Evening Classes

Week Four

Presented by John Campbell

The History of Astronomy

Ancient Astronomy

(Ireland, Australia, Africa, Americas)

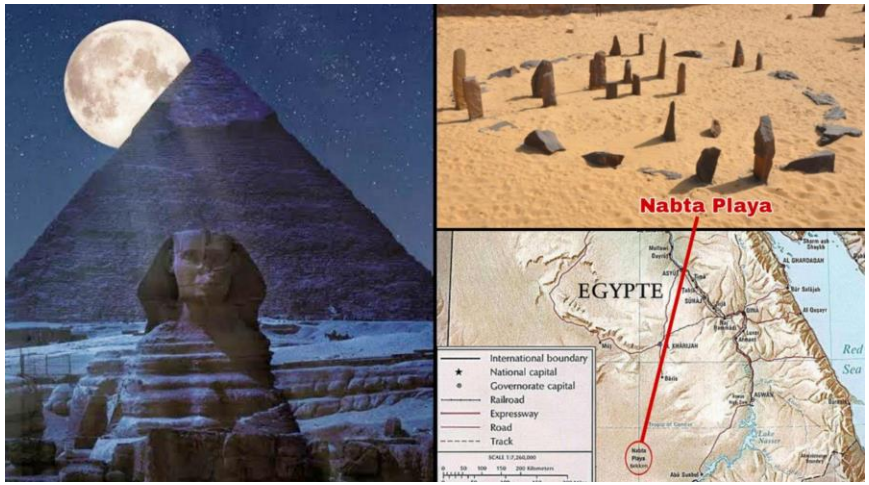
Ancient Babylonian, Egyptian

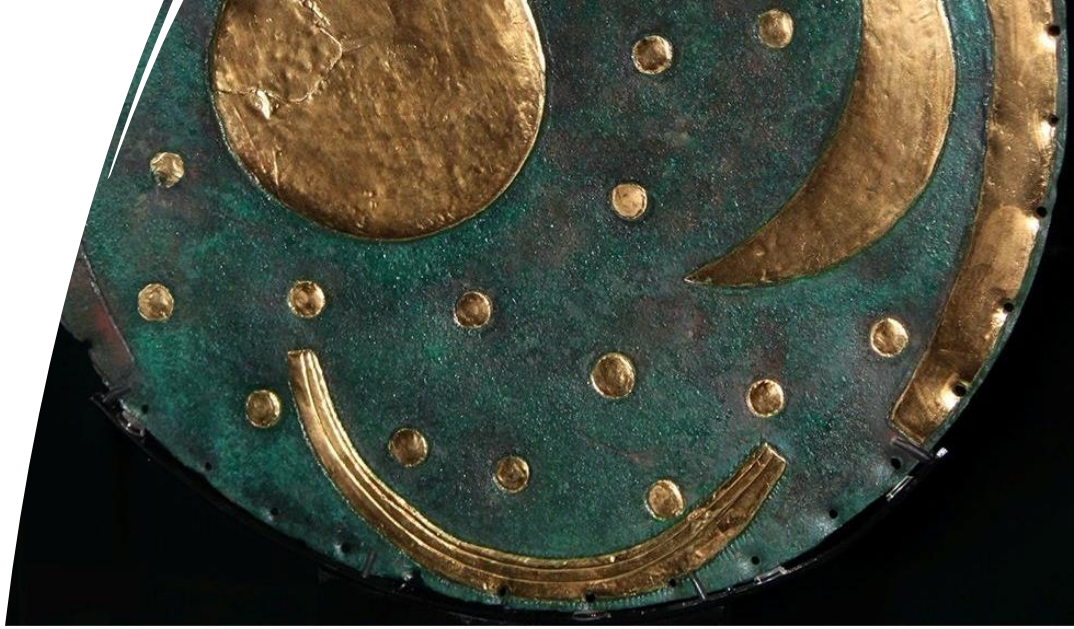
Greek, Chinese, Inca and Arab Astronomy

European Renaissance

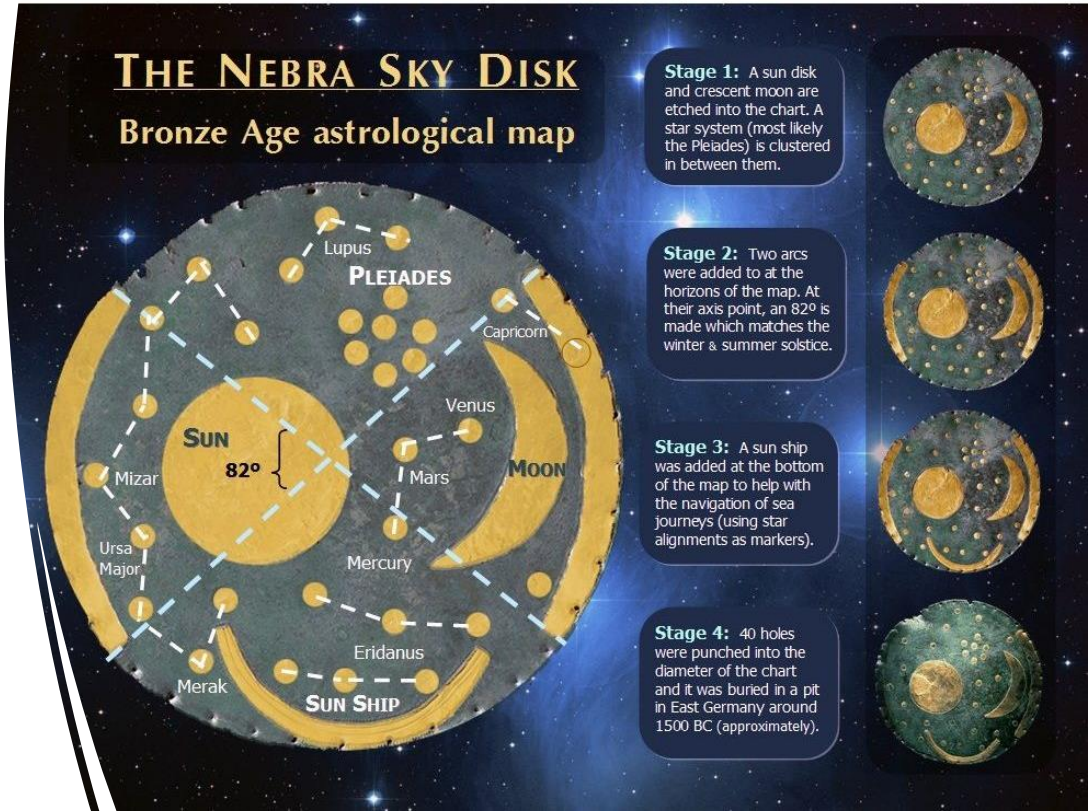
Modern Astrophysics

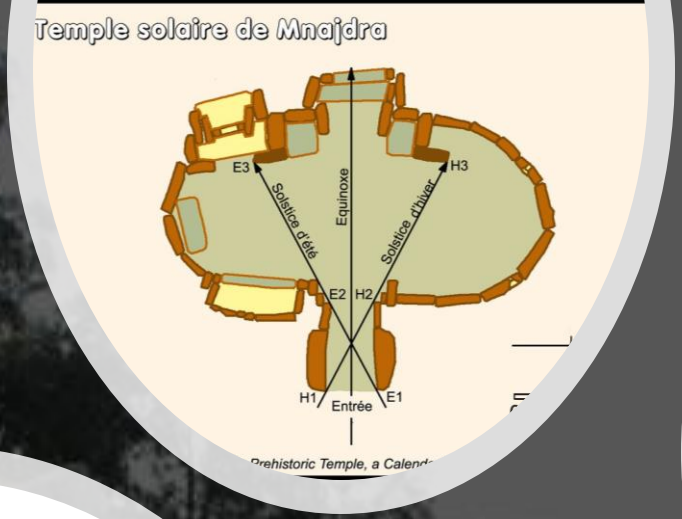
Nabta Playa 7500BC – considered to be the oldest astronomical observatory

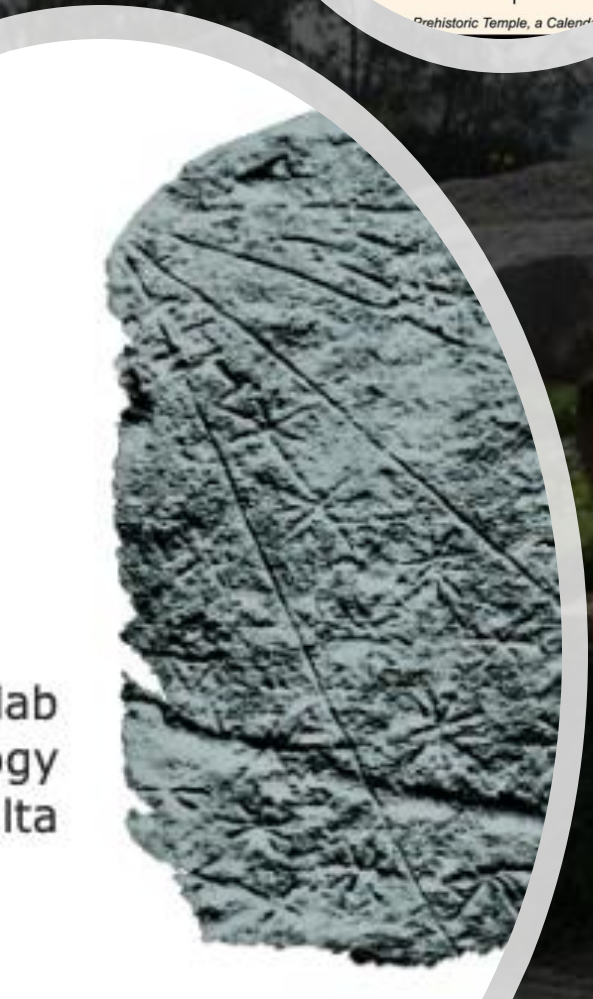




- The Nebra Sky Disc is widely believed to be **3,600 years old**, dating from the Bronze Age. The bronze disc was unearthed in Germany in 1999 and is considered one of the most important archaeological finds of the 20th Century.





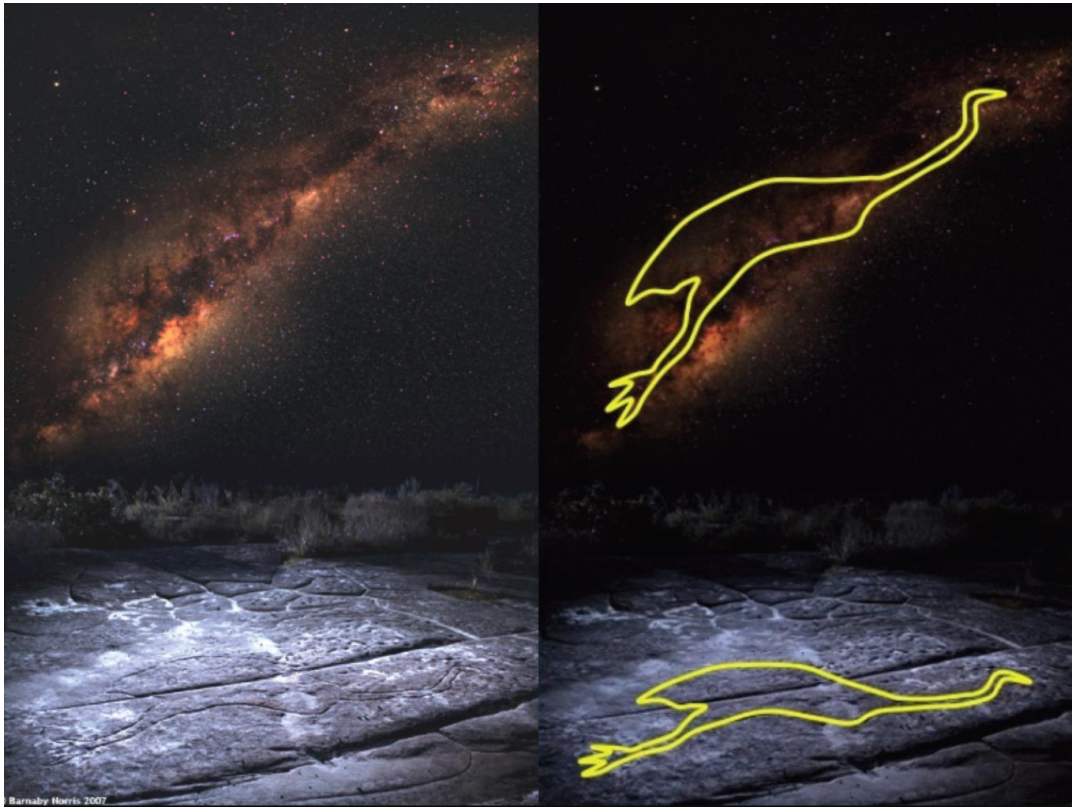


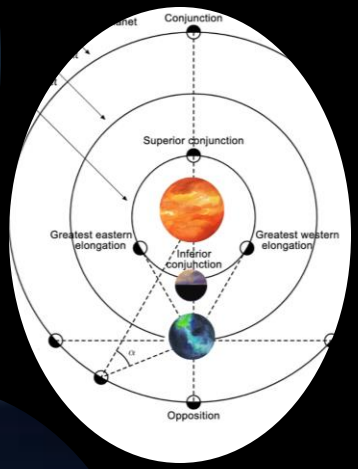
Malta's many pre-historic astronomical sites

Ku-ring-gai Chase National Park in Queensland Australia

5000 year old petroglyphs

Of galactic dust lanes



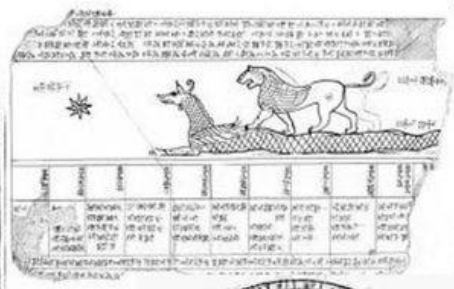


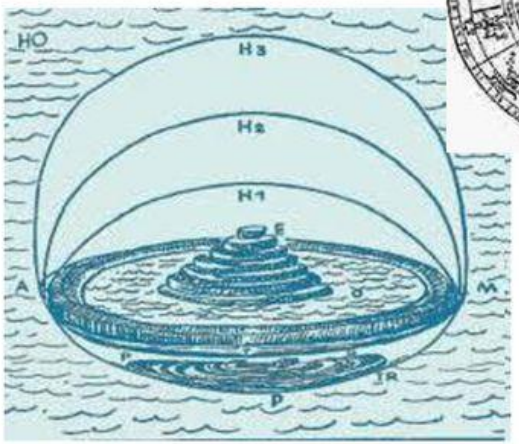
Enheduanna was the EN priestess of the moon god Nanna and Goddess Inanna (ususally associated with Venus) in the Sumerian city-state of Ur in the reign of her father, Sargon of Akkad.

Ancient stories about Inanna descending into the underworld (some of the first recorded religious texts) depicts what we now know is the planet Venus transforming from an evening to a morning star (a death and rebirth cycle)

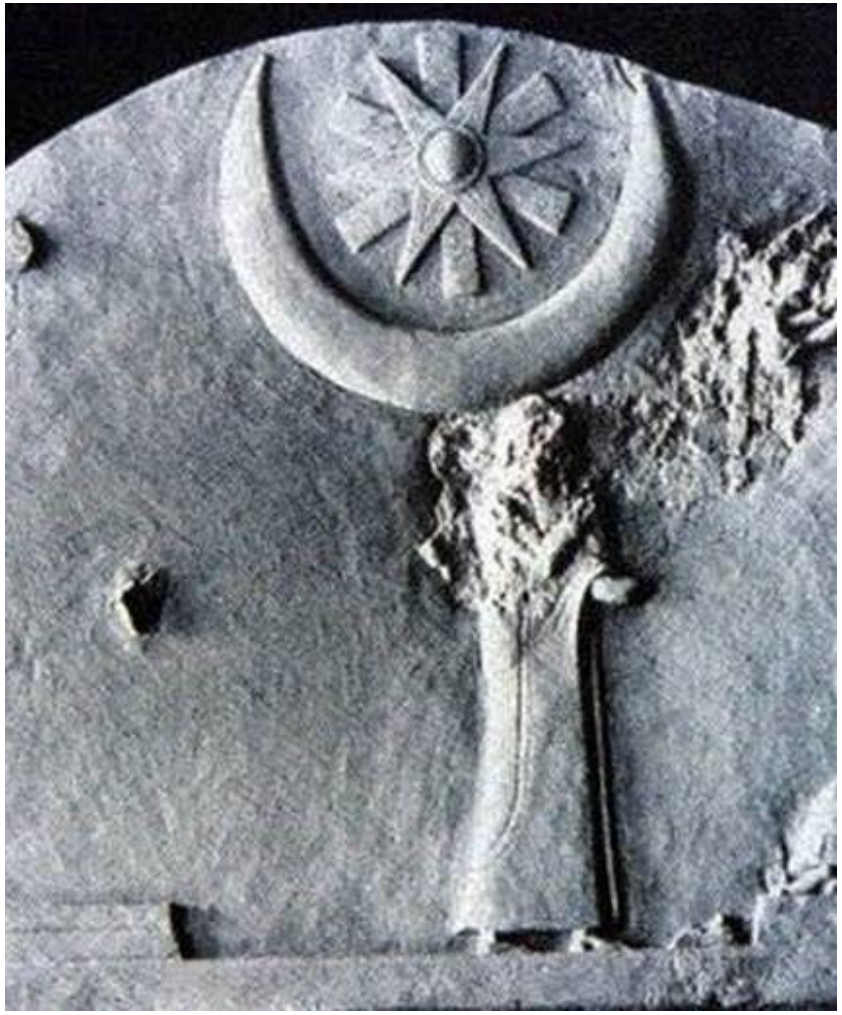
High priests and priestesses observed the stars and moon from the The Great Ziggurat of Ur

Babylonian Astronomers





- 1200 BC - 60 BC
- **Compiled star catalogs**
- First to divide circle into 360 degrees
- Made **calculations of daylength changes, planet motions and lunar eclipses**



A "star of Ishtar" was carved famously on a stele (kudurru) of King Melishipak of Babylon in 1100 BC, next to a bright crescent Moon and the Sun

July 20, 2016 near West Kennett Longbarrow

BC

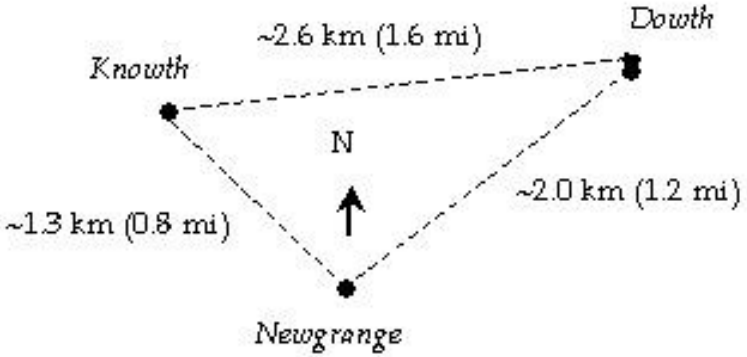
Newgrange

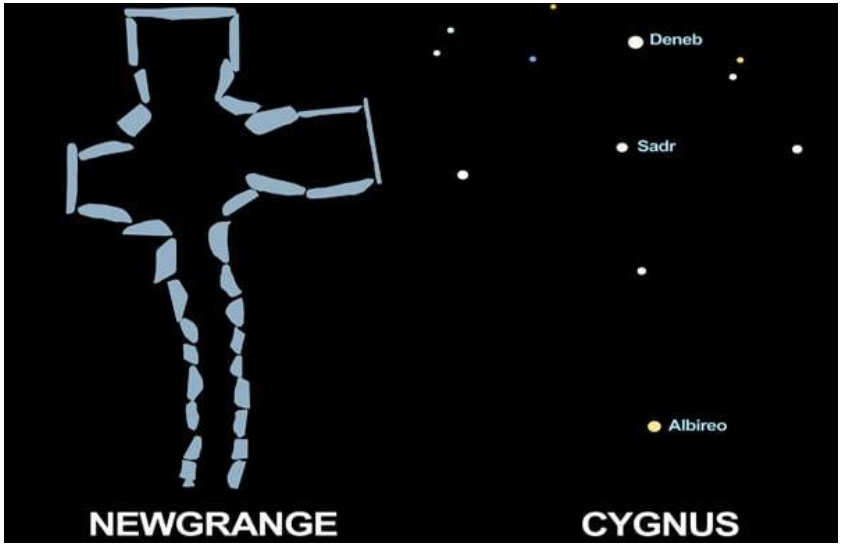
Passage Tomb,
Co Meath

Built 3200BC

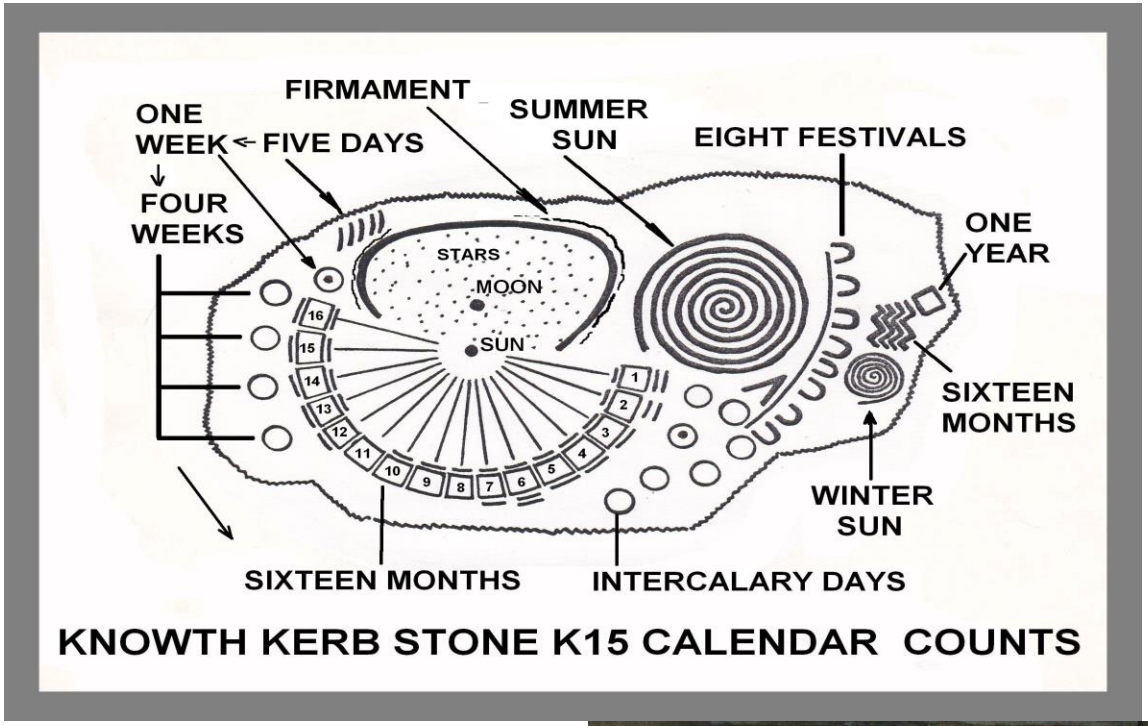
Light Box Aligned
On Winter
Solstice

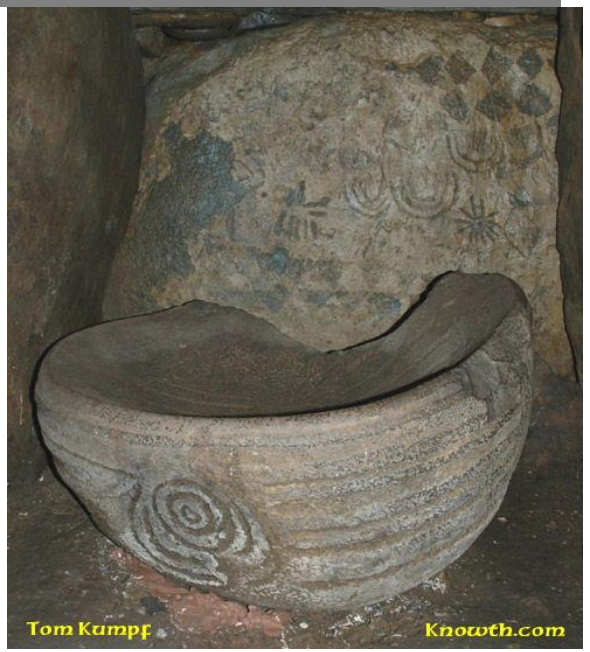
Newgrange Image Jimmy Harris


Dowth
~2.6 km (1.6 mi)
Knowth
N
~2.0 km (1.2 mi)
~1.3 km (0.8 mi)
Newgrange

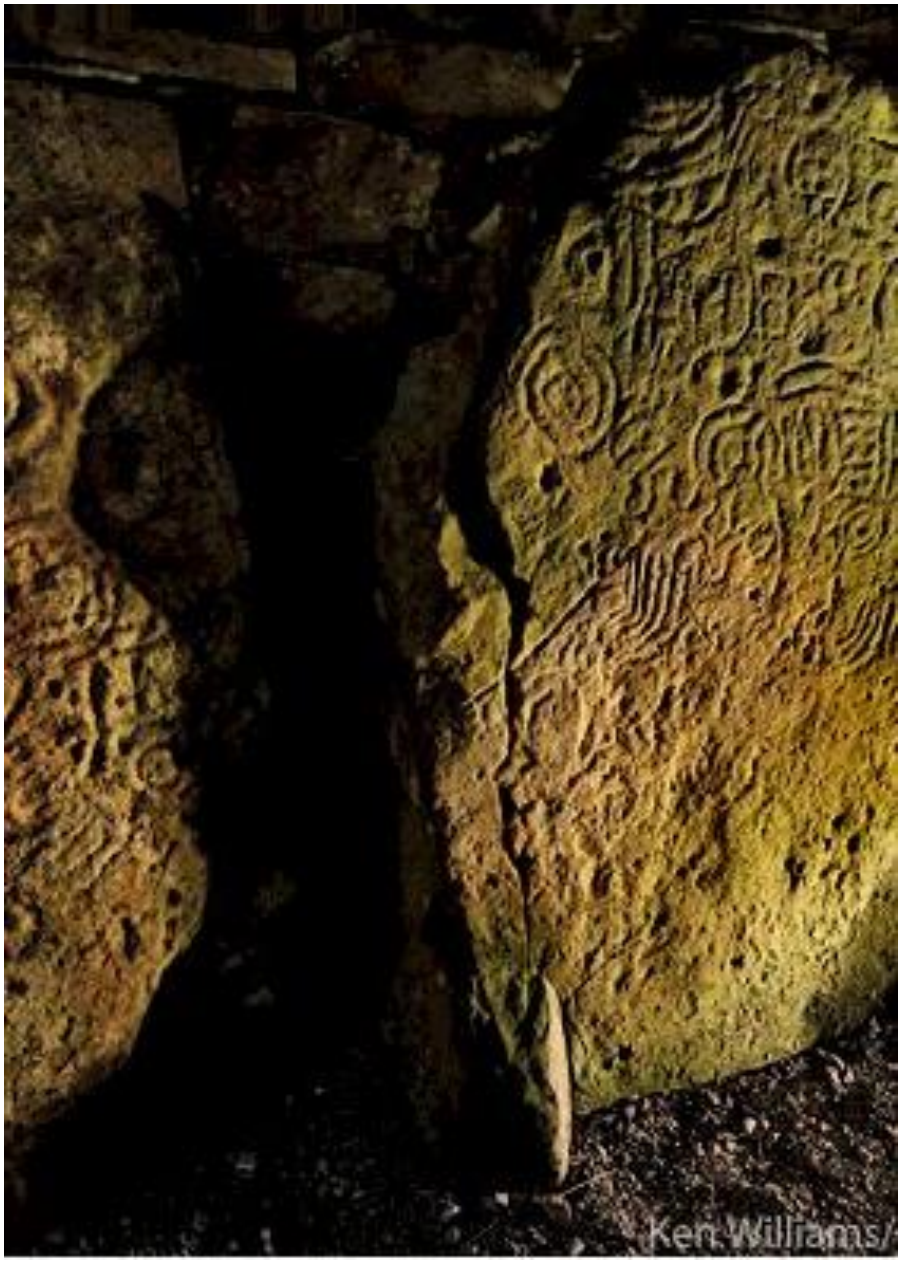

Deneb
Sadr
Albireo
NEWGRANGE
CYGNUS

Knowth Tomb – precision astronomy for rituals






Lougherew passage tomb


Ken Williams


BoyneValleyTours.com

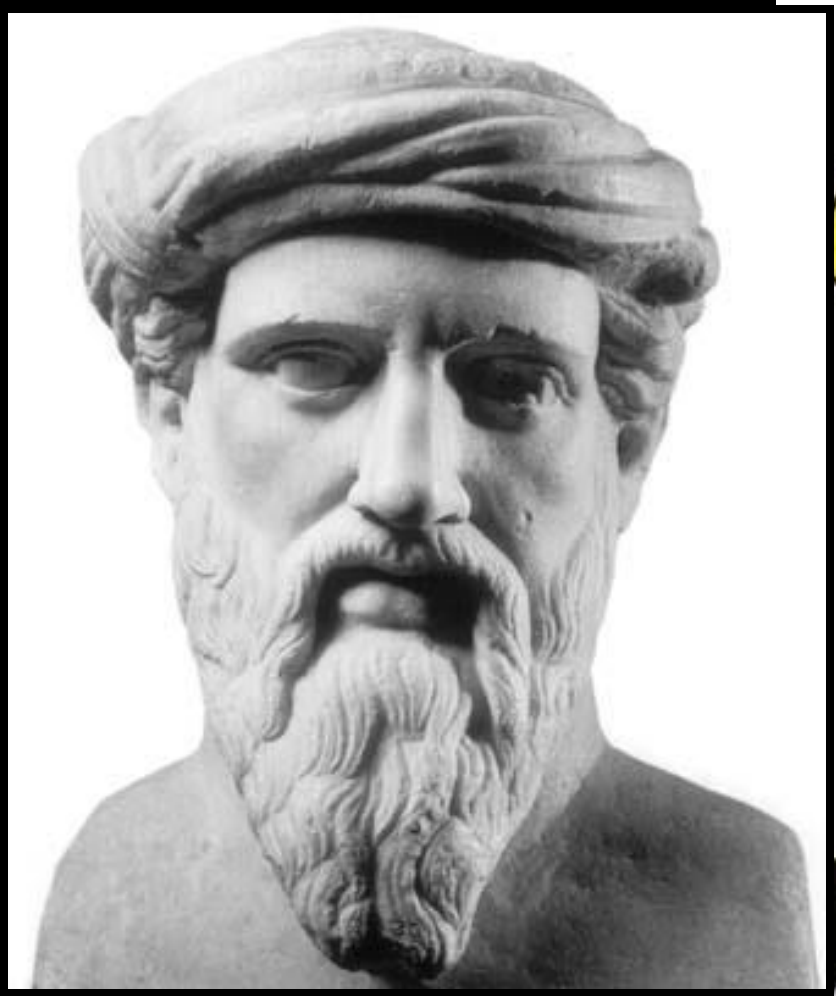
GREEK ASTRONOMY (650 BC - 150 AD).

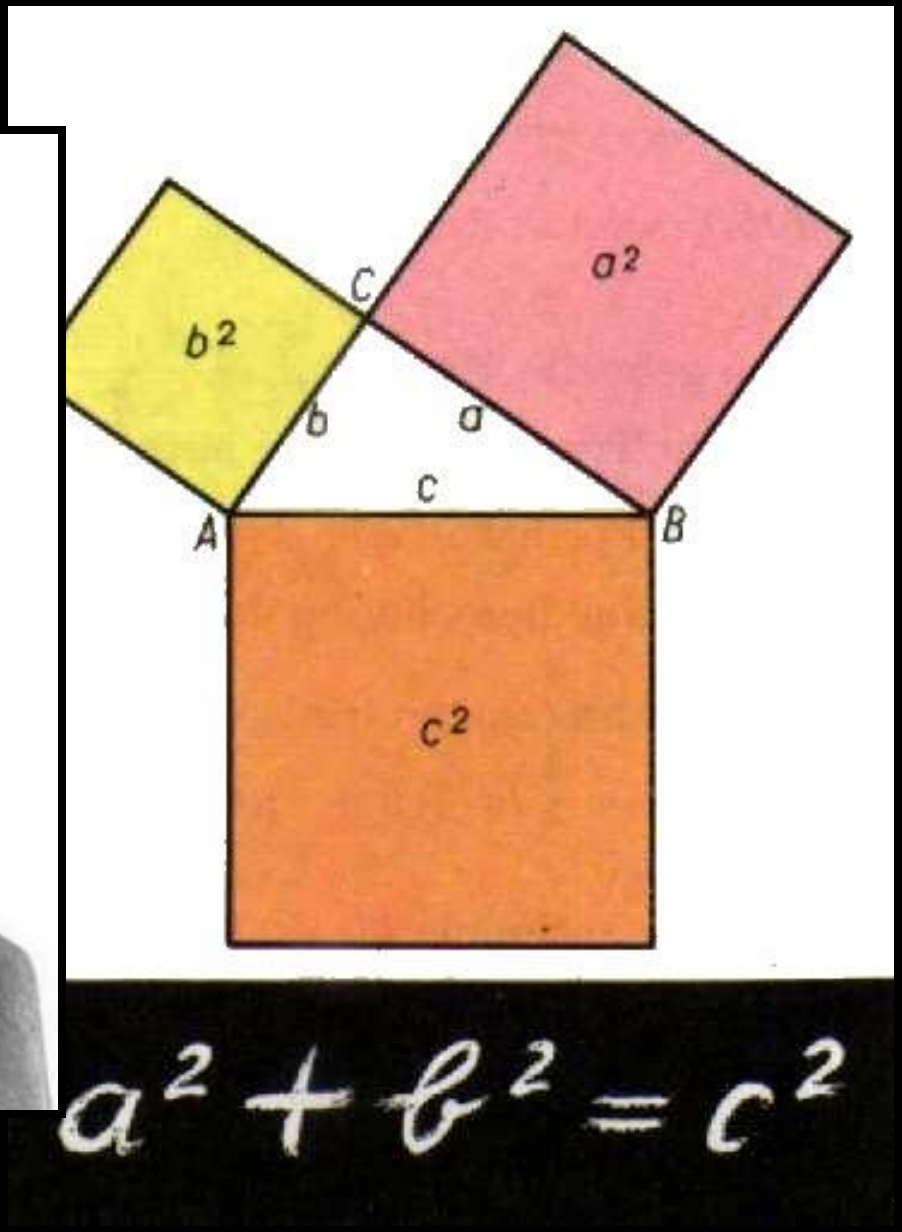
(1)Greeks were great theorists,
but poor observers or experimenters.

(2)Greeks used Babylonian records
& Greek geometry.

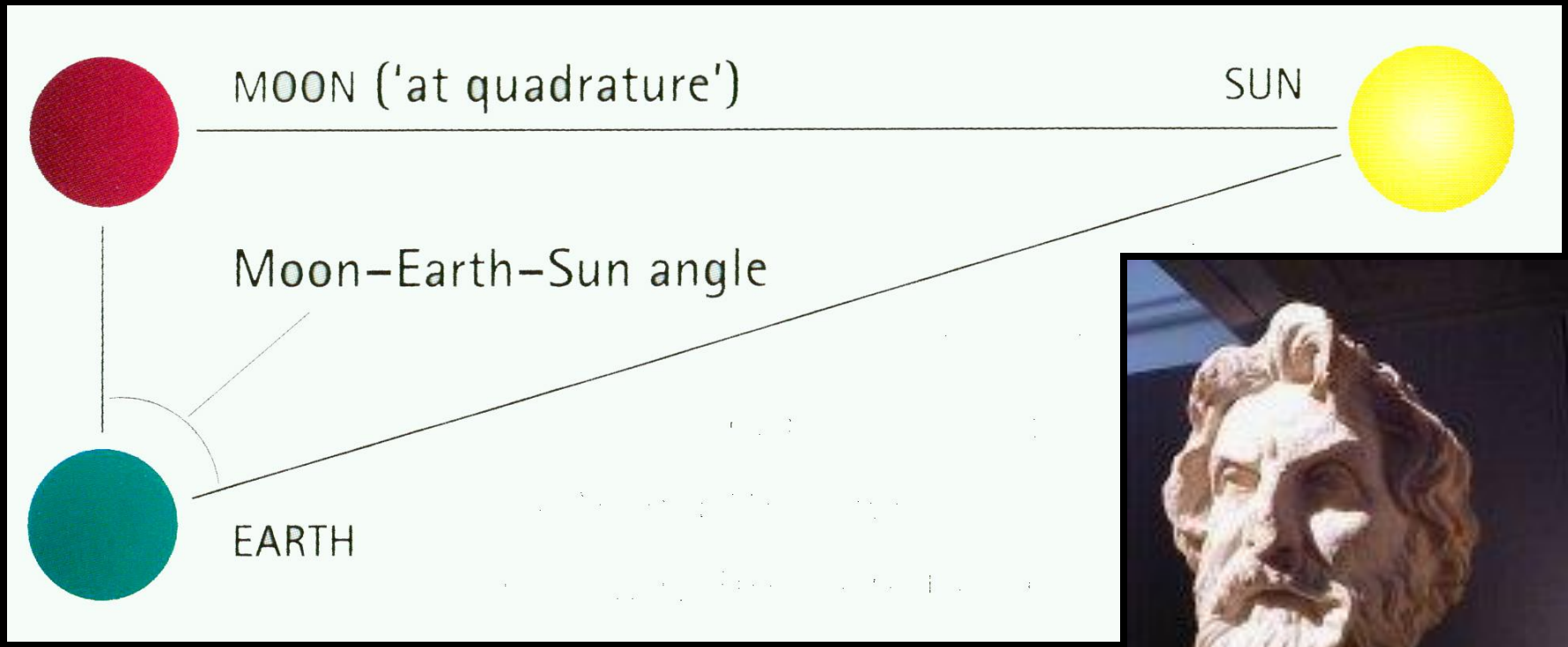
(3)Ionians (c 600 BC) - first Greek
cosmology. Impersonal *laws* replace
Mythology in some instances.

Pythagoras





Aristarchus (310 -230 BC) - How to measure the relative distances between the Earth, Sun and Moon

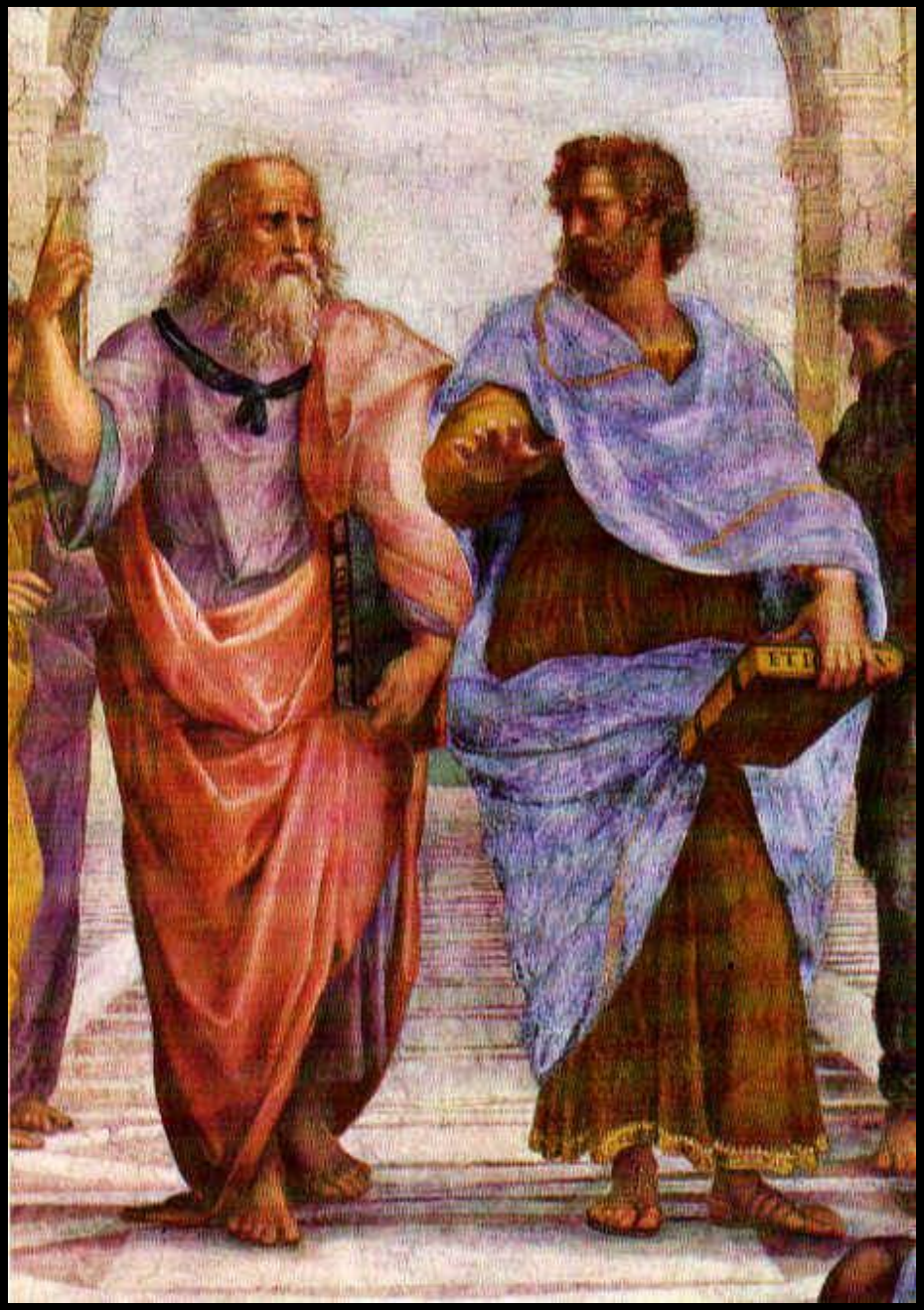


Aristotle & Plato

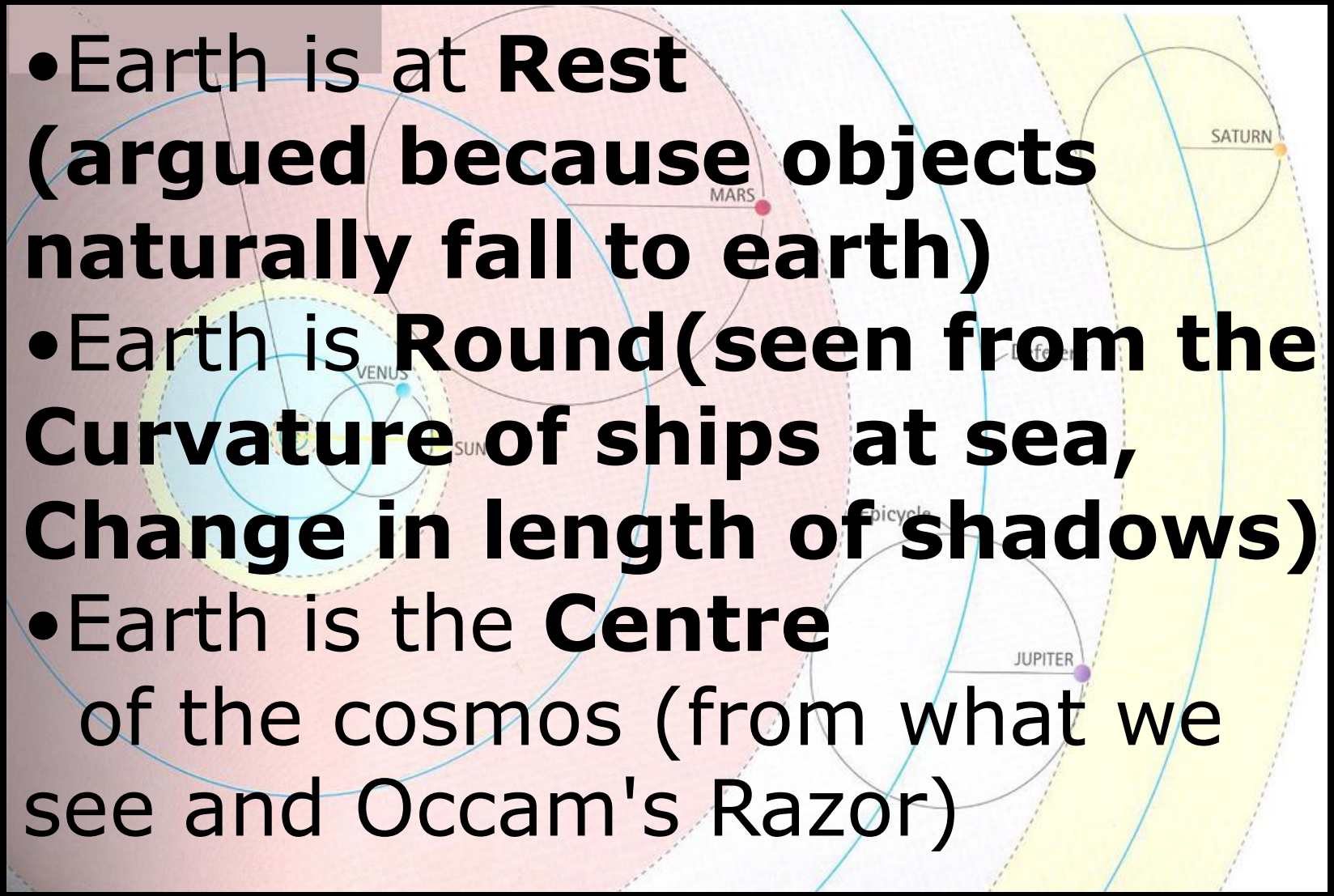
Plato is famous for developing theory of forms
In nature

(5)Aristotle (fl 350 BC)- Developed idea of Round earth at the centre of the cosmos.

Aristotle's cosmology is rooted in common sense & intuitive rationality - Sympathies and Antipathies



Aristotle's Cosmology



- Earth is at **Rest (argued because objects naturally fall to earth)**
- Earth is **Round(seen from the Curvature of ships at sea, Change in length of shadows)**
- Earth is the **Centre** of the cosmos (from what we see and Occam's Razor)

GREEK ASTRONOMY (650 BC - 150 AD).

(6) Celestial Sphere's motions are predictable, what about the 7 planets?

Plato (fl 400 BC) challenged geometricians to describe planetary motion in lawful terms.

This became Astronomy's project for next 2000 years.

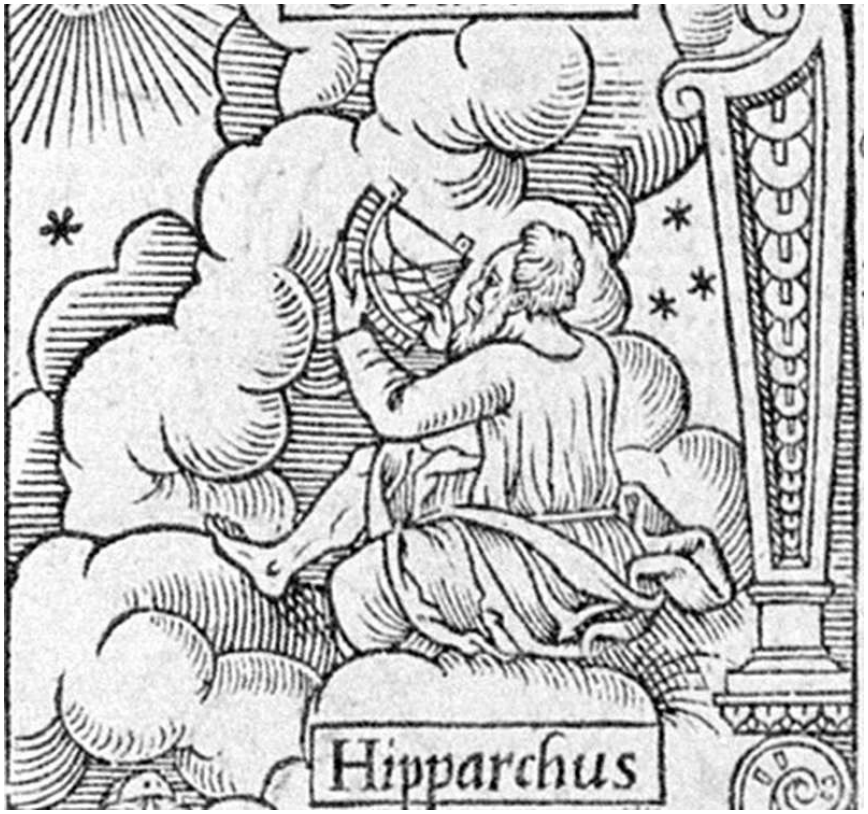
Ptolemy of Alexandria

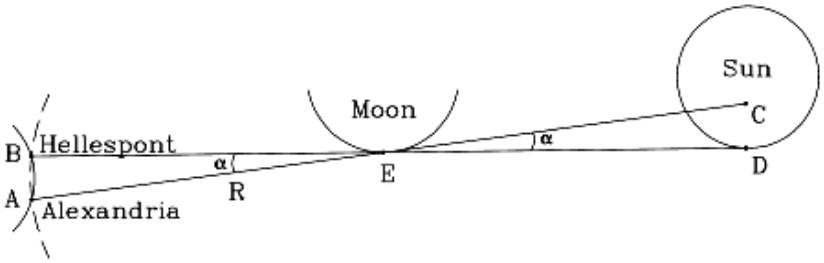
(7) The most elaborate Greek astronomer.

The "Almagest" (c 145 AD) gave mathematical model of planet's motions that could be calculated for any date, past or future.

- Hypatia Last of the great philosophers of Alexandria – killed by an angry mob

Hipparchus of Rhodes





Persian and Arab Medieval Astronomy

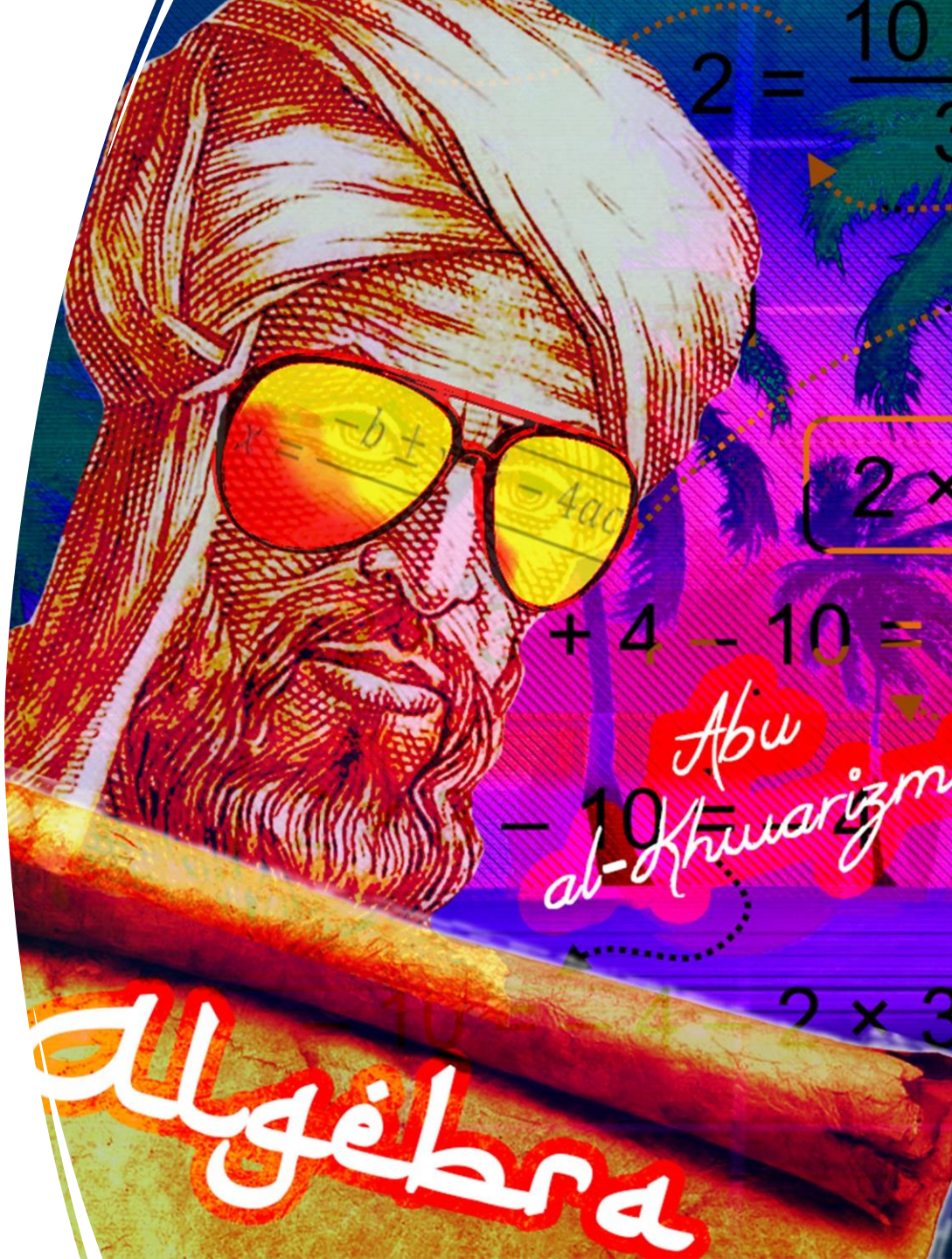
Early formal catalogues
- Names of brightest stars

Refined Greek Models
- Doubts about Ptolemy

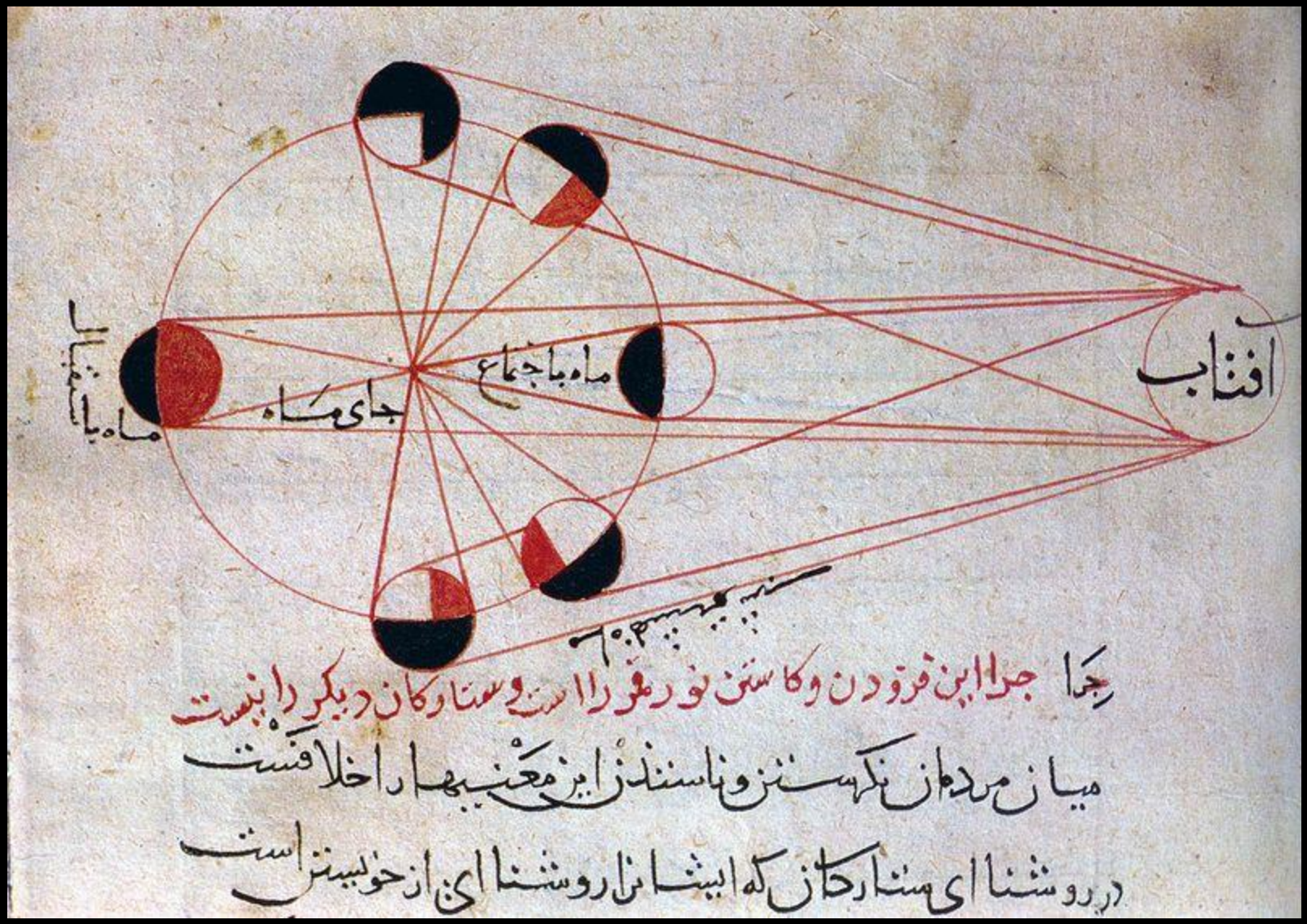
Advanced Mathematics
- Calculated movement

- **Persian al-Khwarizmi** in 830. The work contains tables for the movements of the Sun, the Moon, and the five planets known at the time. The work is significant as it introduced Ptolemaic concepts into Islamic sciences.

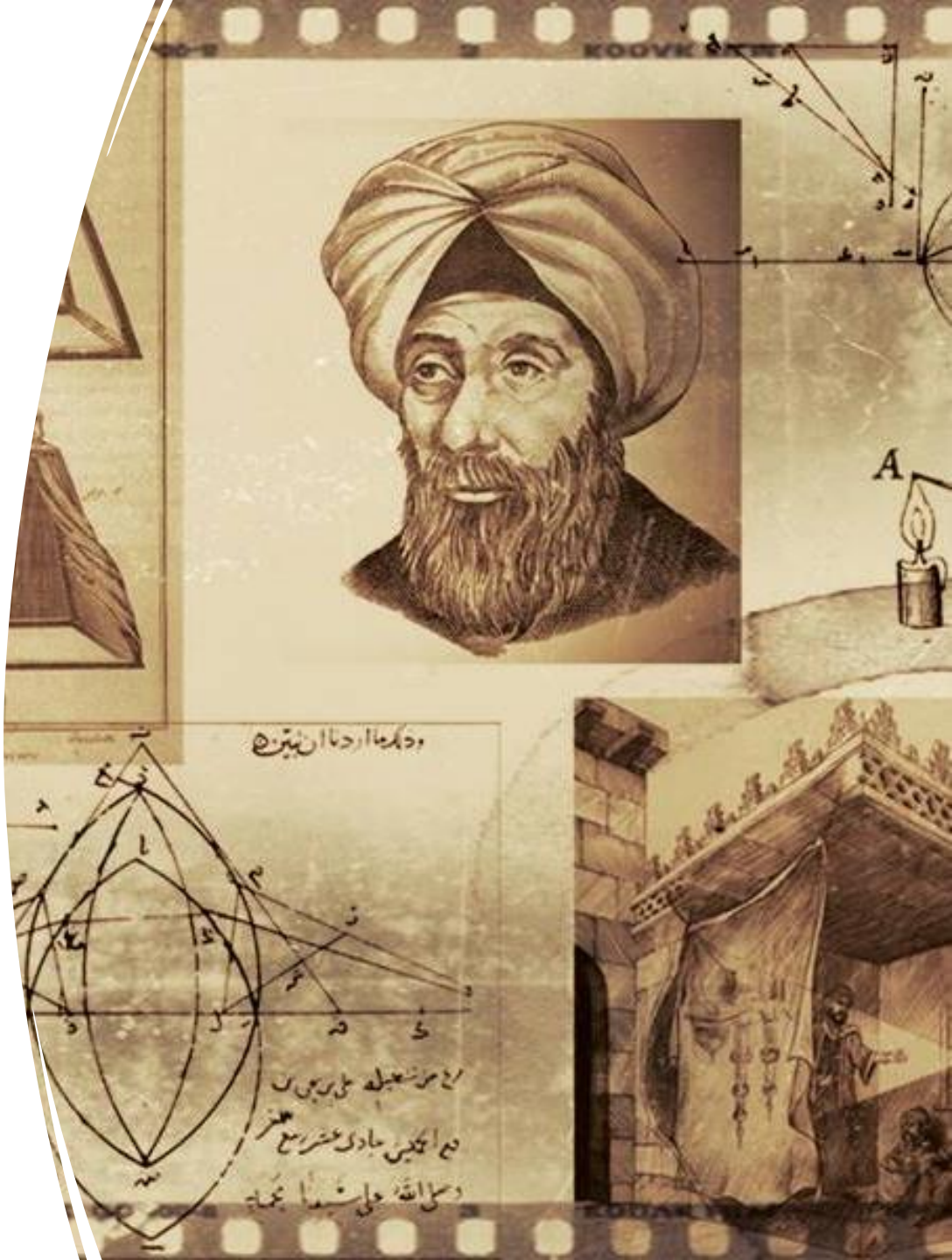
- Also invented algebra



Arab Medieval Astronomy



Ibn Al-Haytham (Alhazen) inventor of the camera obscura and pioneer in optics



Mayan Astronomers

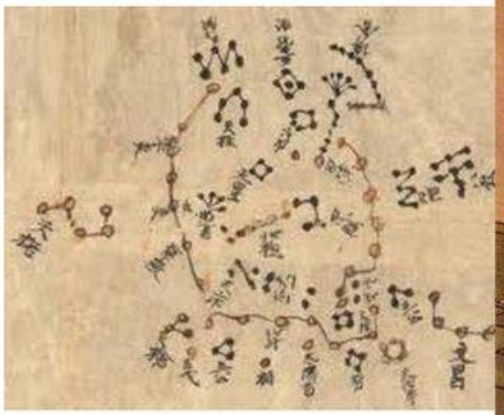
- Civilization lasted for 2000 years, peaked between 300 and 900 AD
- Carefully studied the sun, moon, planets, especially Venus
- Predicted eclipses
- Their architecture was laid out with respect to astronomy
- Created two major calendaring systems, but the Long Count was calculated from August, 3114 BC

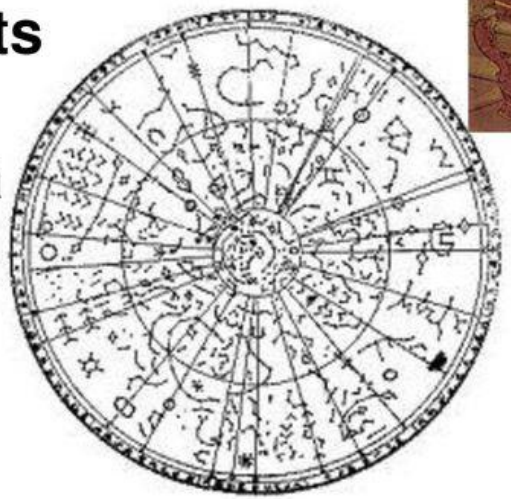
All over the world, across time, cultures have created patterns in the sky called constellations

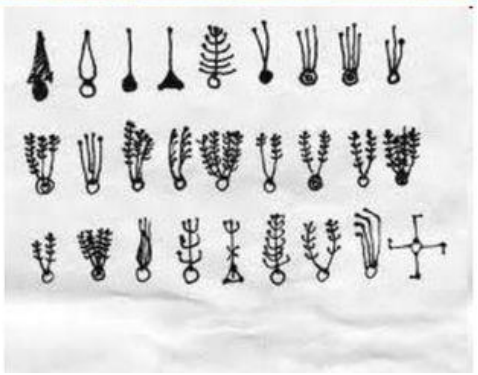
- In Peru

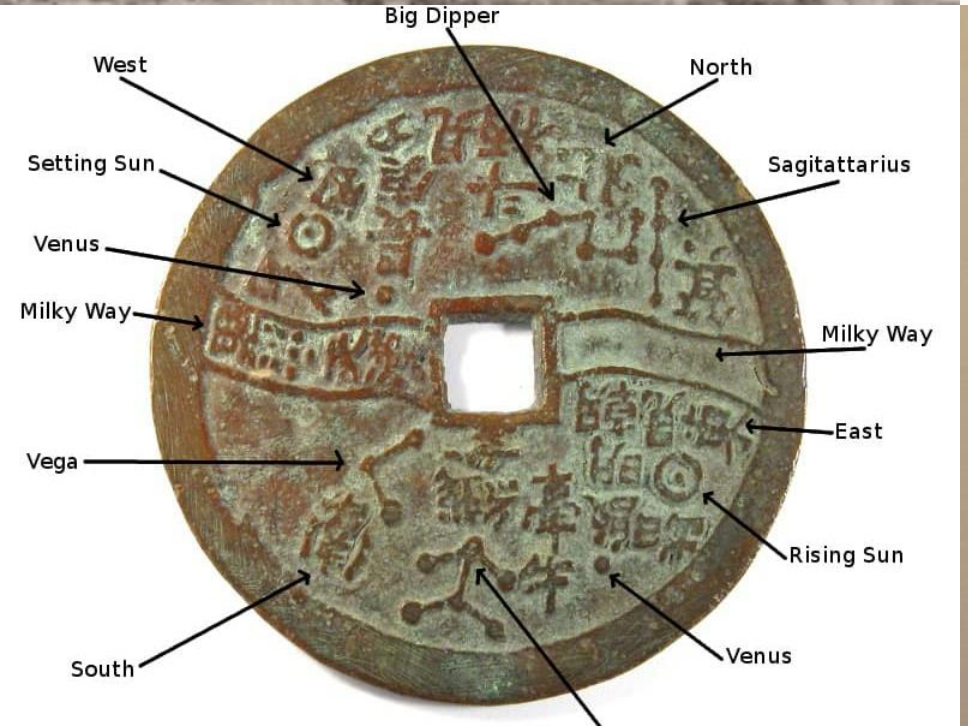
Chinese Astronomers

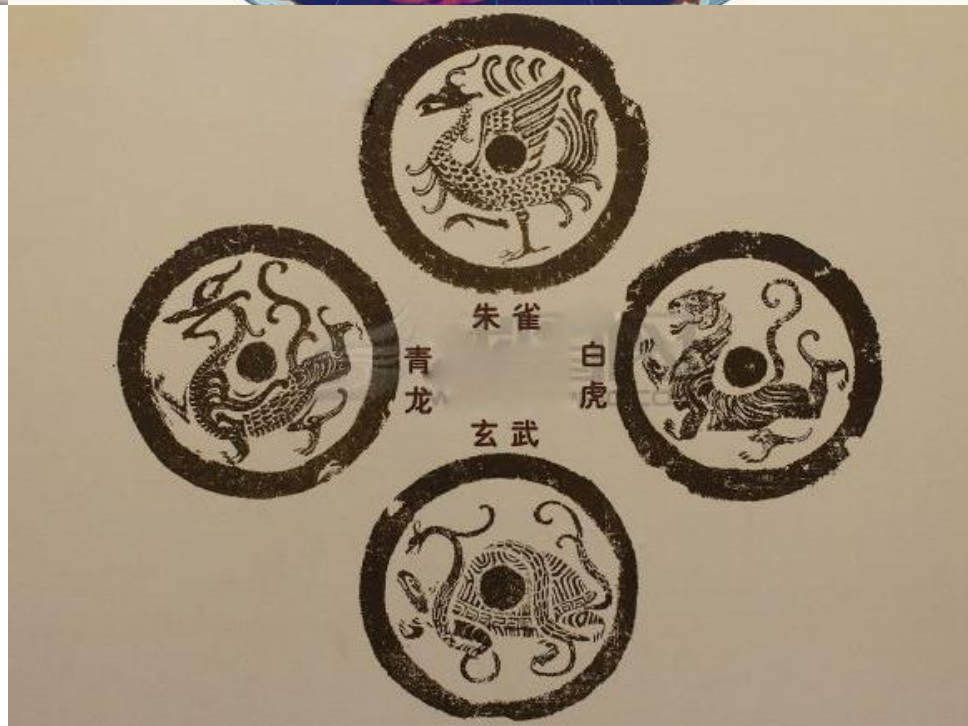
- 600 BC onward
- **Compiled star catalogs**
- Used for **timekeeping**
- **Observed and predicted comets and eclipses**
- **First to record a** ‘guest star’, a **supernova**, in 185 AD.







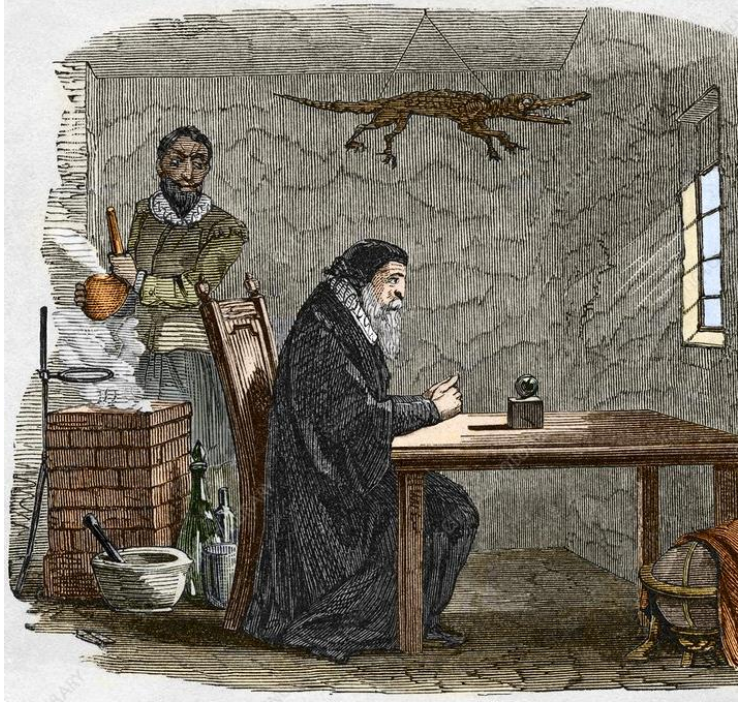

Big Dipper
West
North
Setting Sun
Sagitattarius
Venus
Milky Way
Milky Way
East
Vega
Rising Sun
South
Venus


朱雀
青龙
白虎
玄武

Meanwhile in Europe...Astronomy was used for Astrology

By figures such as John Dee and Francis Bacon

John Dee (13 July 1527 – 1608 or 1609) in many ways was a bridge between the occult ideas of nature popular in the Middle Ages and the Enlightenment Worldview that was to Emerge

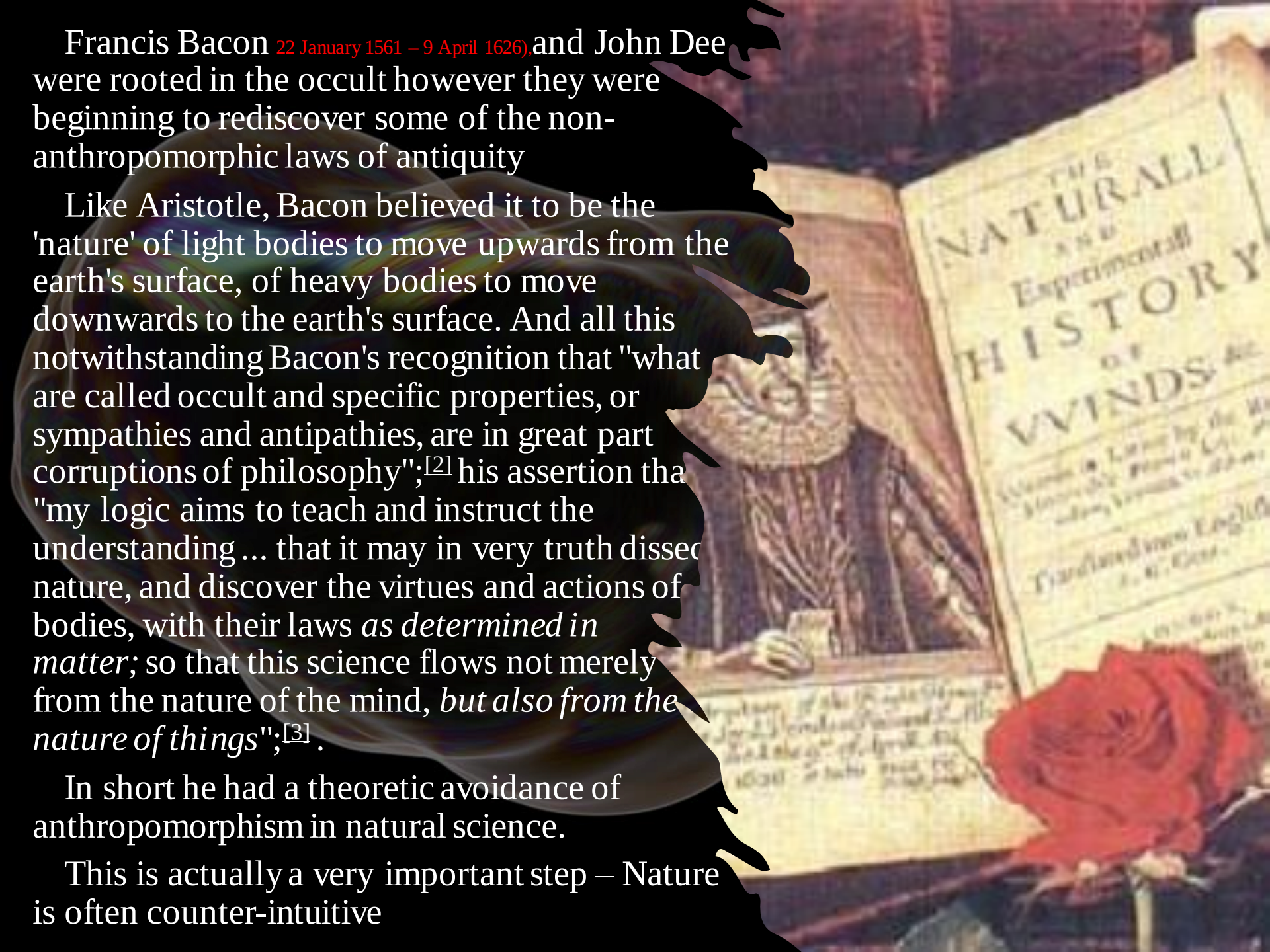


Francis Bacon 22 January 1561 – 9 April 1626), and John Dee were rooted in the occult however they were beginning to rediscover some of the non-anthropomorphic laws of antiquity

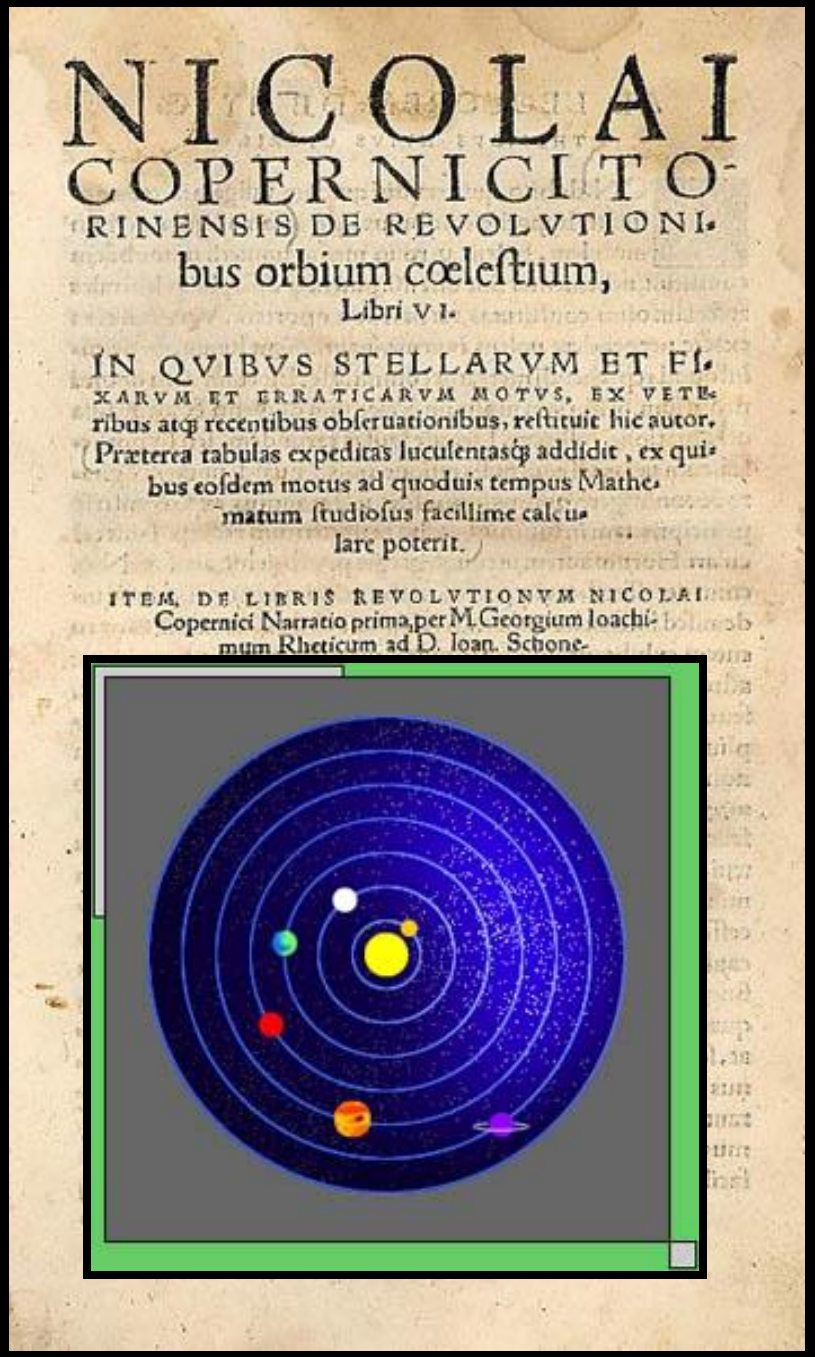
Like Aristotle, Bacon believed it to be the 'nature' of light bodies to move upwards from the earth's surface, of heavy bodies to move downwards to the earth's surface. And all this notwithstanding Bacon's recognition that "what are called occult and specific properties, or sympathies and antipathies, are in great part corruptions of philosophy";[2] his assertion tha "my logic aims to teach and instruct the understanding ... that it may in very truth dissec nature, and discover the virtues and actions of bodies, with their laws *as determined in matter;* so that this science flows not merely from the nature of the mind, *but also from the nature of things*";[3] .

In short he had a theoretic avoidance of anthropomorphism in natural science.

This is actually a very important step – Nature is often counter-intuitive



Nicholas Copernicus



NICOLAI
COPERNICI TO-
RINENSIS DE REVOLVTIONI-
bus orbium cœleſtium,
Libri VI.

IN QVIBVS STELLARVM ET FI-
XARVM ET ERRATICARVM MOTVS, EX VETE-
ribus atq; recentibus obſeruationibus, reſtituit hic autor.
Præterea tabulas expeditas luculentasq; addidit, ex qui-
bus eoſdem motus ad quoduis tempus Mathe-
matum ſtudioſus facillime calcu-
lare poterit.

ITEM, DE LIBRIS REVOLVTIONVM NICOLAI
Copernici Narratio prima, per M. Georgium Ioachi-
mum Rheticum ad D. Ioan. Schone-

Tycho Brahe
(14 December 1546 –
24 October 1601)

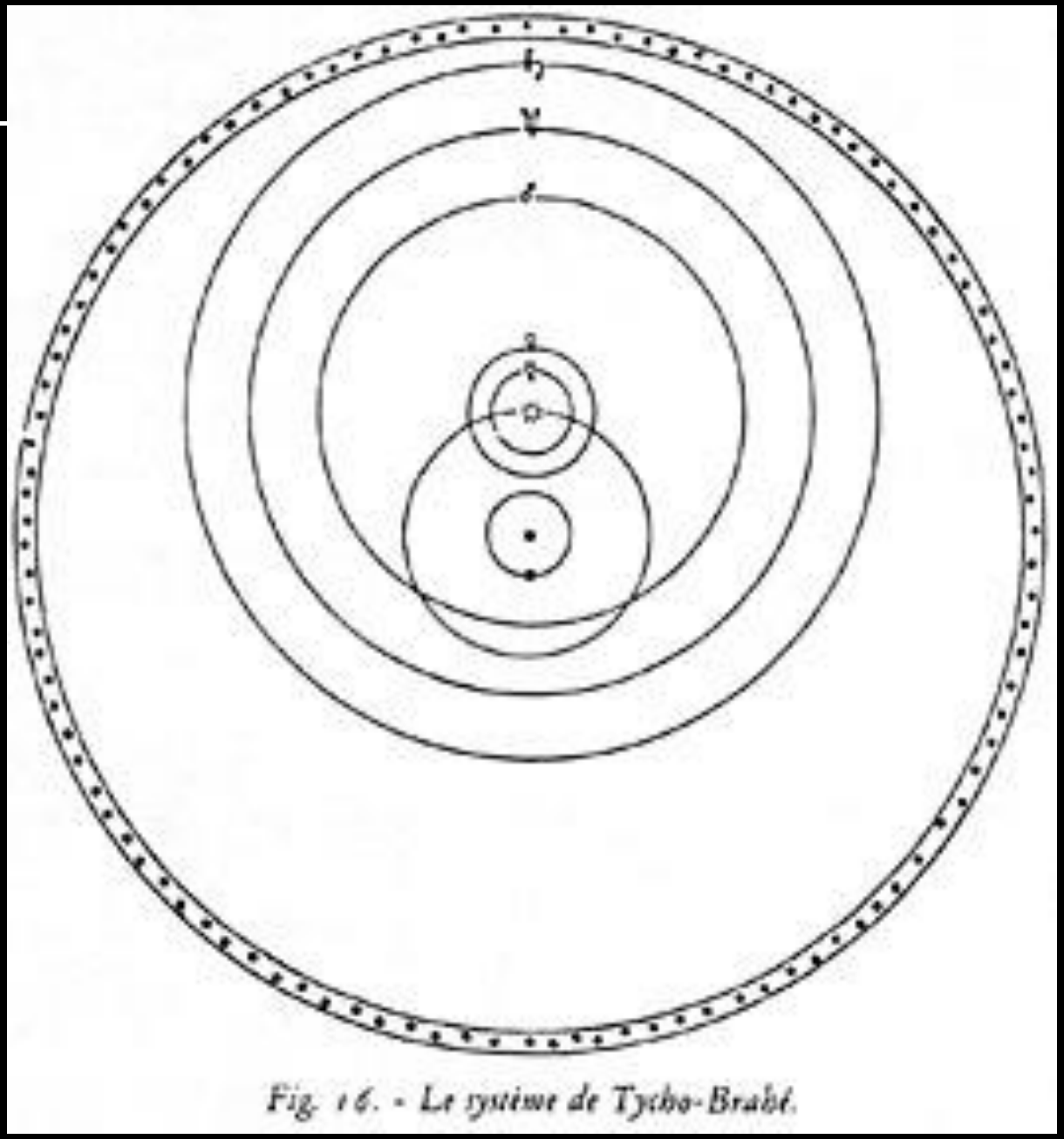
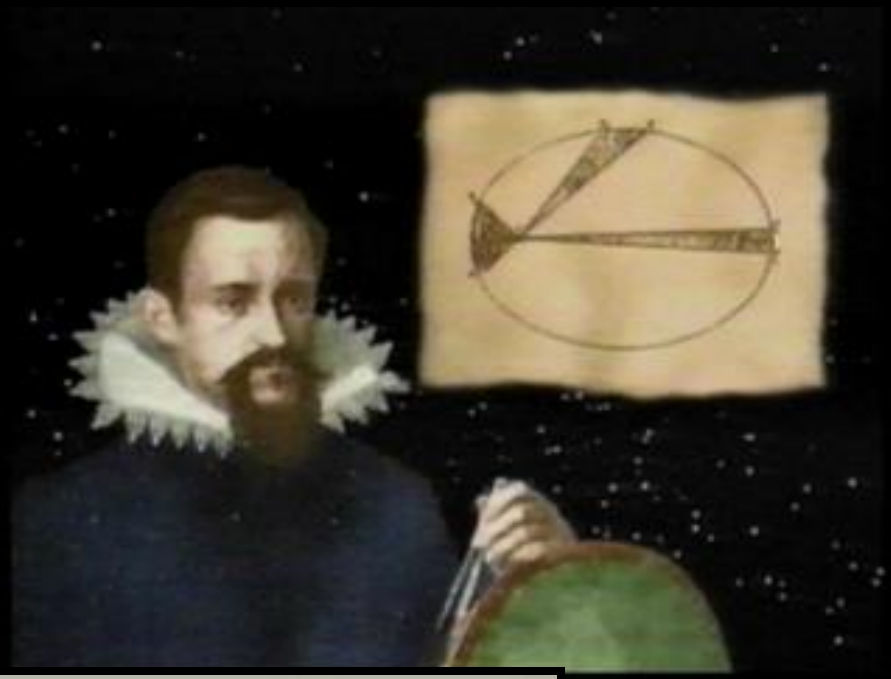
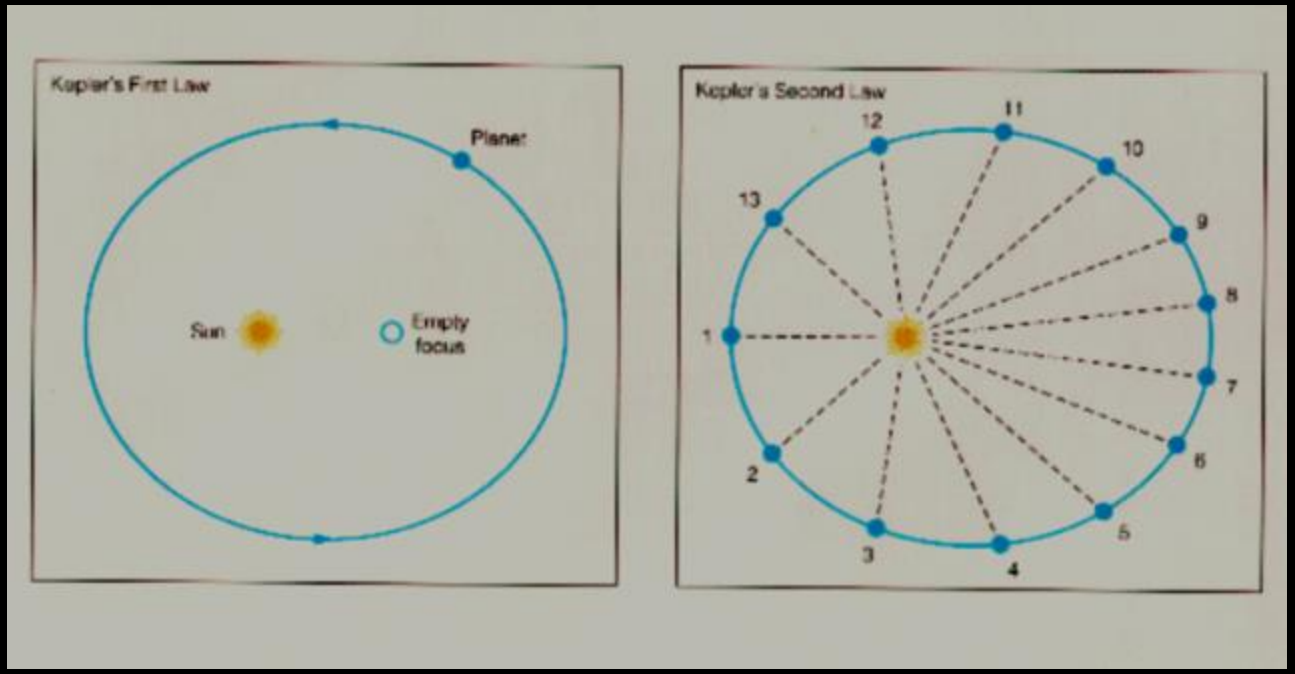
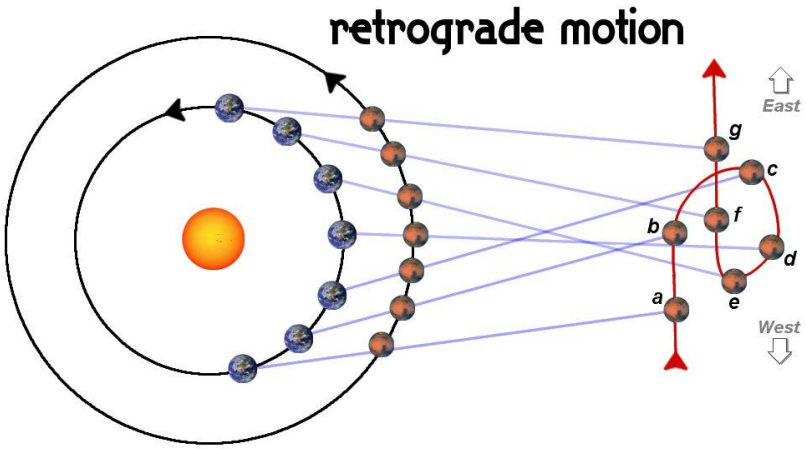


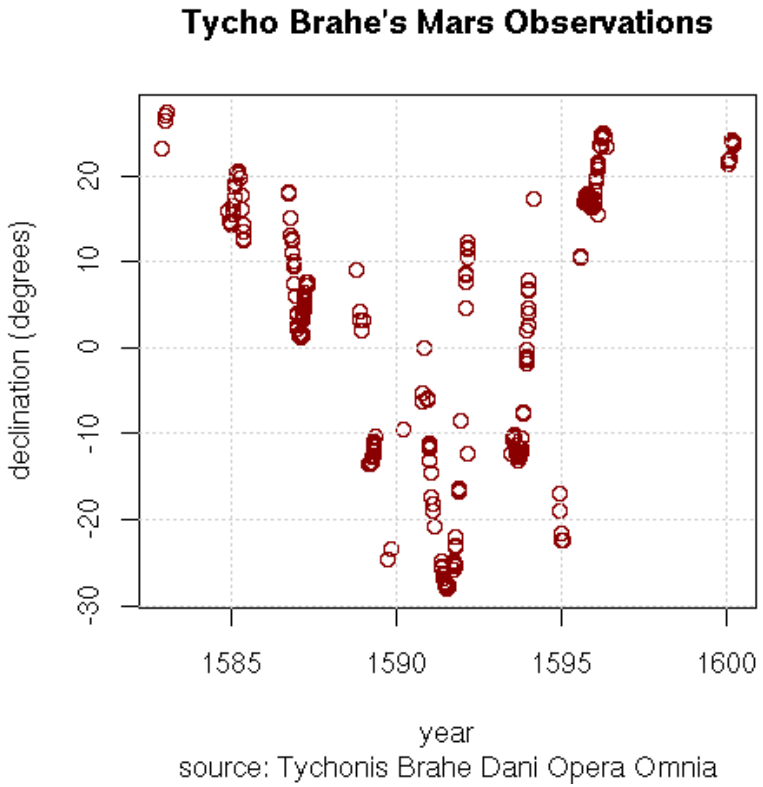
Fig. 16. - Le système de Tycho-Brahé.

Johannes Kepler

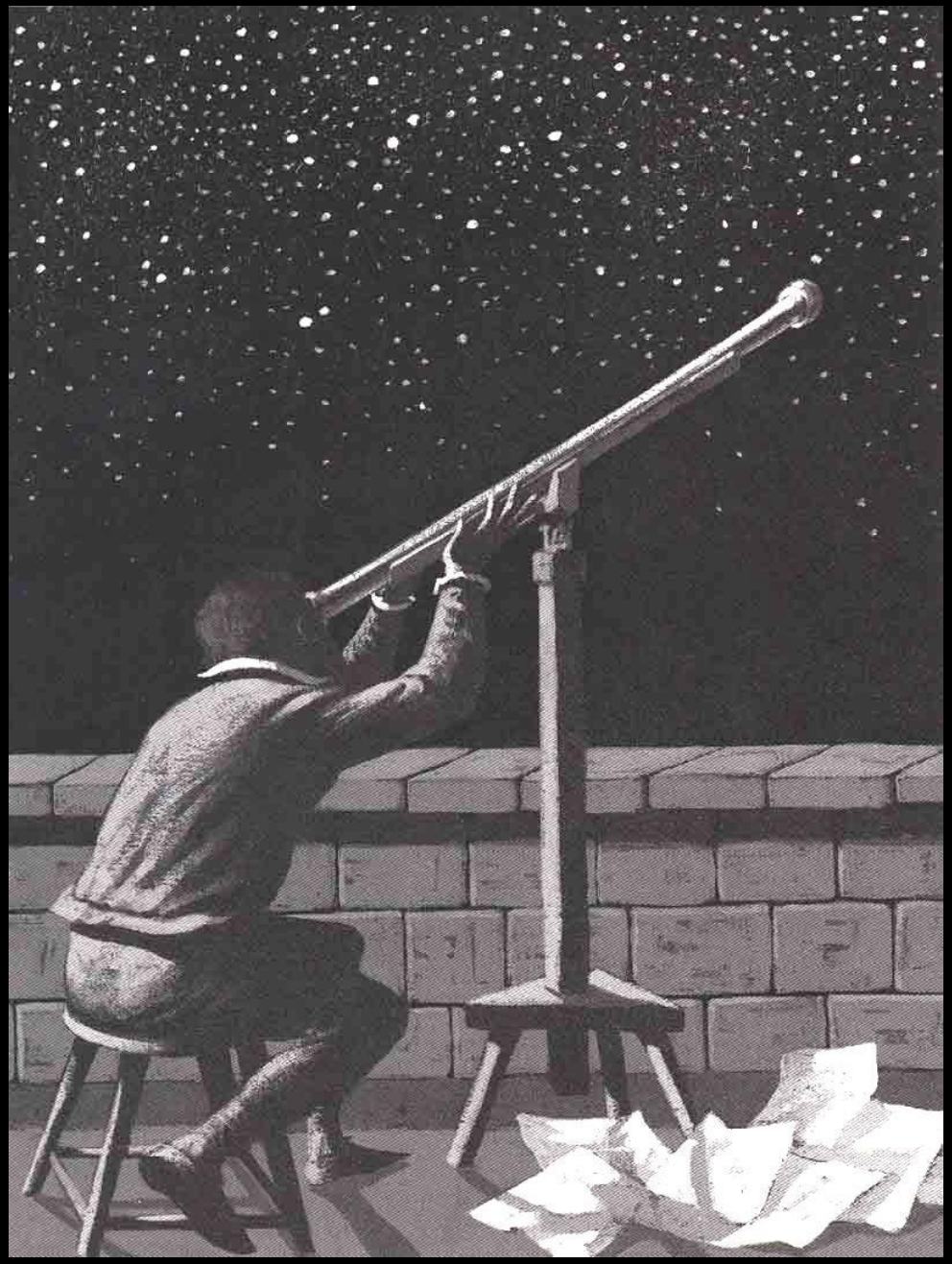




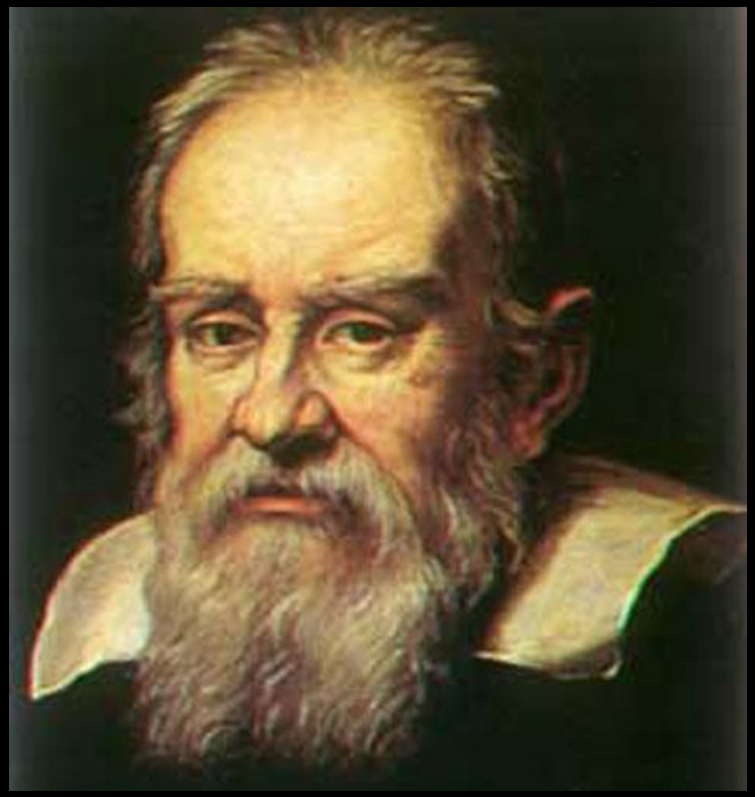

retrograde motion
East
West
a
b
c
d
e
f
g

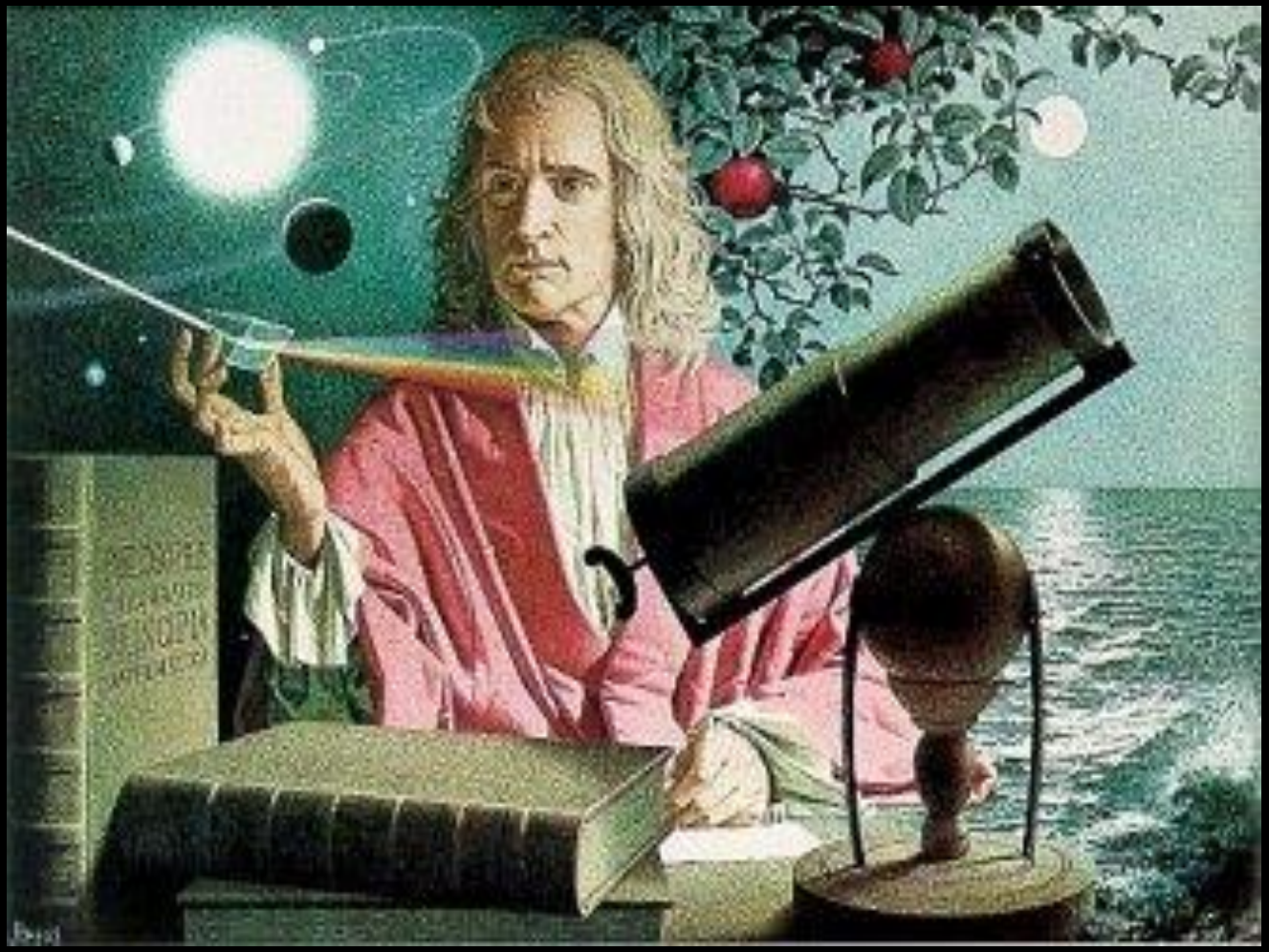

Tycho Brahe's Mars Observations
declination (degrees)
20
10
0
-10
-20
-30
1585
1590
1595
1600
year
source: Tychonis Brahe Dani Opera Omnia


HIS
101



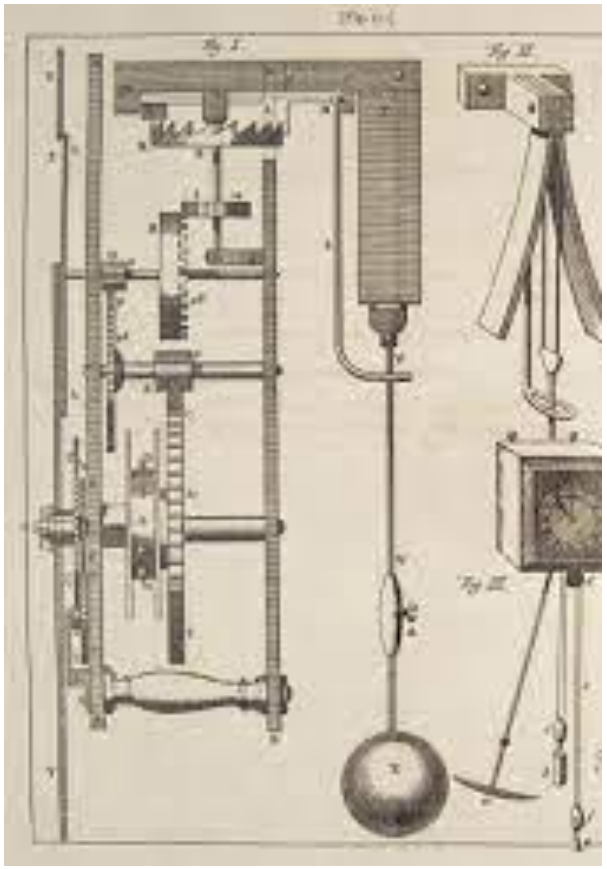
Galileo Galilei

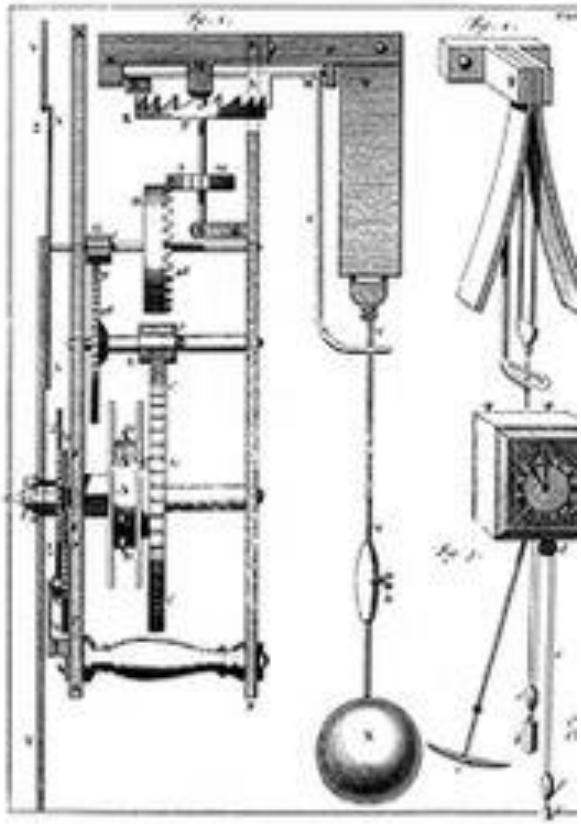


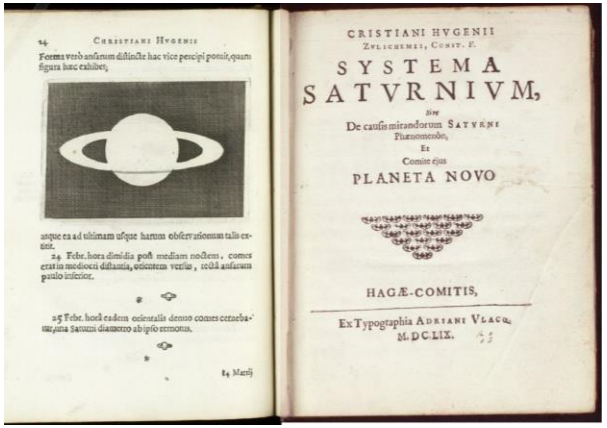


Isaac Newton(1642-1727) -
First Laws of Gravity that did not "invoke" Aristotle

When white light is passed through a prism it is split up into its component colours.

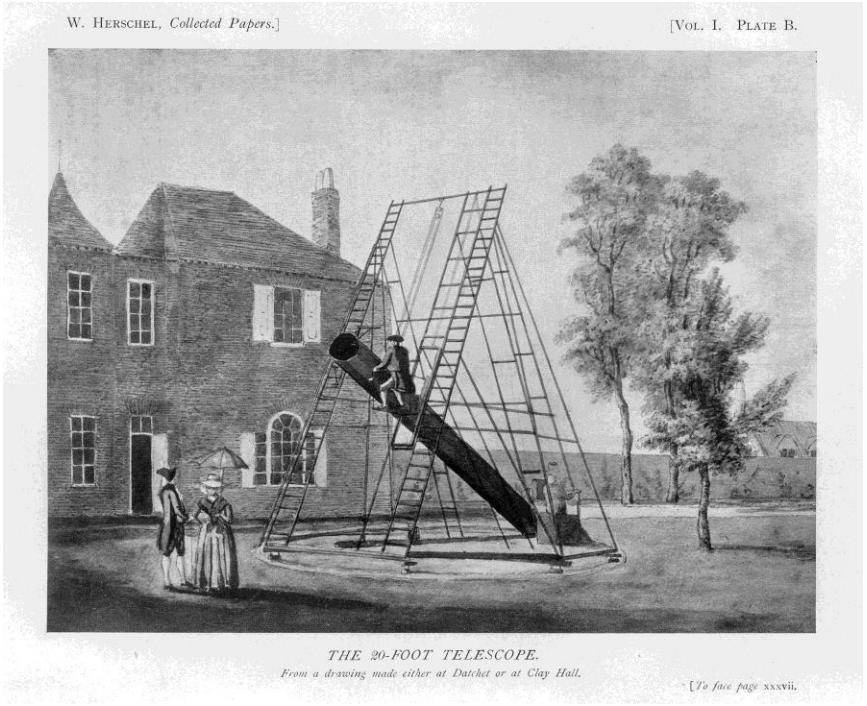


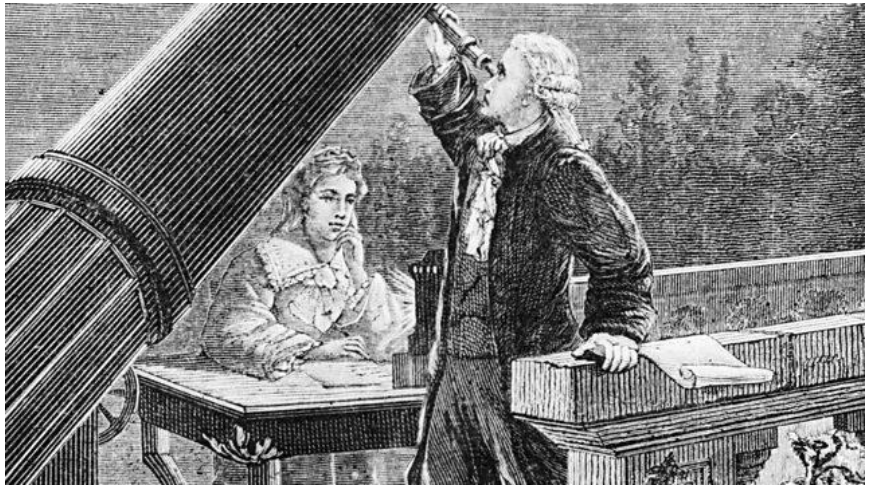




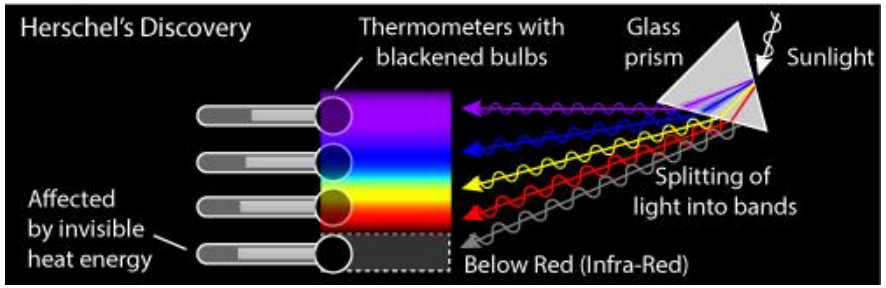
Christian Huygens Dutch Scientist– discoverer of Titan, emergent synchronization in pendulum clocks, Natural philosopher 14 April 1629 – 8 July 1695)

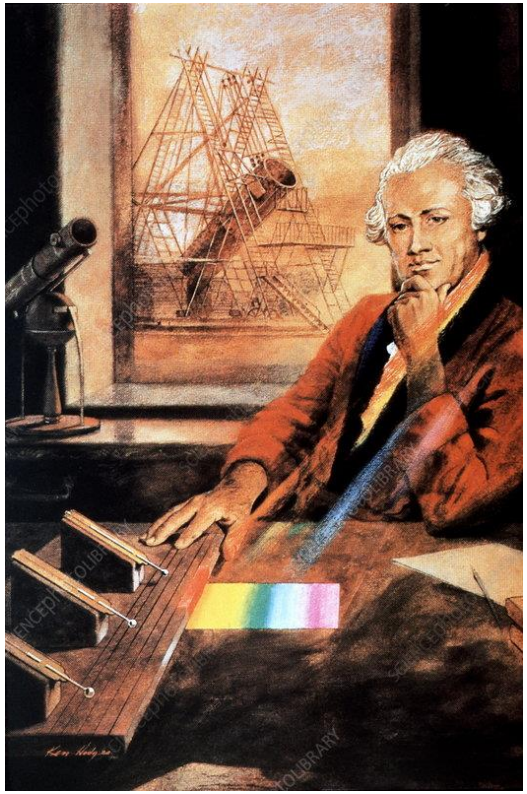
Observational Science Greatly expanded by William and Caroline Herschel





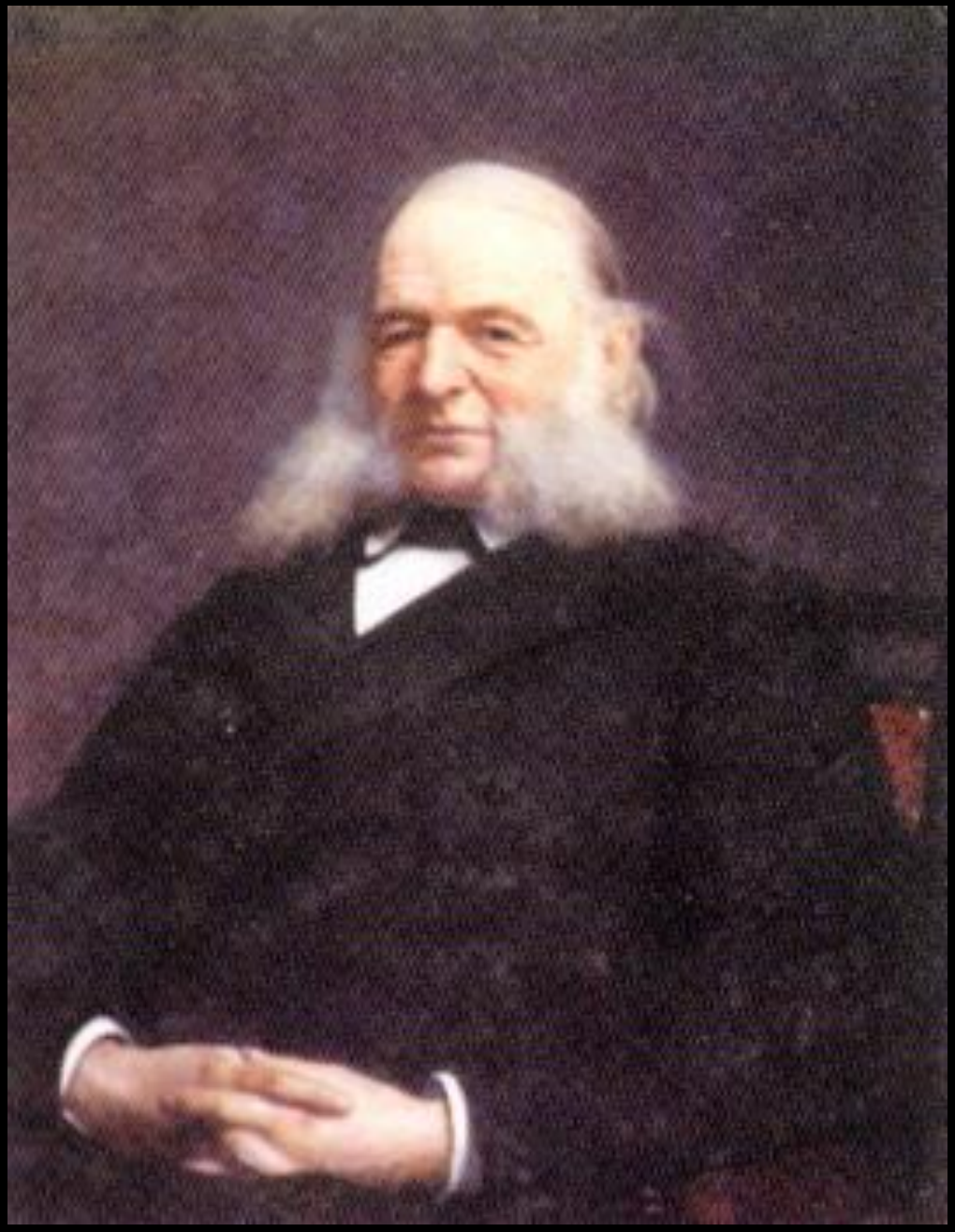
- Discovery of Infrared



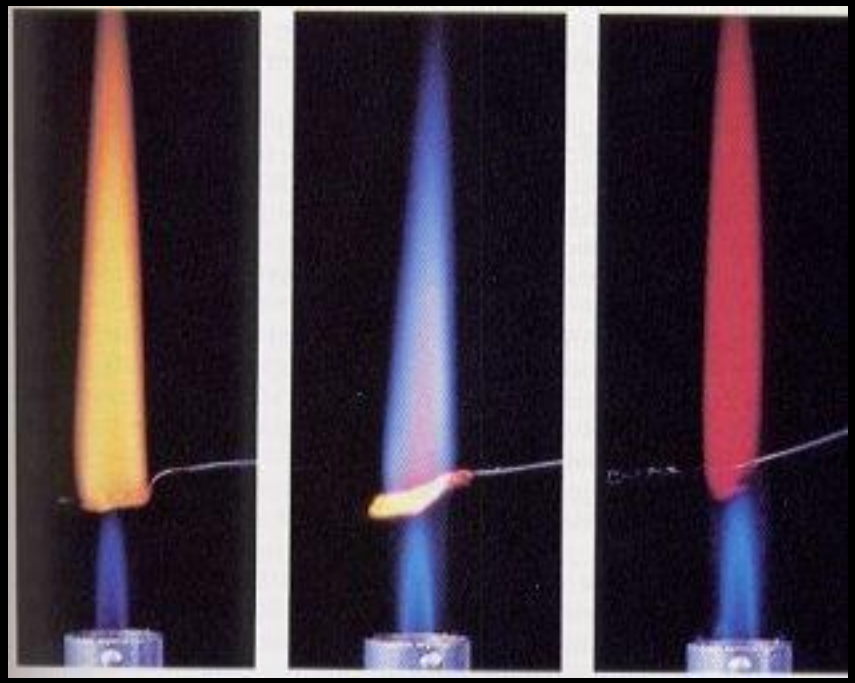


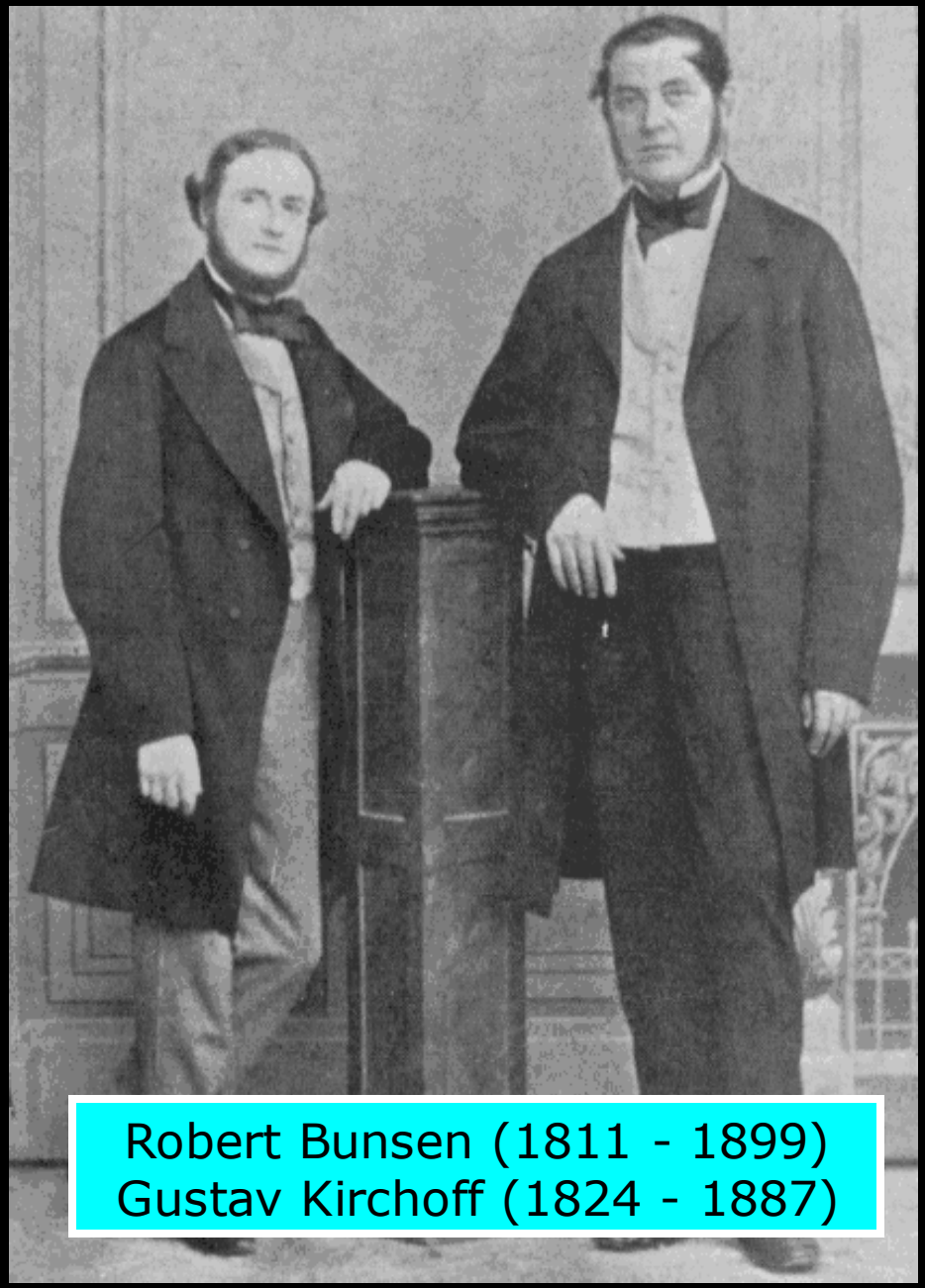
Otto Struve

Used *parallax* measurements to determine distance to nearby stars.



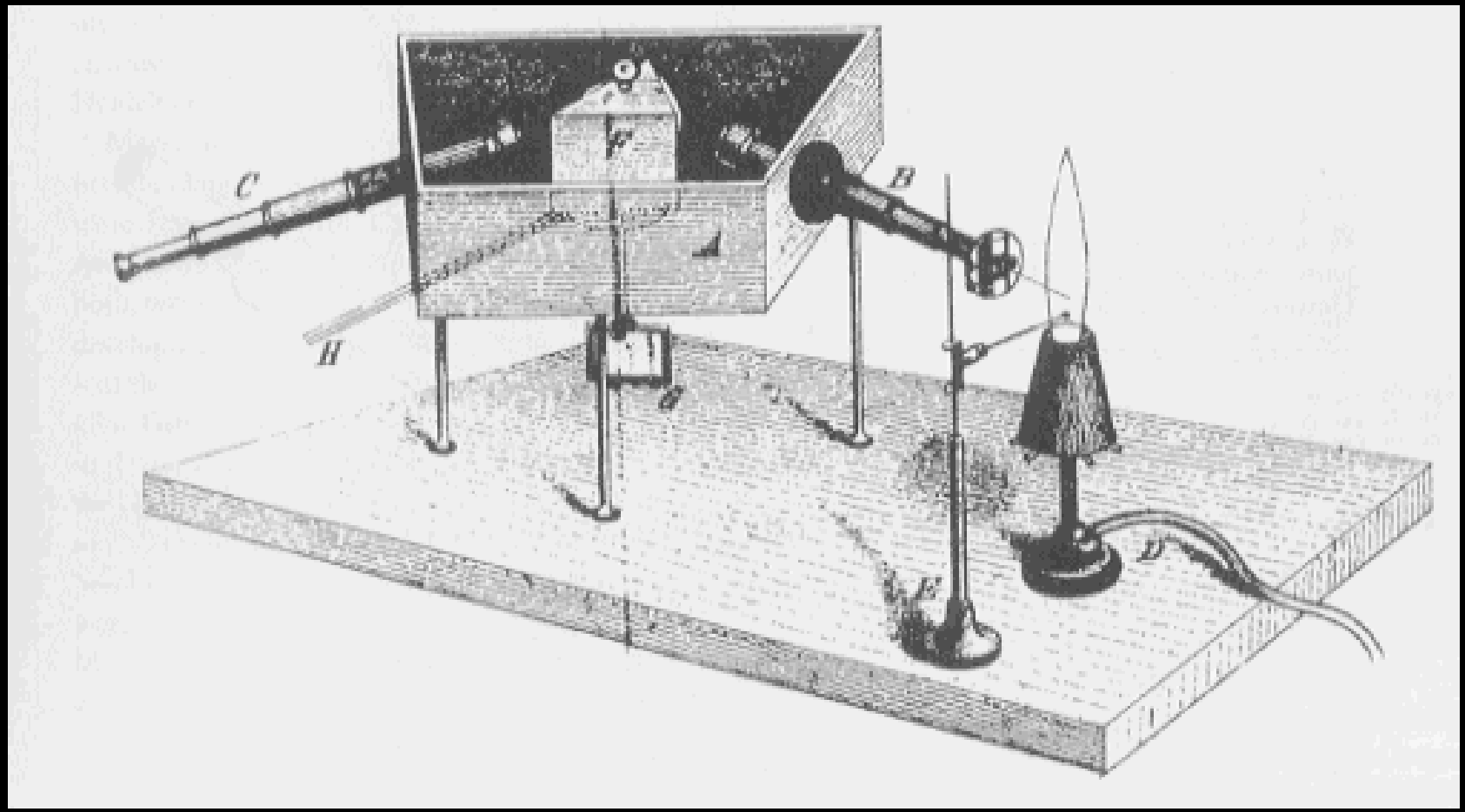
1859 - Elements are identified in Sunlight using spectroscopy



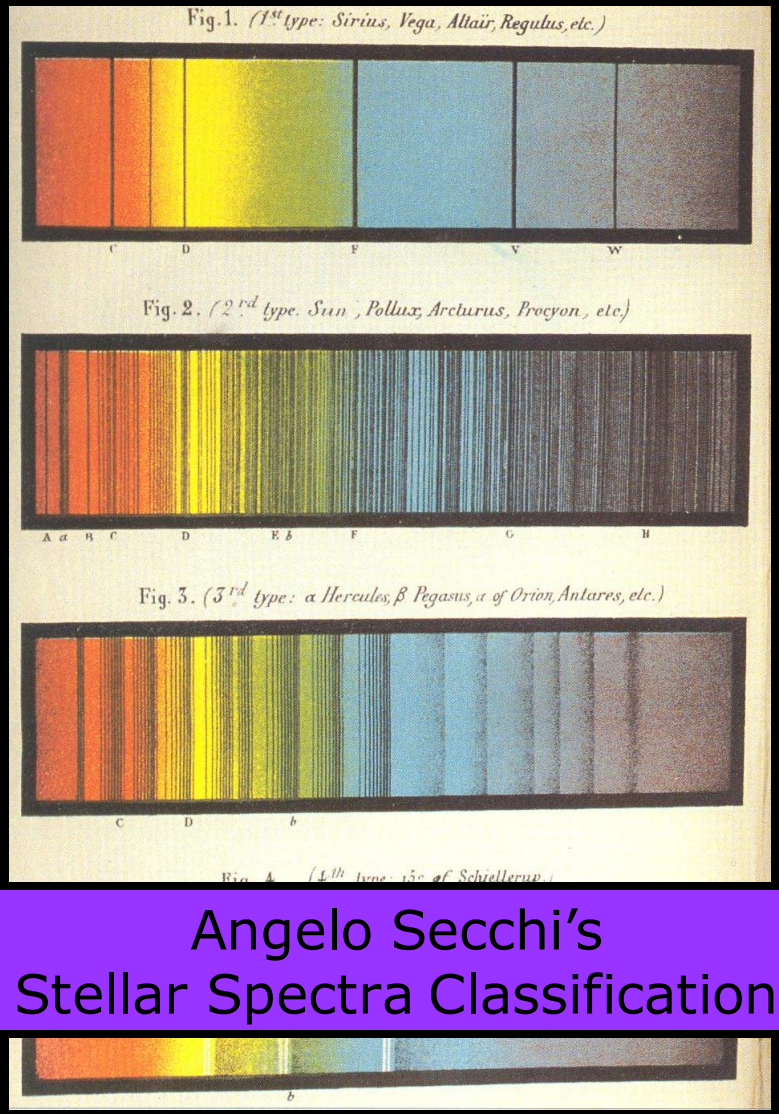


Robert Bunsen (1811 - 1899)
Gustav Kirchoff (1824 - 1887)

The Spectroscope



Frauenhofer Lines



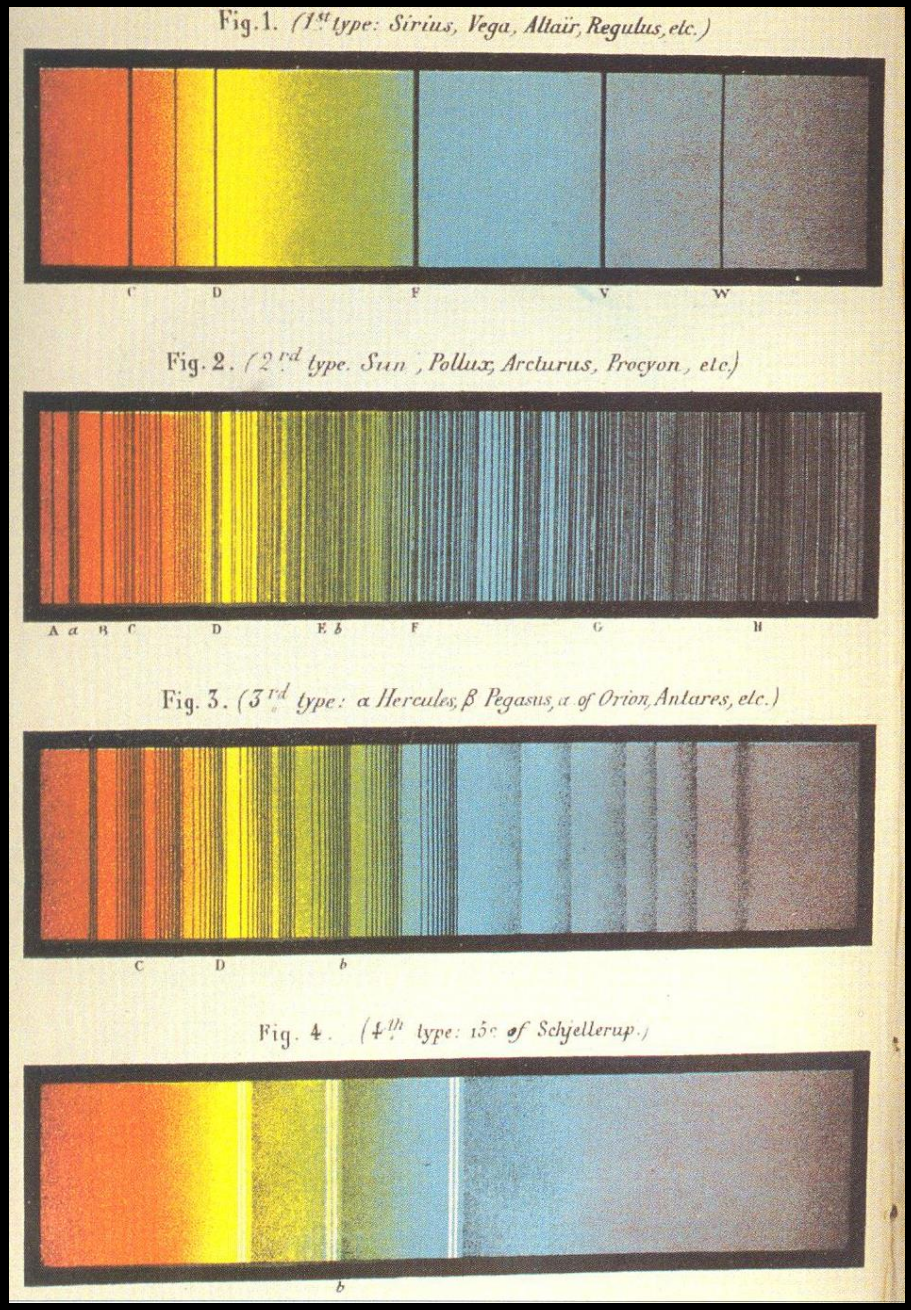
Angelo Secchi's
Stellar Spectra Classification

Sirius Type Stars

Sun-like stars

Red-Giant Variables

Red-dwarfs



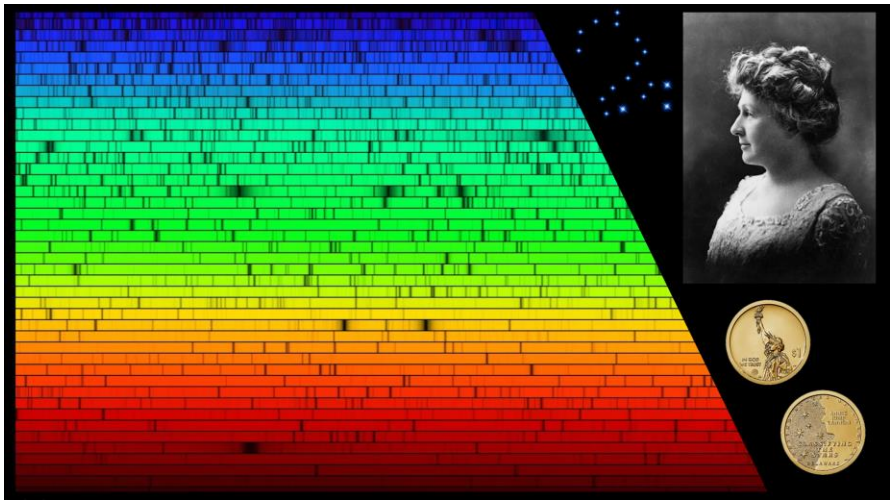
Annie jump cannon and stellar classification

WOMAN MAKING INDEX OF 100,000 STARS FOR A CATALOGUE

Astronomer at Harvard Plans to Learn What Objects Are Made Of.

She Hopes to Have Little "Sheep of Sky" Ticketed In Two Years.

WHAT are the stars made of? This is one of the first questions asked by childhood. It was one of the first questions of a novice as to how Miss Cannon finds out what is in the stars, no guess could be more extraordinary than the plain scientific fact.



Cepheid Variables

History of Astronomy's Use of Cepheids

Henrietta Leavitt, a computer (data analyst) at Harvard made observations of more than 2500 variable stars, and knew that every variable star had an exact period where its luminosity would get larger and smaller and repeat. She wanted to know if there was a relationship between the period of the star and the maximum luminosity it reached. But there was a problem…

HENRIETTA SWAN LEAVITT

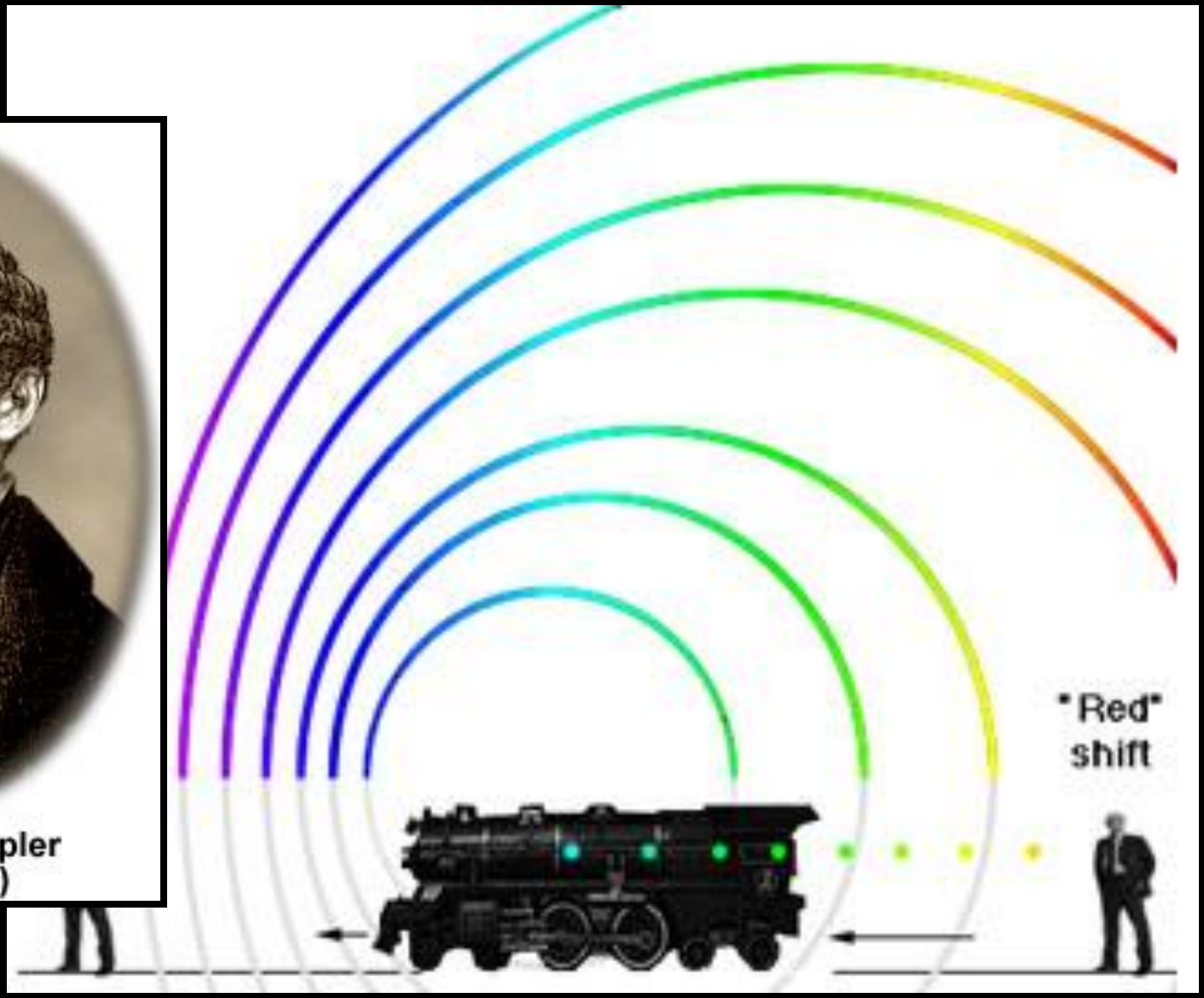
Astronomy **1868 - 1921**

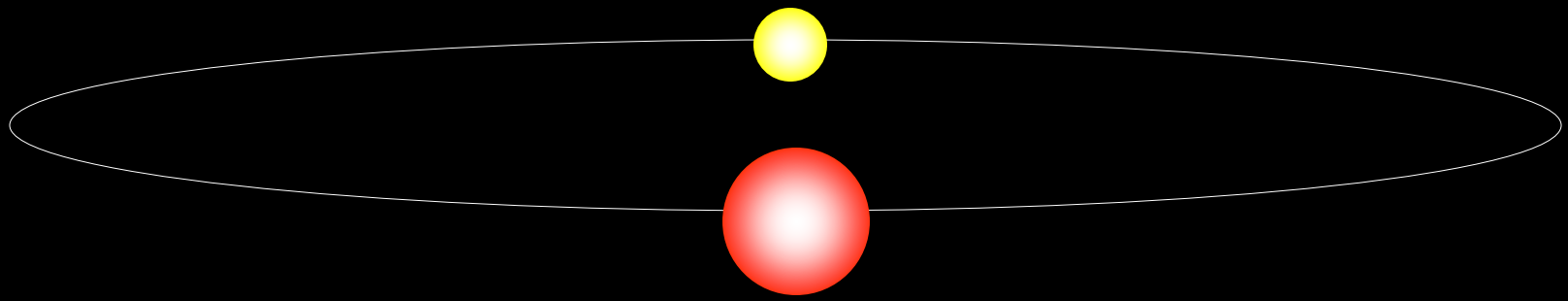
- **Measured over 2000 Cepheid variable stars**
- **Discovered the Period-Luminosity Relation**
- **Leavitt's cosmic beacons used by Edwin Hubble for distance to galaxies**
- **Opened the way for measuring the universe**

"Miss Leavitt . . . . [was] steadfastly loyal to her principles, and deeply conscientious and sincere in her attachment to her religion and church. She had the happy faculty of appreciating all that was worthy and lovable in others, and was possessed of a nature so full of sunshine that, to her, all of life became beautiful and full of meaning."

– Solon I. Bailey, 1922

Christian Doppler





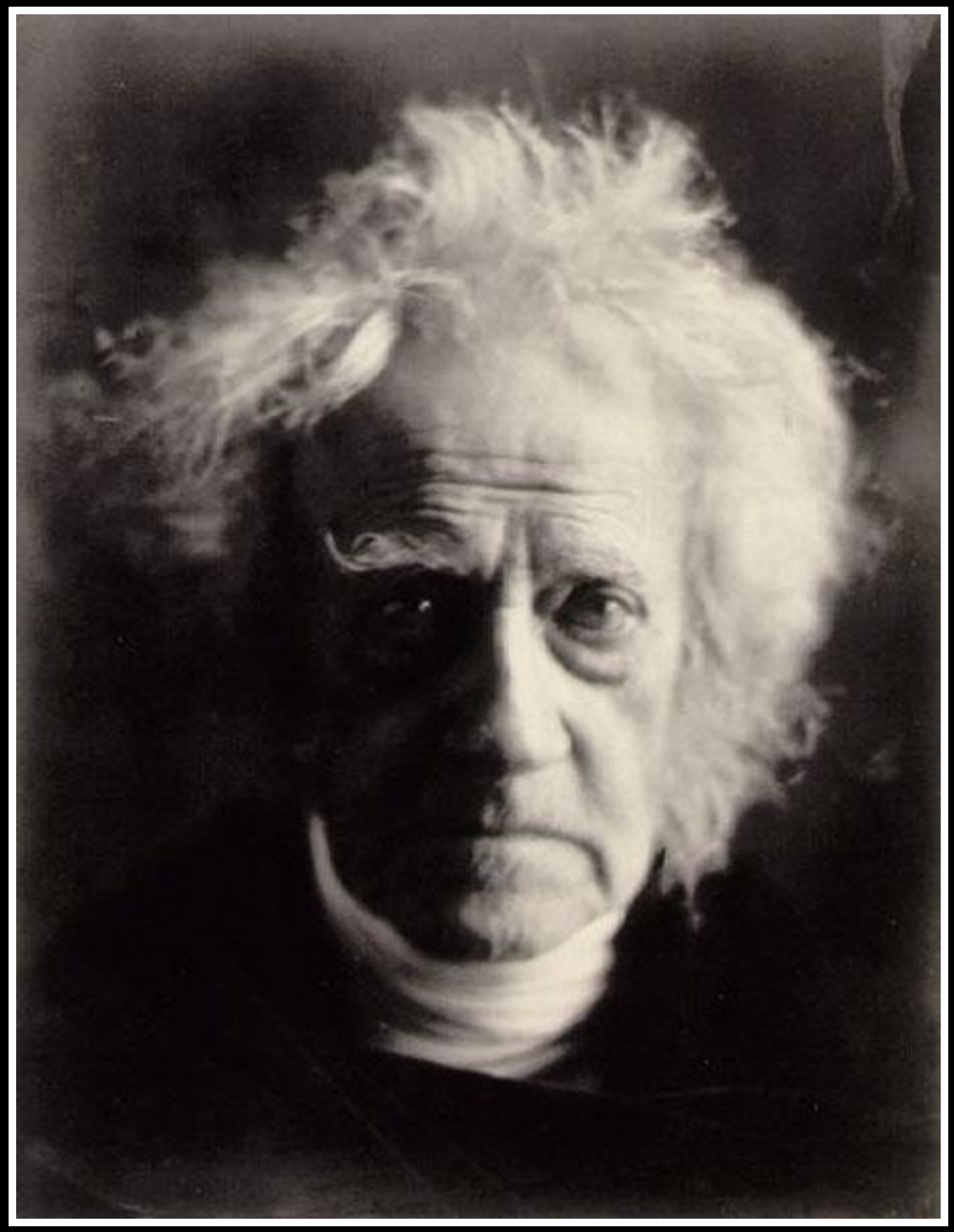
Crab Nebula (M1) Original SN1054 Lord Rosse Observed 1848

Messier Catalogue

Long observation

John Herschel
(1792-1870)

Pioneer of
Astrophotography



Herman von Helmholtz

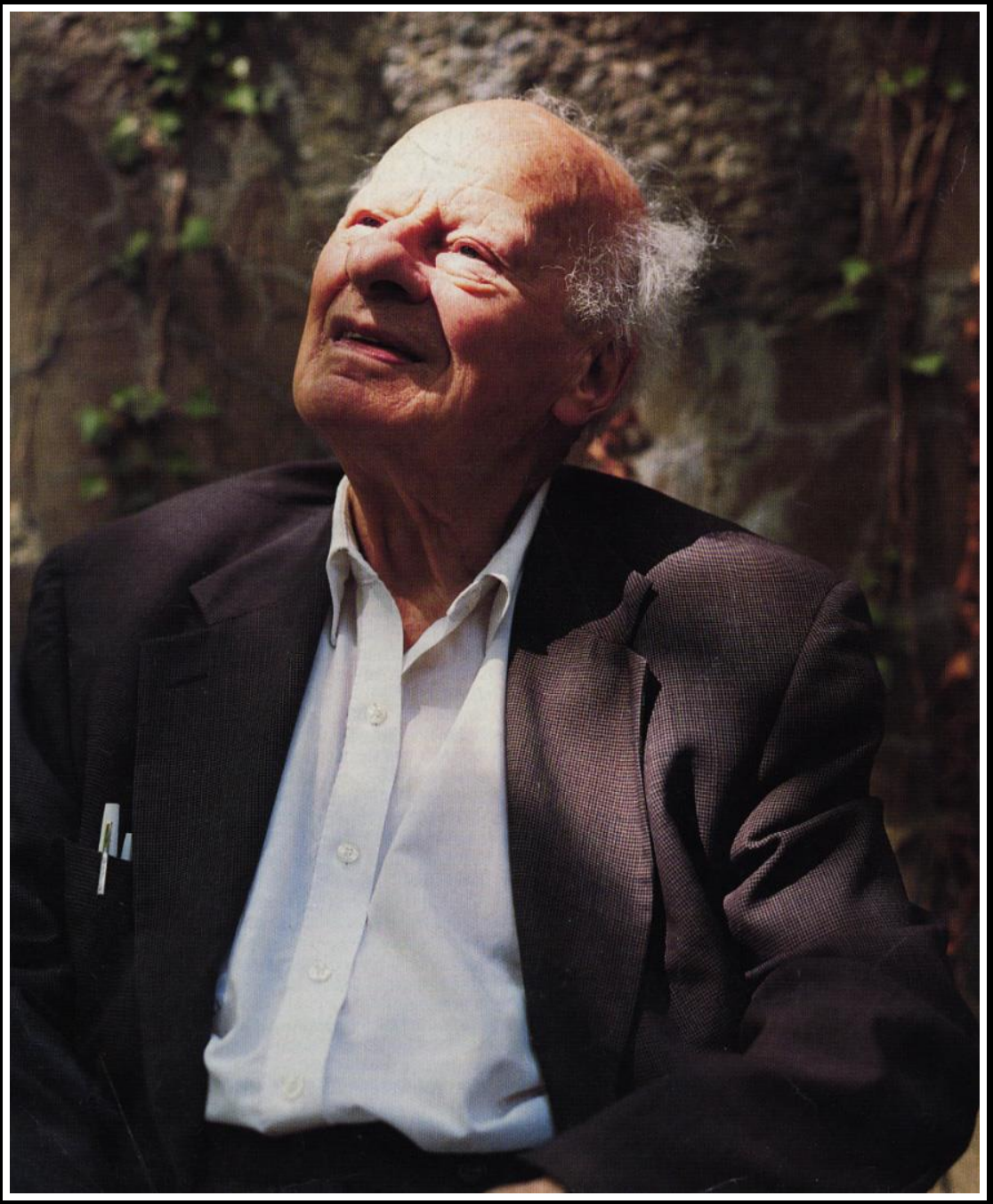
Suggested that gravitational contraction was the source of the Sun's energy.

Edwin Hubble

"The spiral nebulae are receeding at speeds proportional to their distances"

Hans Bethe

Worked out that sunlight comes from hydrogen fusion (1939).



JOAN FEYNMAN

HER EXPERTISE INCLUDED

•••

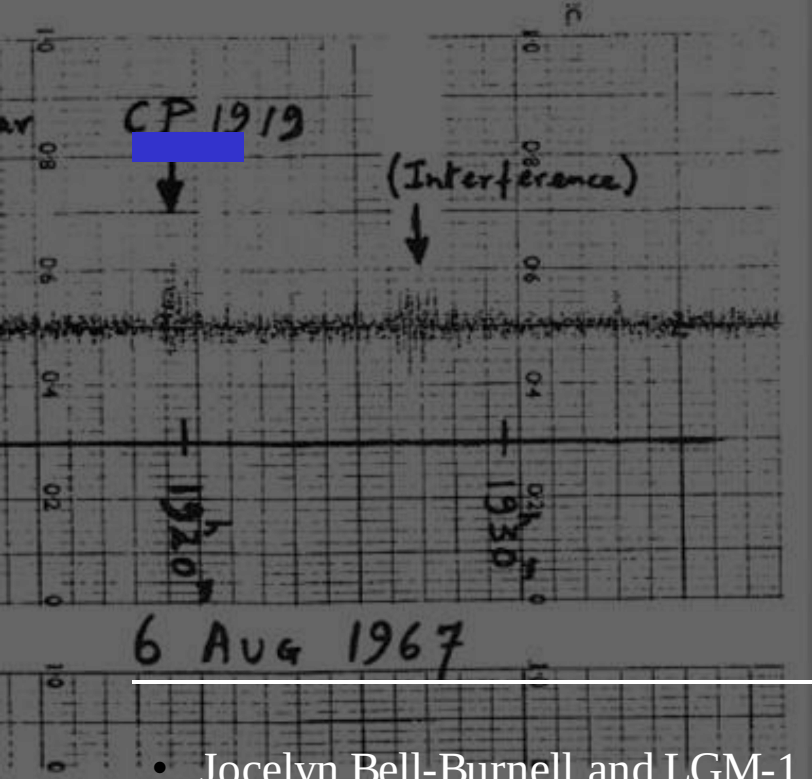
AURORAS
SOLAR WINDS
ASTROPHYSICS
MAGNETOSPHERIC PHYSICS

•••

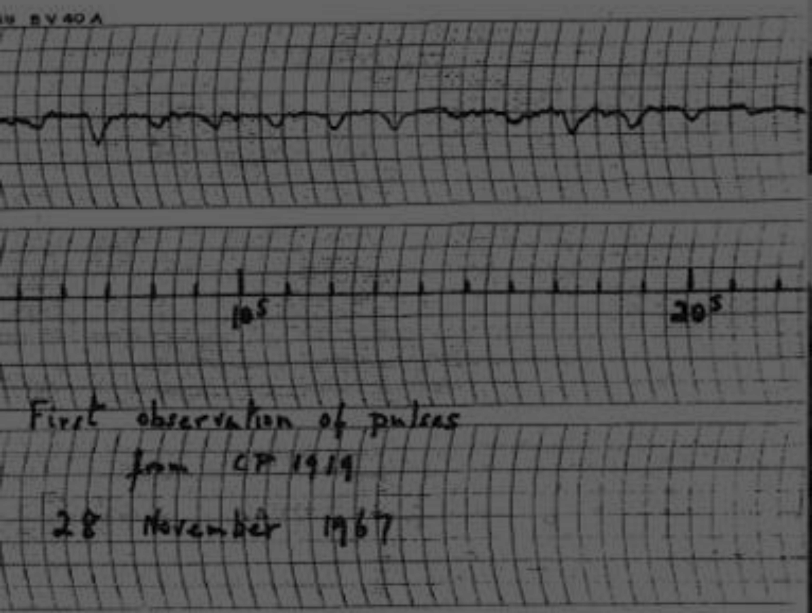
FIRST WOMAN TO BE ELECTED AS AN OFFICER OF THE AMERICAN GEOPHYSICAL UNION.

Post WW 2

The observable spectrum is broadened



- Jocelyn Bell-Burnell and LGM-1

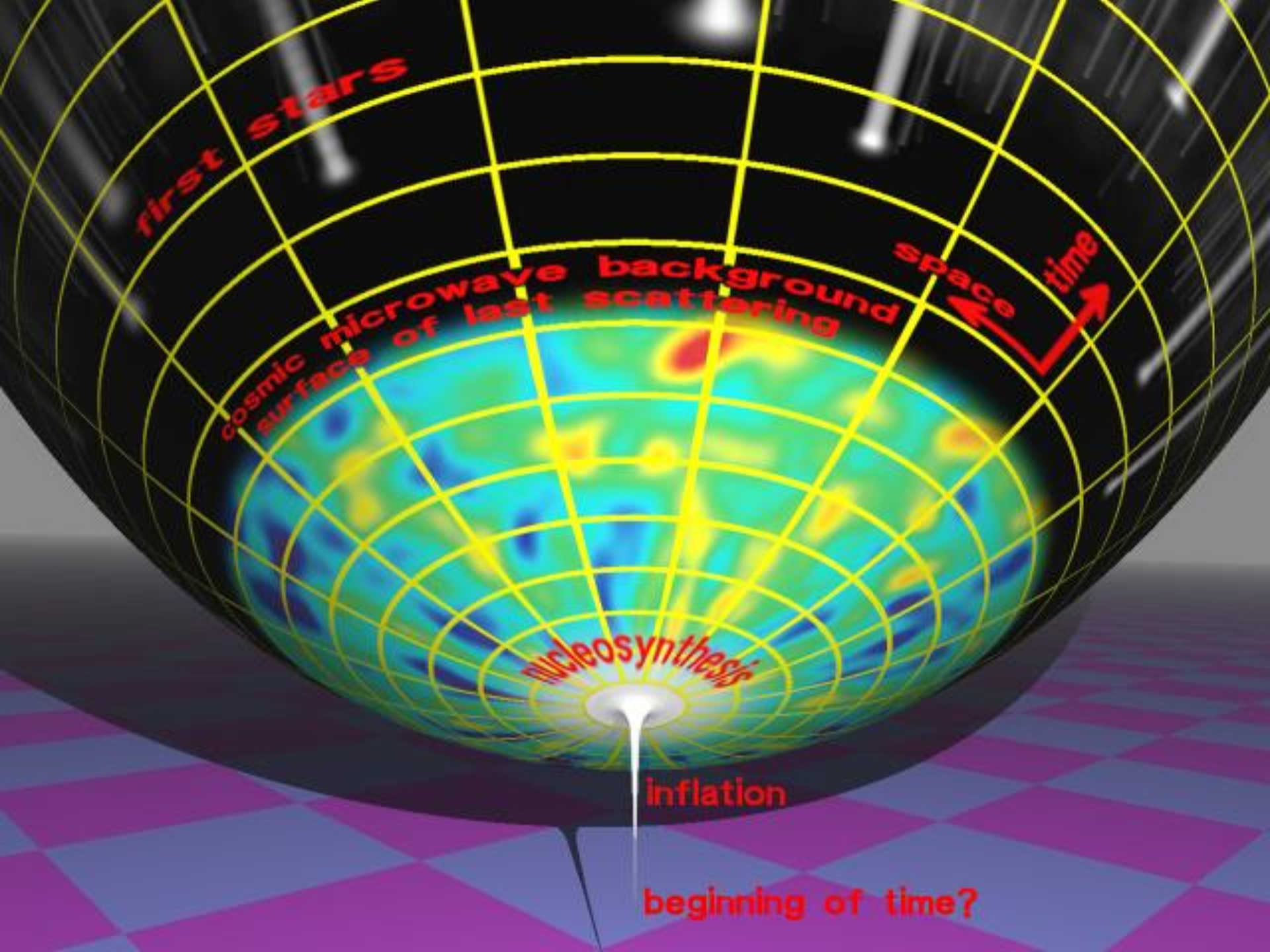



Don't shoot for the stars; we already know what's there. Shoot for the space in between because that's where the real mystery lies.
—VERA RUBIN
ASTRONOMER WHO DISCOVERED EVIDENCE FOR DARK MATTER
World Science Festival

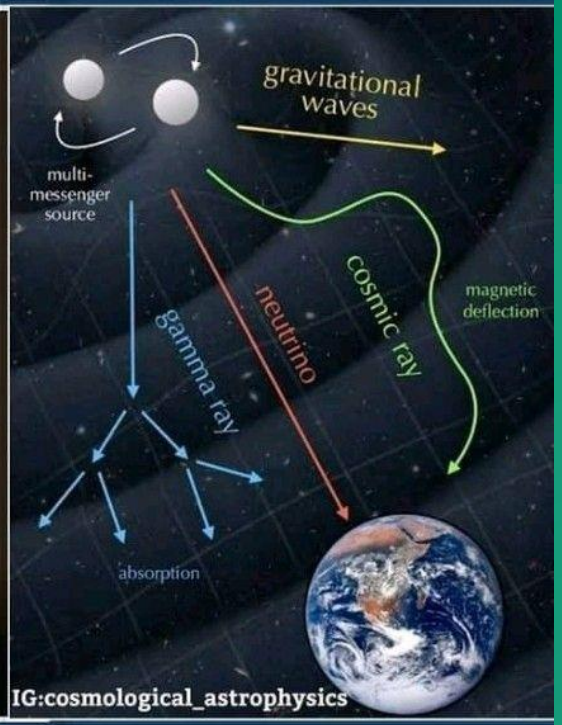
Hawking,
Penrose,

Penzias and
Wilson

CMB
And Big
Bang
Cosmology


first stars
cosmic microwave background
surface of last scattering
space
time
nucleosynthesis
inflation
beginning of time?

Scientist of the Day



Masatoshi Koshiba

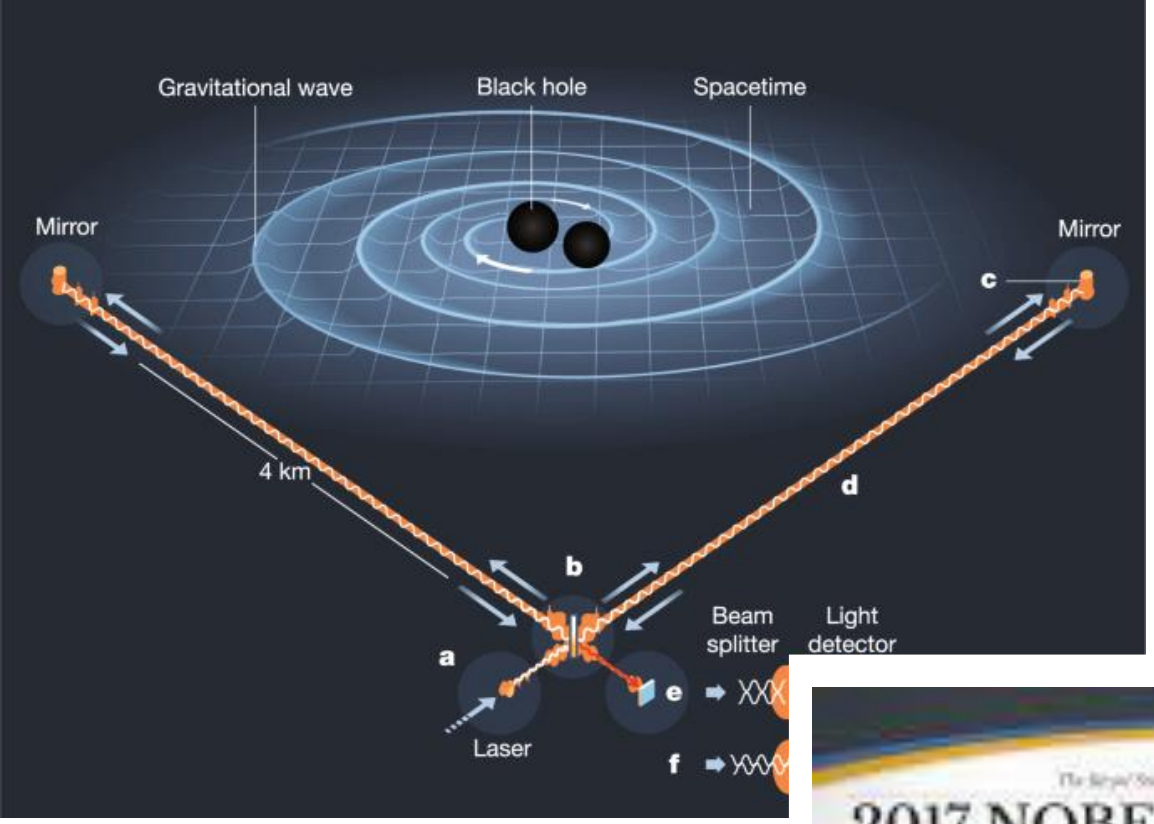
One of the founders of Neutrino Astronomy.

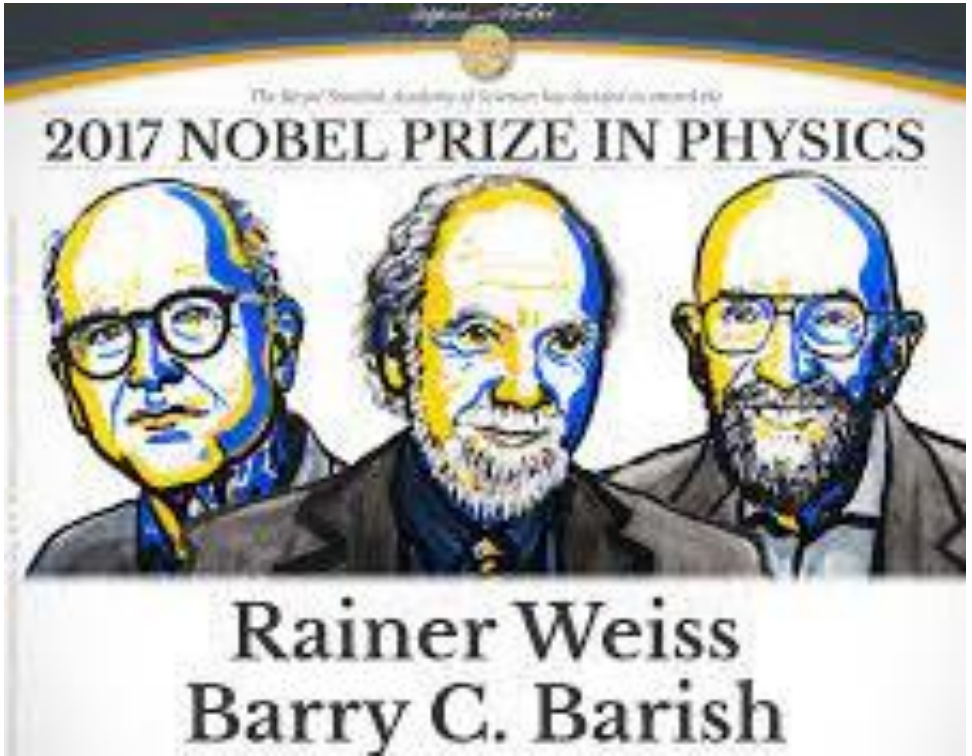
Saul Perlmutter

Brian P. Schmidt

Adam G. Riess

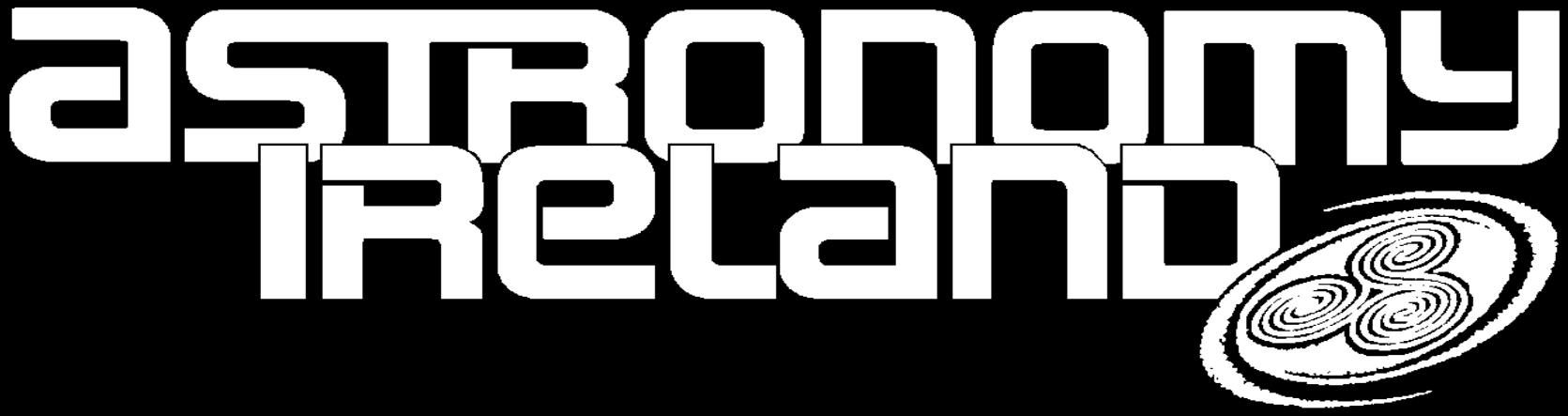
The Nobel Prize in Physics 2011 was awarded *"for the discovery of the accelerating expansion of the Universe through observations of distant supernovae"* with one half to Saul Perlmutter and the other half jointly to Brian P


Gravitational wave
Black hole
Spacetime
Mirror
Mirror
c
4 km
d
b
a
Beam splitter
Light detector
e
Laser
f


2017 NOBEL PRIZE IN PHYSICS
Rainer Weiss
Barry C. Barish

If I have seen further than others, it is
by standing upon the shoulders of giants.

Isaac Newton



Useful websites

www.astronomy.ie/handouts

www.stellarium.org

Thank You