planetary Theories During the Golden Age of Islam, 1994
  - Whose Science is Arabic Science in Renaissance Europe? (his web site at Columbia University)

Further Reading

2bits

- David A. King
  - The Astronomy of the Mamlukes, 1986
  - In Synchrony with the Heavens: Studies in Astronomical Timekeeping and Instrumentation in Medieval Islamic Civilization. Vol. 1,Call of the Muezzin, 2004, Vol. 2, Instruments of Mass Calculation, 2005

Further Reading

- Paul Kunitzsch, Munich University
  - Scientific Contacts and Influences Between The Islamic World and Europe: The case of Astronomy, 2007
  - Various works on Islamic Astronomy, transmission to the West, and Star Names
- UNESCO and IAU
  - Astronomy and World Heritage: Thematic Study
  - AstronomicalHeritage.net

Further Reading

2bits

- MuslimHeritage.com/astronomy
  - In depth articles on astronomy
  - Also a variety of other topics, on science, technology, medicine, cuisine, ... etc.
- 1001inventions.com
  - Travelling show

Questions?

2bits

Questions? Comments?