

The Depth of Heavens

Belief and Knowledge during 2500 Years

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Content:

- ***The universe, as we know: 14 billion years old***
- ***Dante's universe, 700 years ago: Divine Comedy***
- ***Science, how we came to know:
From the Greeks to Tycho Brahe and our time***

The Disc of Heavens from Germany
The Nebra disc



1600 B.C.
early bronze age.

Sun, Moon, and stars

*First known image of
the cosmos.*

What is in the Heavens ?

For man at all times :

- **Moon, Sun , planets, stars**

For Christians in Antiquity and Middle Ages :

- furthermore *God, the angels, the saints*

For modern astronomers :

- **Moon, Sun, planets, stars**

+ star clusters, galaxies, dust, gas

+ white dwarfs, neutron stars, black holes

+ quasars, invisible Dark Matter

Crab Nebula - Dust and gas at distance 3400 light years
A supernova exploded here in the year 1054 AD
seen by astronomers in China and Japan

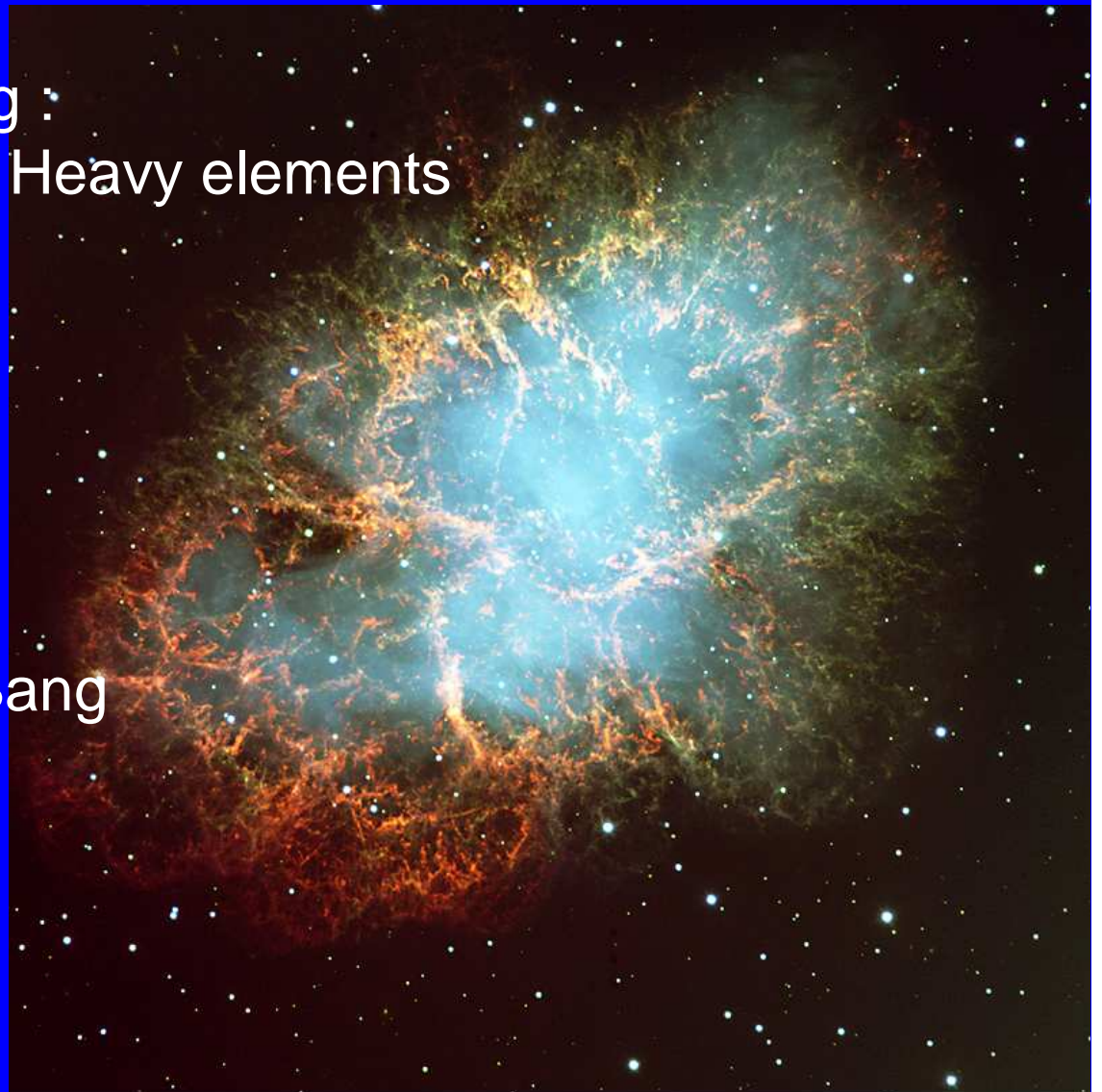
Stars do cosmic recycling :
Hydrogen → Energy + Heavy elements

Some stars live
only 10 mio. years !

Through hundreds of
generations of stars
9 billion years after Big Bang

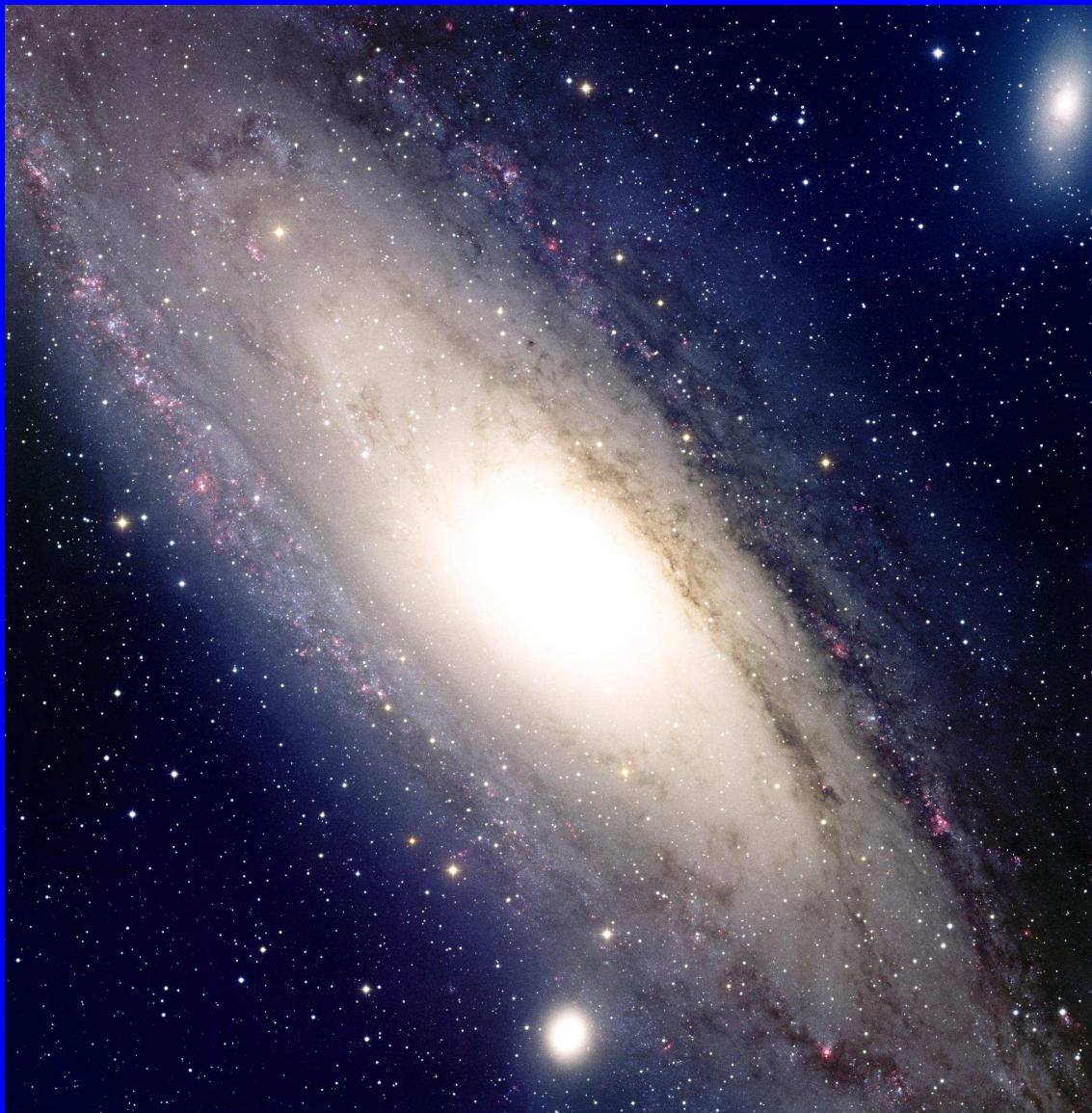
→ **Sun + Earth**

→ **Man**



Andromeda galaxy

with two dwarf galaxies



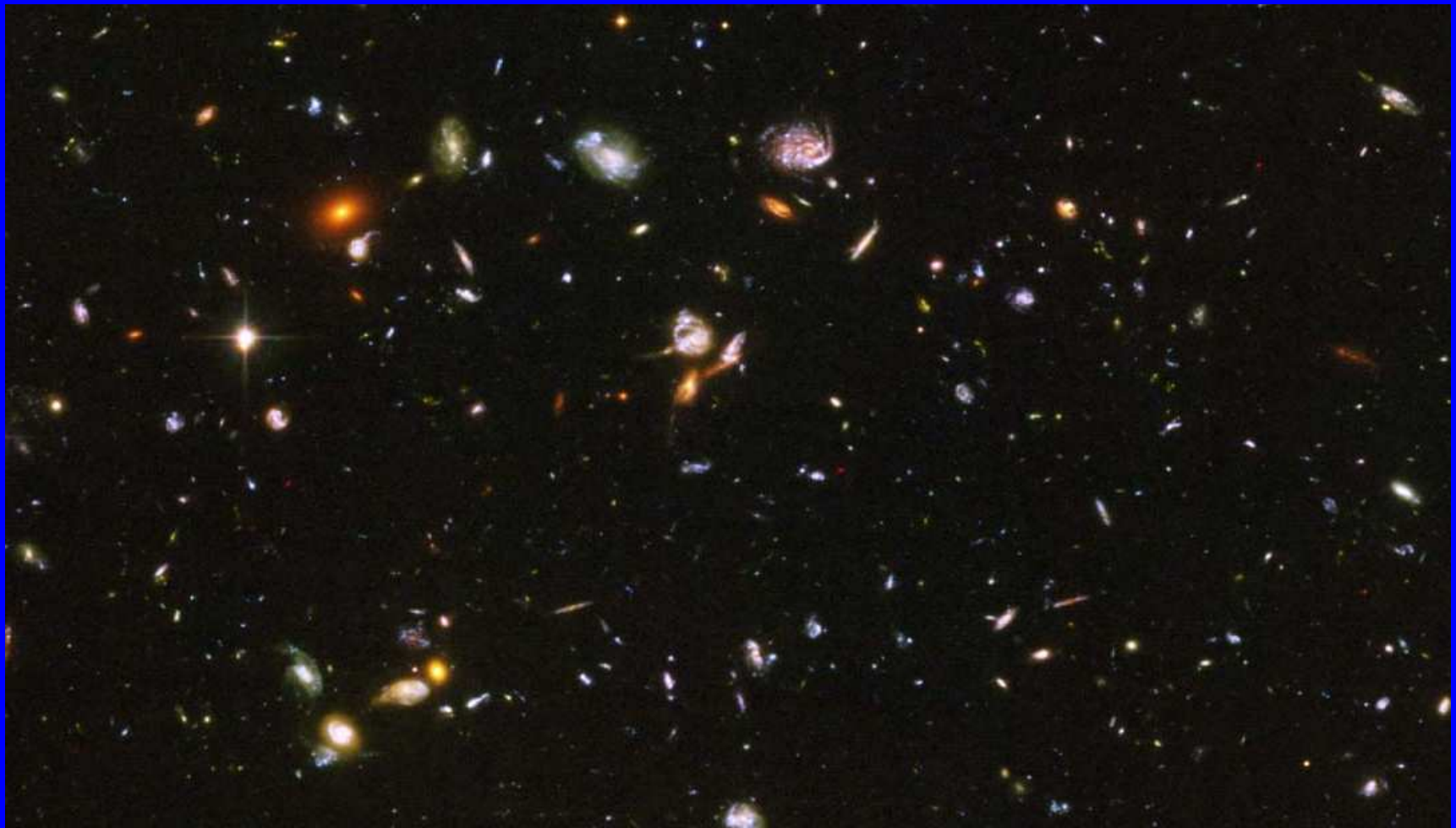
100 billion stars
**= 20 stars for every
person on Earth**

Distance =
2.2 million light years

1 light year =
9,500,000,000,000 km

The whole universe is about 14 billion years
It began with the Big Bang

Hubble Space Telescope:
The faintest galaxies are seen 13 billion years back



Dante Alighieri (1265-1321)

The Divine Comedy (1307-1320)

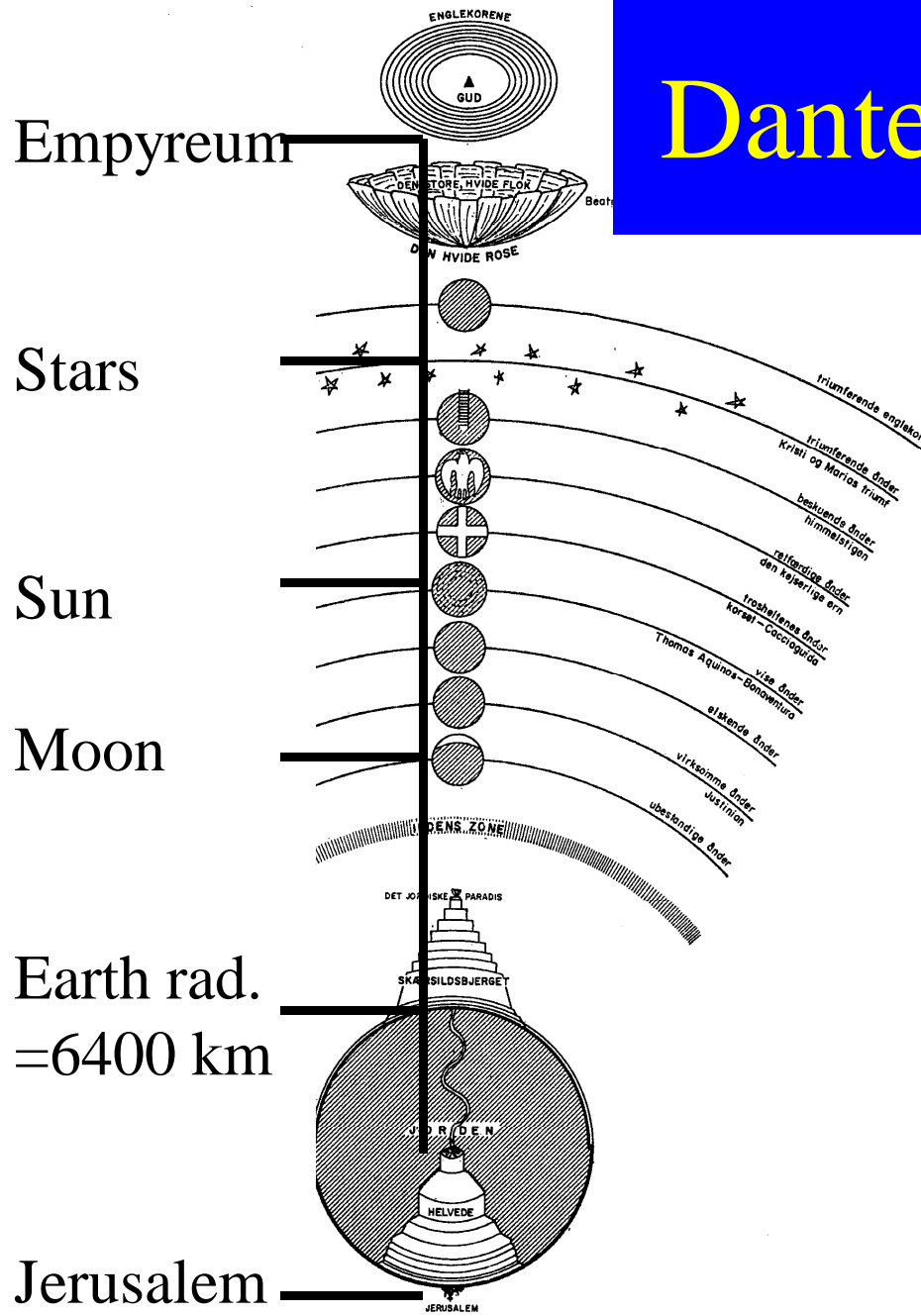
UNIVERSE:

Empyreum with
God, angels, and saints

Celestial Spheres of
fixed stars, planets, and Moon

Spherical Earth with
Purgatory mountain
opposite to Jerusalem
and **Hell** inside Earth

Dante's Universe

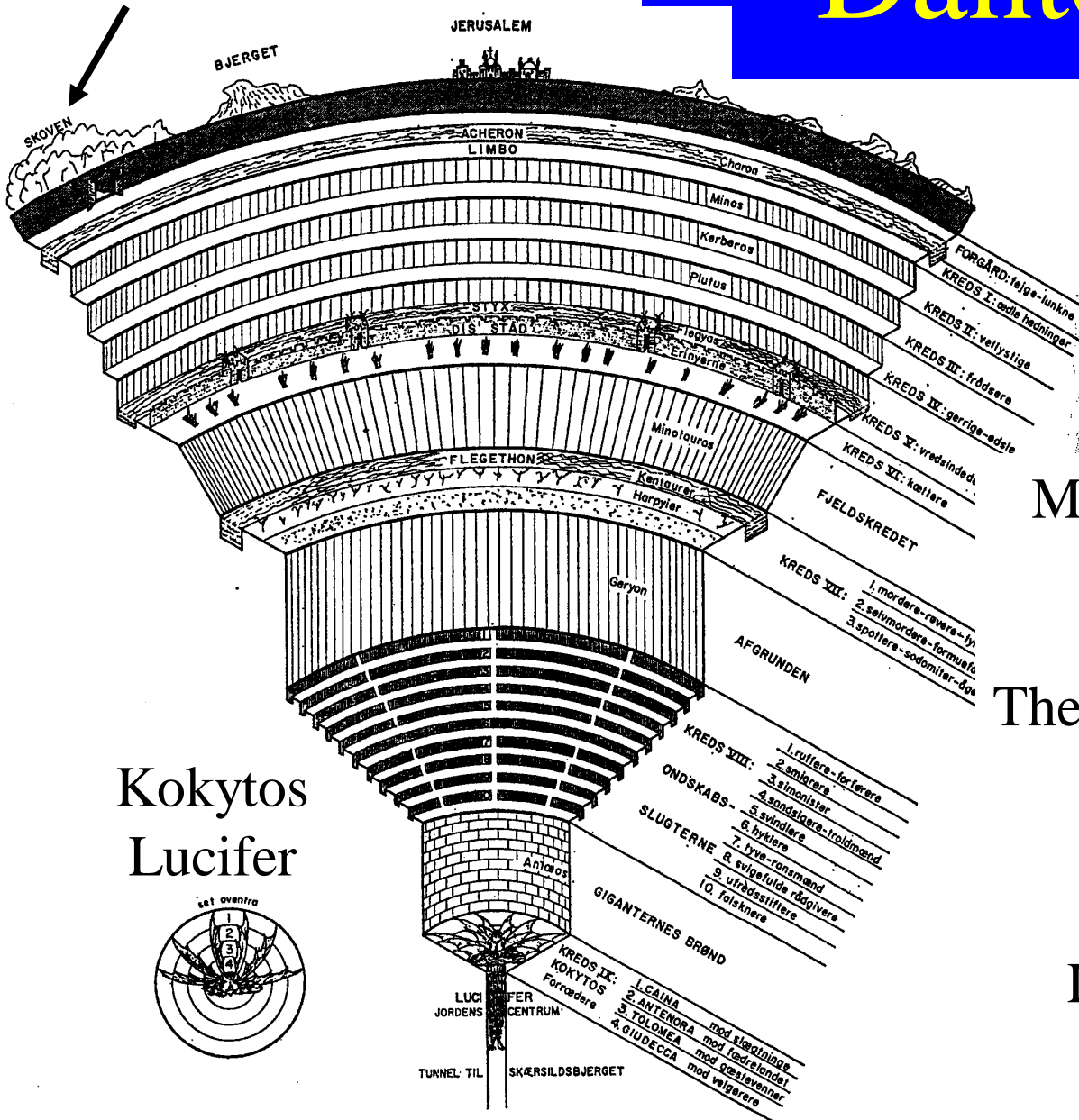


	Ptolemy	True value
Stars	20,000	> 10,000 million
Sun	1210	25,000
Moon	33-64	60 Earth rad.
Earth radius = 6400 km		

Dante's Hell

The forest

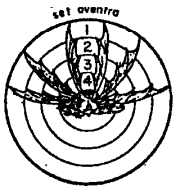
Jerusalem



Murderers

The most evil

Kokytos
Lucifer



Lucifer



Dante and Vergil with Lucifer

*Sandro Botticelli ~1500:
Divina Commedia*

Dante and Beatrice towards the Moon



Dante with Beatrice and lunar spirits



Dante and Beatrice with the stars



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A historical overview of science

Physics is simple, contrary to e.g. meteorology or biology

Philosophy and science *Babylonians and Greeks*

- 3300 Babylon: 60-base numerals; mathematics and astronomy

- 570 Thales: Everything is water; natural explanations

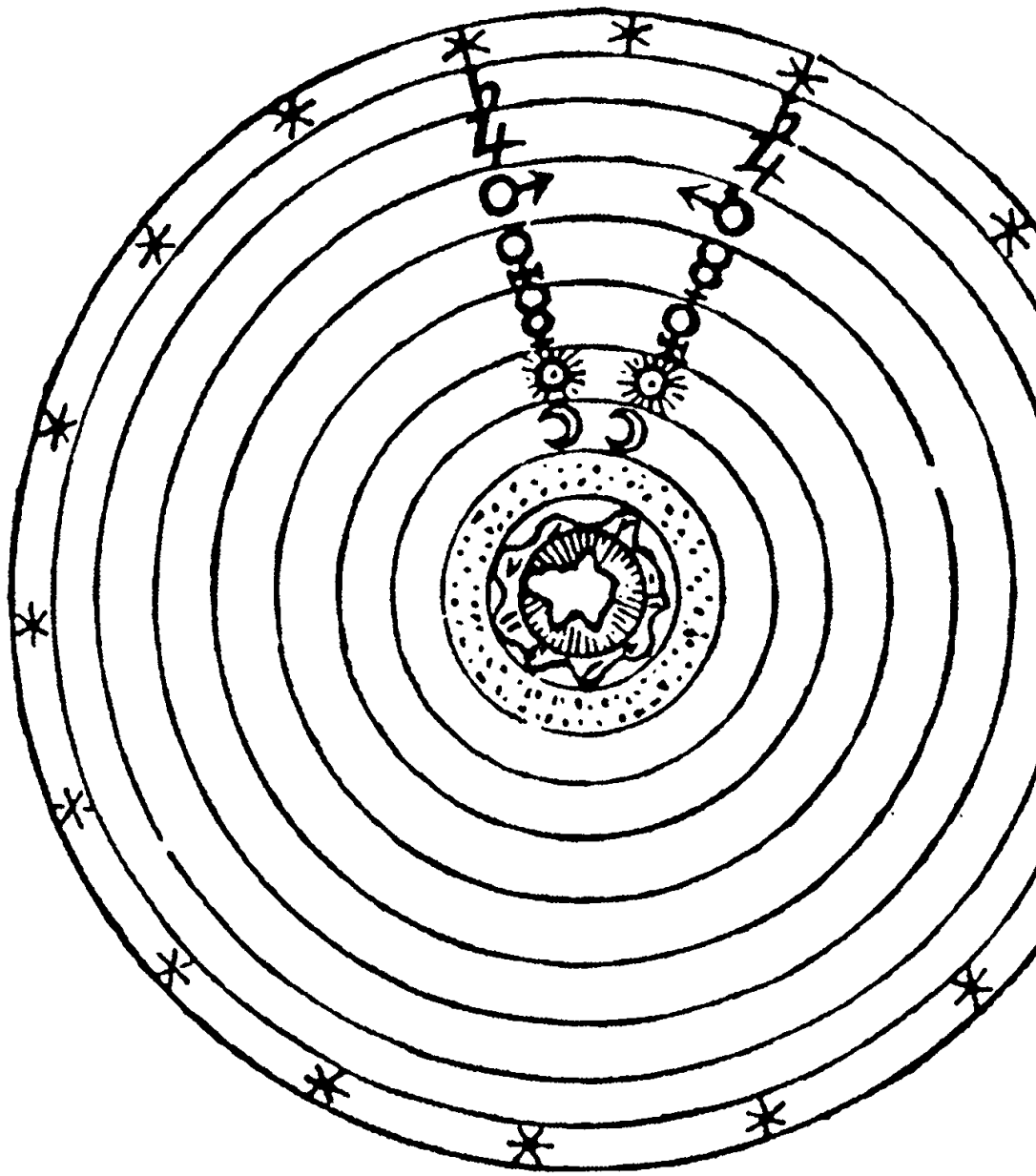
- 450 **Anaxagoras:**

The sun is a glowing rock

as big as Peloponnisos

- 350 *Aristotle*: Causes; time is cyclic

- 250 *Archimedes*: Mathematical description of measures
not causes

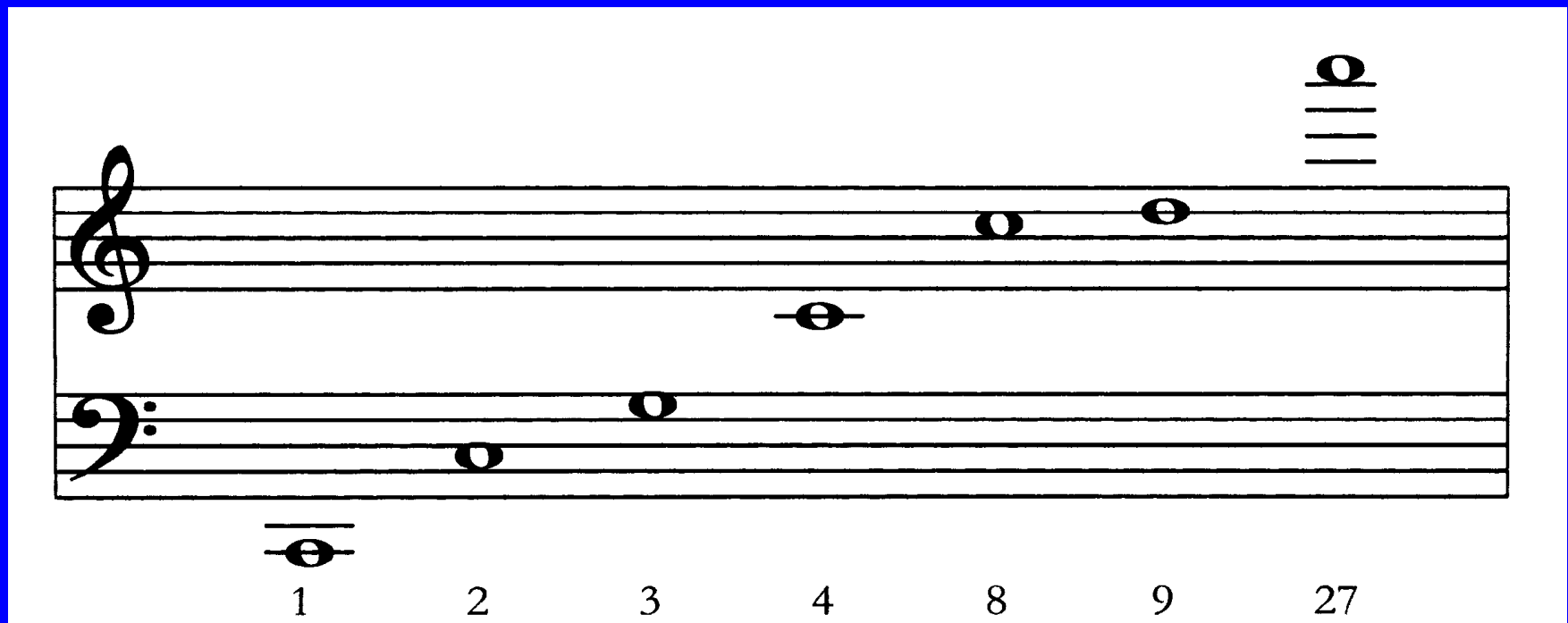


The Greek Cosmos ~ 500 B.C.

The Earth consists
of **earth, water,
air, and fire**

Around the Earth
are **spheres**
with **Moon, planets,
Sun and stars**

Plato's distance scale for the planets ~ 400 B.C.



Moon Sun Venus Mercury Mars Jupiter Saturn

Plato and *Aristotle*

~ 350 B.C.



Aristotle:

Causes

Theory for the universe

Time is cyclic

Speculation !

An ingenious attempt

Archimedes:

Mathematical description
of measures – **not causes.**

E.g. Theory of equilibrium:

Eternal law of nature !

School of Athens

Painted by Raphael 1510



Aristotle



Archimedes
~ 250 B.C.
Laws of nature
for **equilibrium**



Newton 1687
Laws of nature
for **motion**

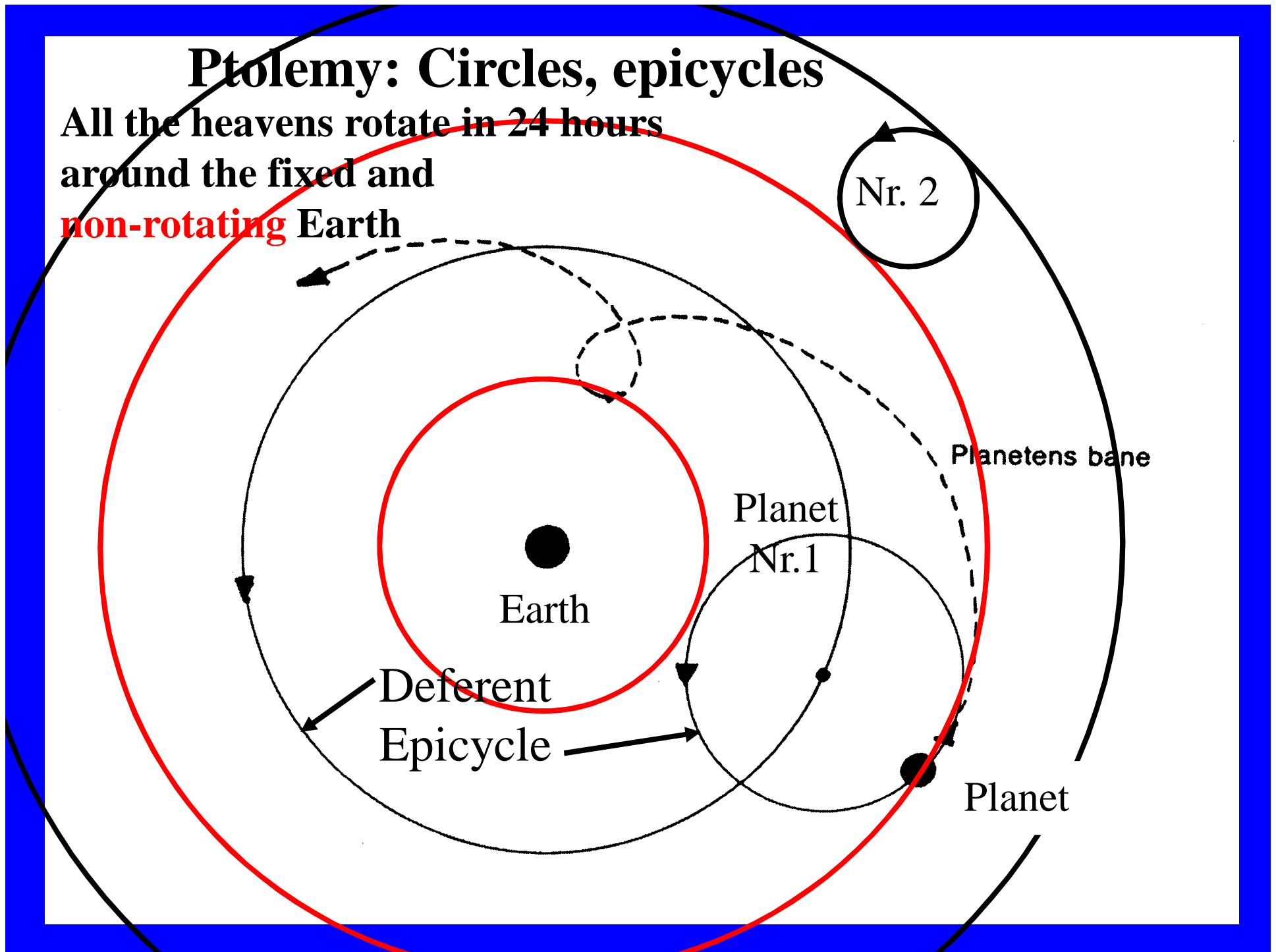
Ptolemy
measuring
~150 AD

*From G. Reisch,
1512*



Ptolemy: Circles, epicycles

All the heavens rotate in 24 hours
around the fixed and
non-rotating Earth



The Arabs:

Translation of Greek texts and Science

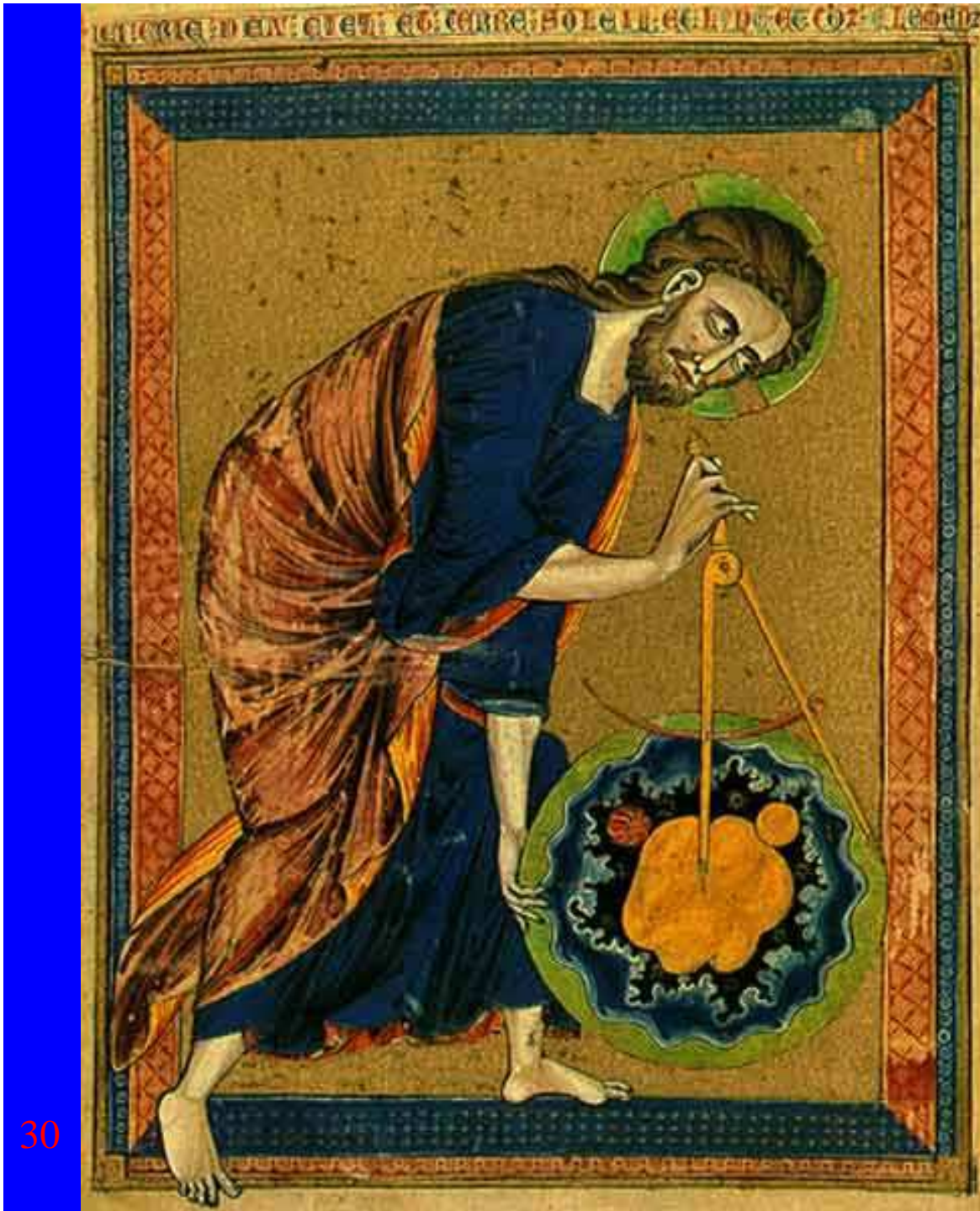


Harun al-Rashid

766 - 809

Our arabic numerals: from India to Europe:

- 500 In India: "Position" numerals: e.g. **0, 10, 203**
- 820 Al-Khwarizmi: Algorithm; astronomy
- 1021 Alhazen: Book on light and optics
- 1085 Toledo taken by Christians: large Arab library**
- 1120 In Europe:
 - Al-Khwarizmi's book on algebra is translated



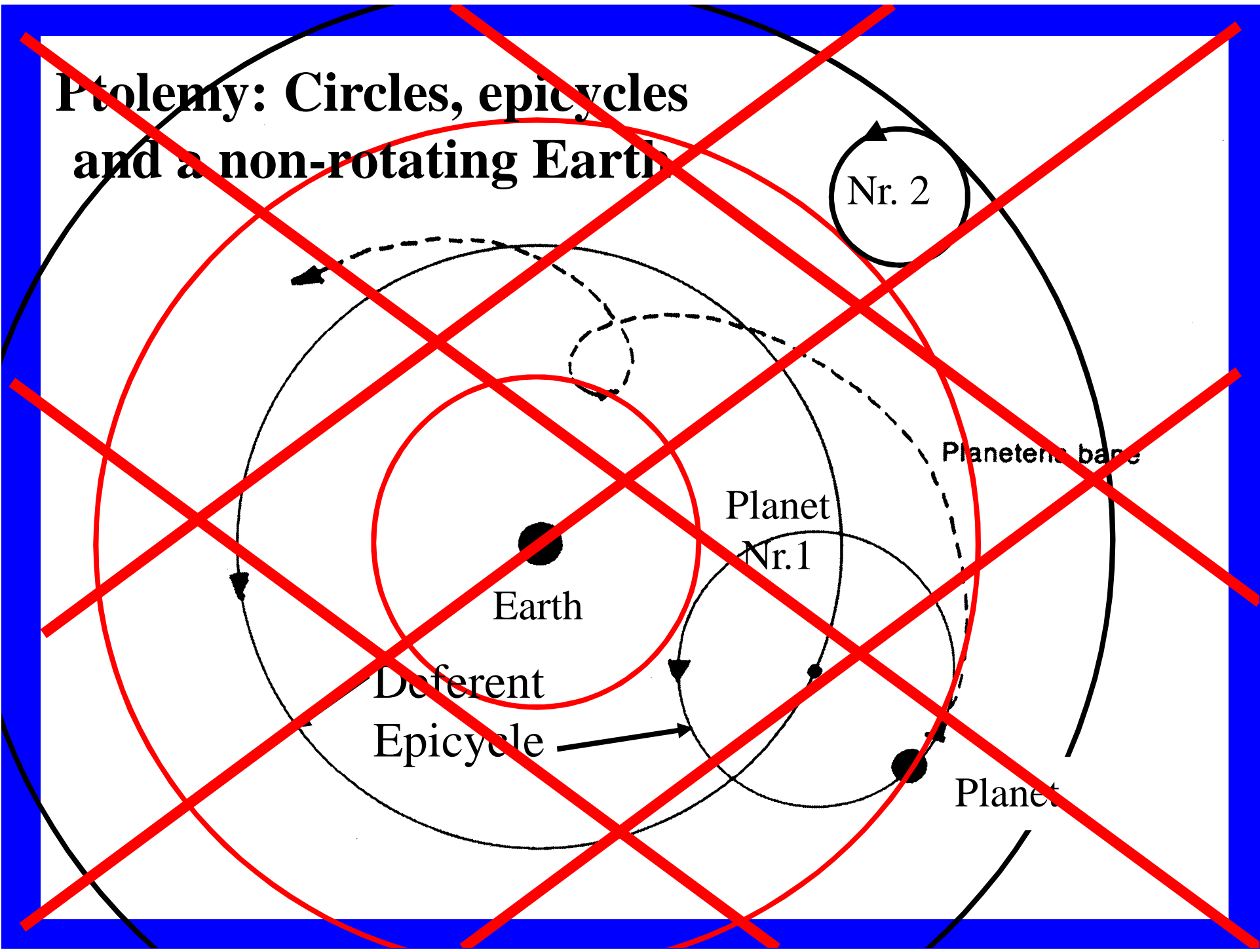
God as the architect of the world

*from a Middle Age Bible
ca. 1250*

Codex Vindobonensis

And: Men of church
had time to think
and to teach

Ptolemy: Circles, epicycles and a non-rotating Earth



Copernicus 1514 and 1543
after Aristarch of Samos ~310-230 B.C.



New theory of the universe:

The Sun is at the centre,
NOT the Earth

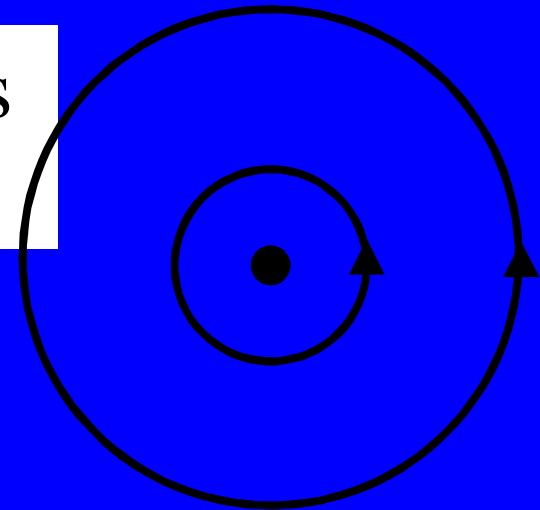
Copernicus 1473 - 1543

The Earth circles the Sun in **a year**

The Sun and two planets
Heliocentric system

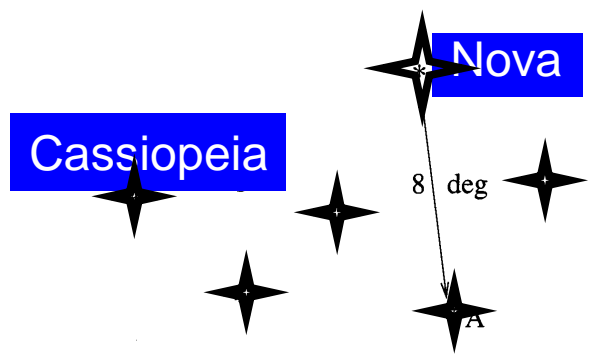
and

the Earth rotates in **24 hours**



11 Nov. 1572 Nova Stella

R.A. 0.5 h
Dec. 63 deg



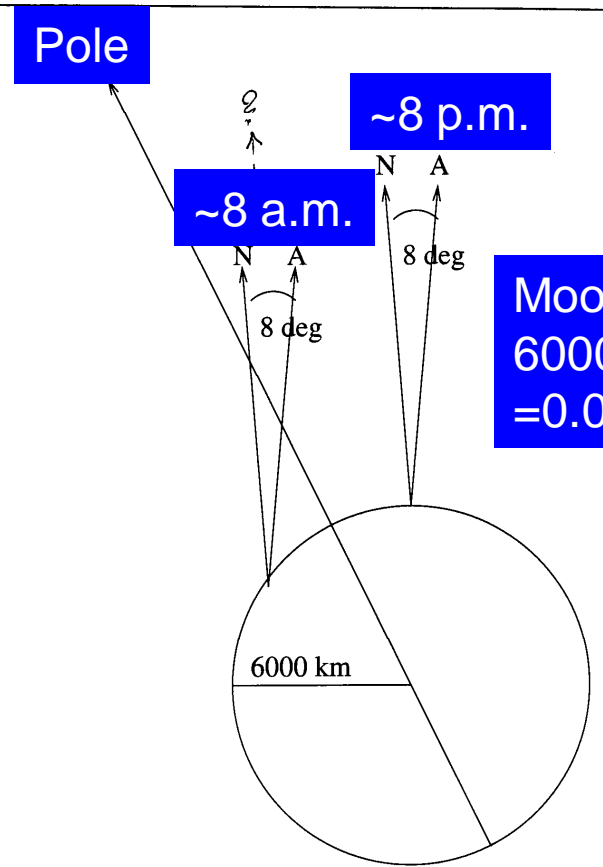
Tycho Brahe measured the nova:
Larger distance than the Moon

He concluded in 1572:

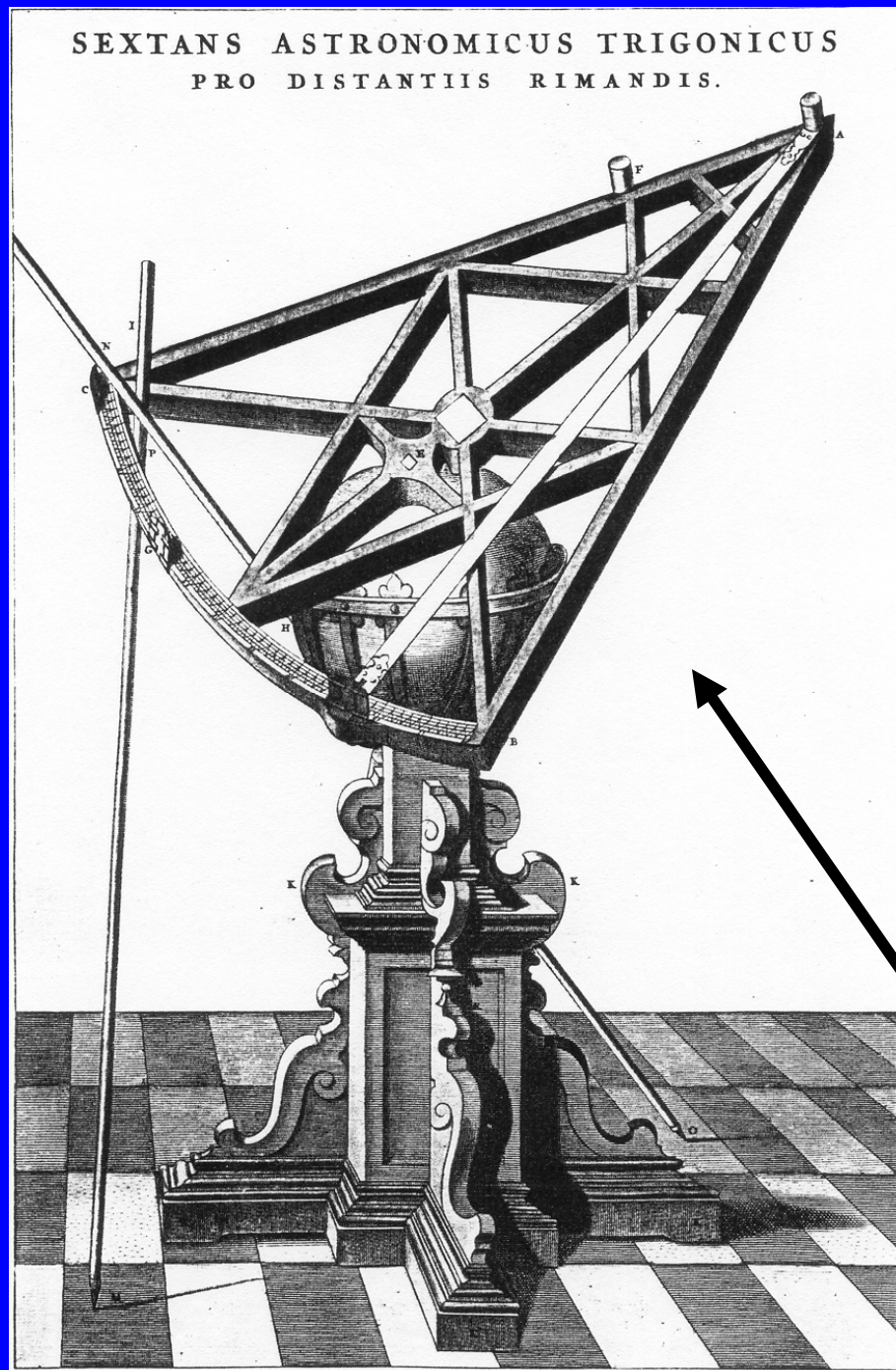
This is a miracle
a sign from God

We say:

He tipped the
antique picture of the world



Moon's horiz. parallax
 $6000 \text{ km} / 380,000 \text{ km}$
 $= 0.016 = 0.9 \text{ deg}$

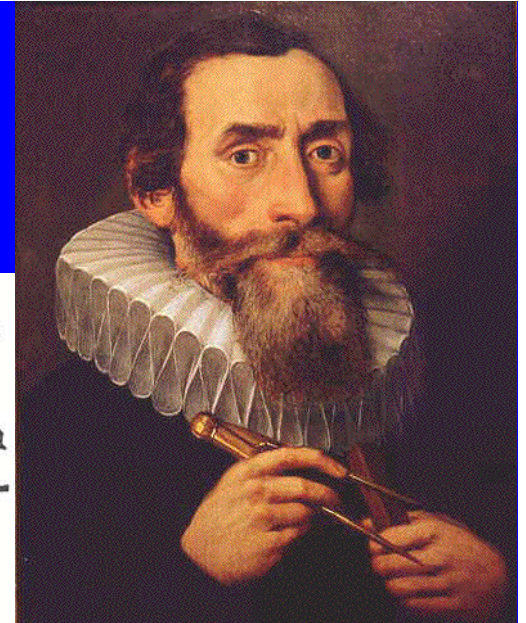


Tycho Brahe
on Hven
1576-97
A barrel of gold

Sextant 1580

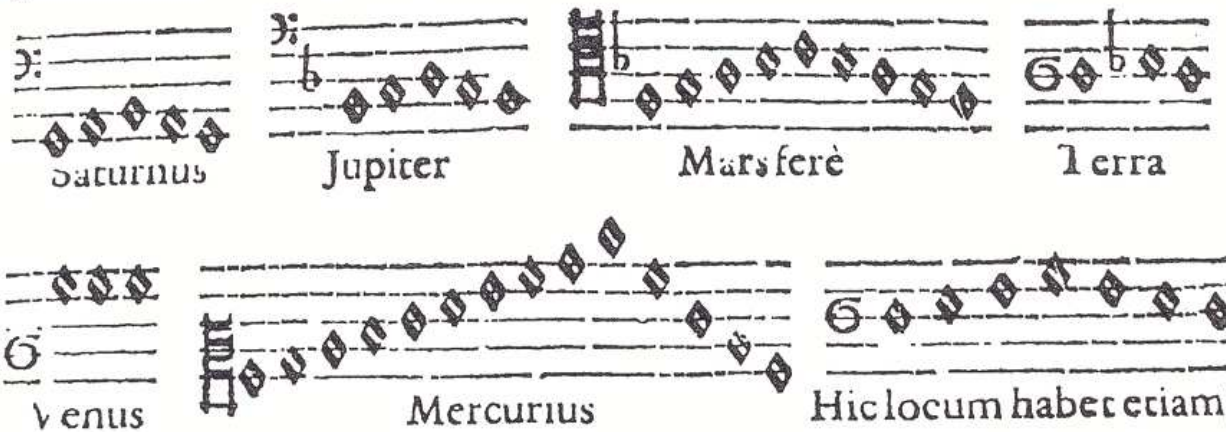
Høg

Kepler 1619 *Harmonices Mundi*



HARMONICIS LIB. V. 207

omnia (infinita in potentiâ) permeantes actu: id quod aliter à me non potuit exprimi, quam per continuam seriem Notarum intermedia-



Figur 17 Planetskalaer fra Harmonices mundi. En skalas længde er et direkte udtryk for den pågældende planets excentricitet. Jorden og Ve-

Kepler found ~70 laws for the motion of planets
But we usually mention only **3** of these...

Isaac Newton 1687:

Philosophiæ Naturalis Principia Mathematica

Mathematics 1665-66:

Differential- and integral calculus

+ Clear concepts 1687:

Gravity, force, acceleration,
absolute time, velocity

>>> Laws of motion:

Kepler's **3** laws;

motions in the heavens and on Earth....

>>> The technical revolution



Telescope: *Galilei 1610*

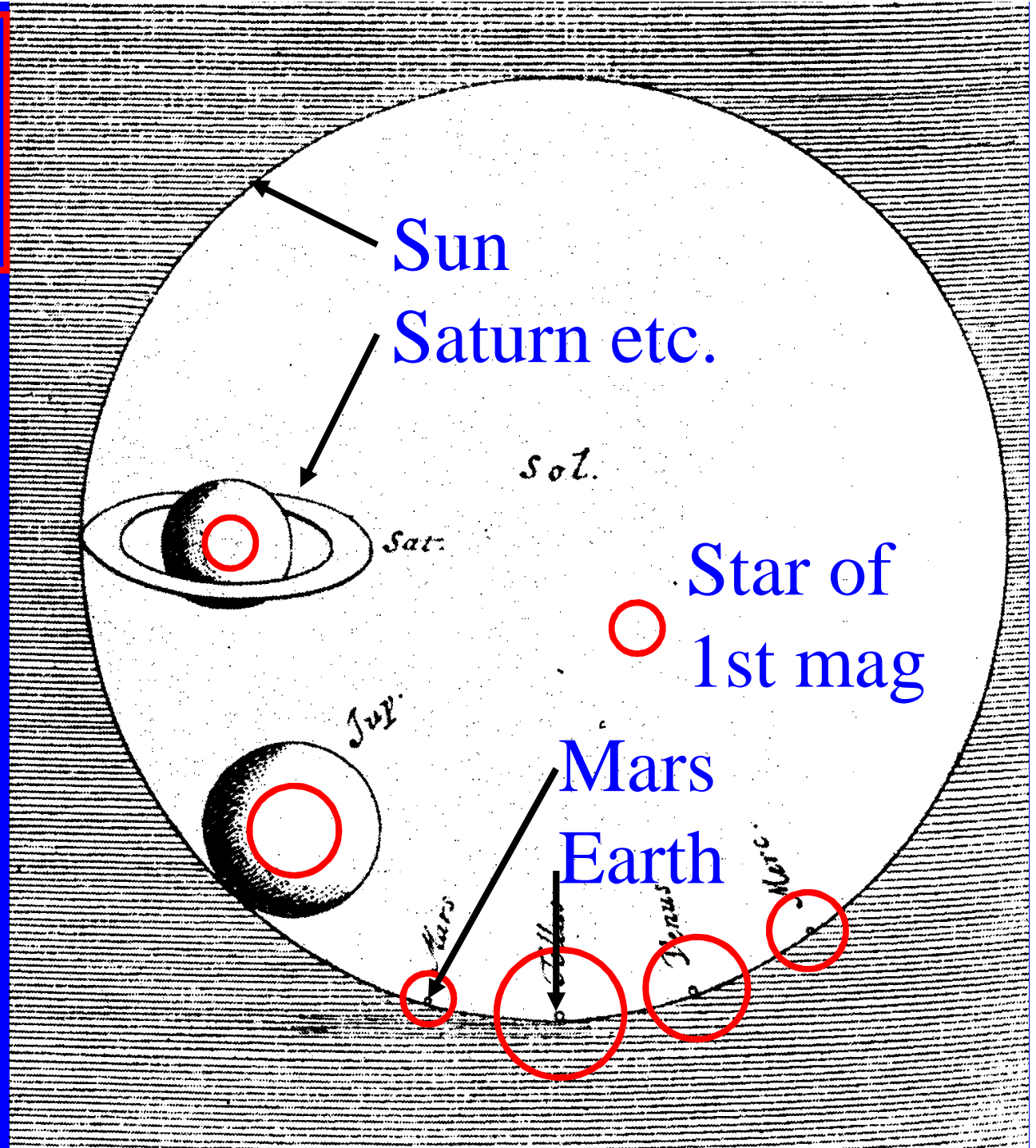
Planet sizes

Huygens 1698

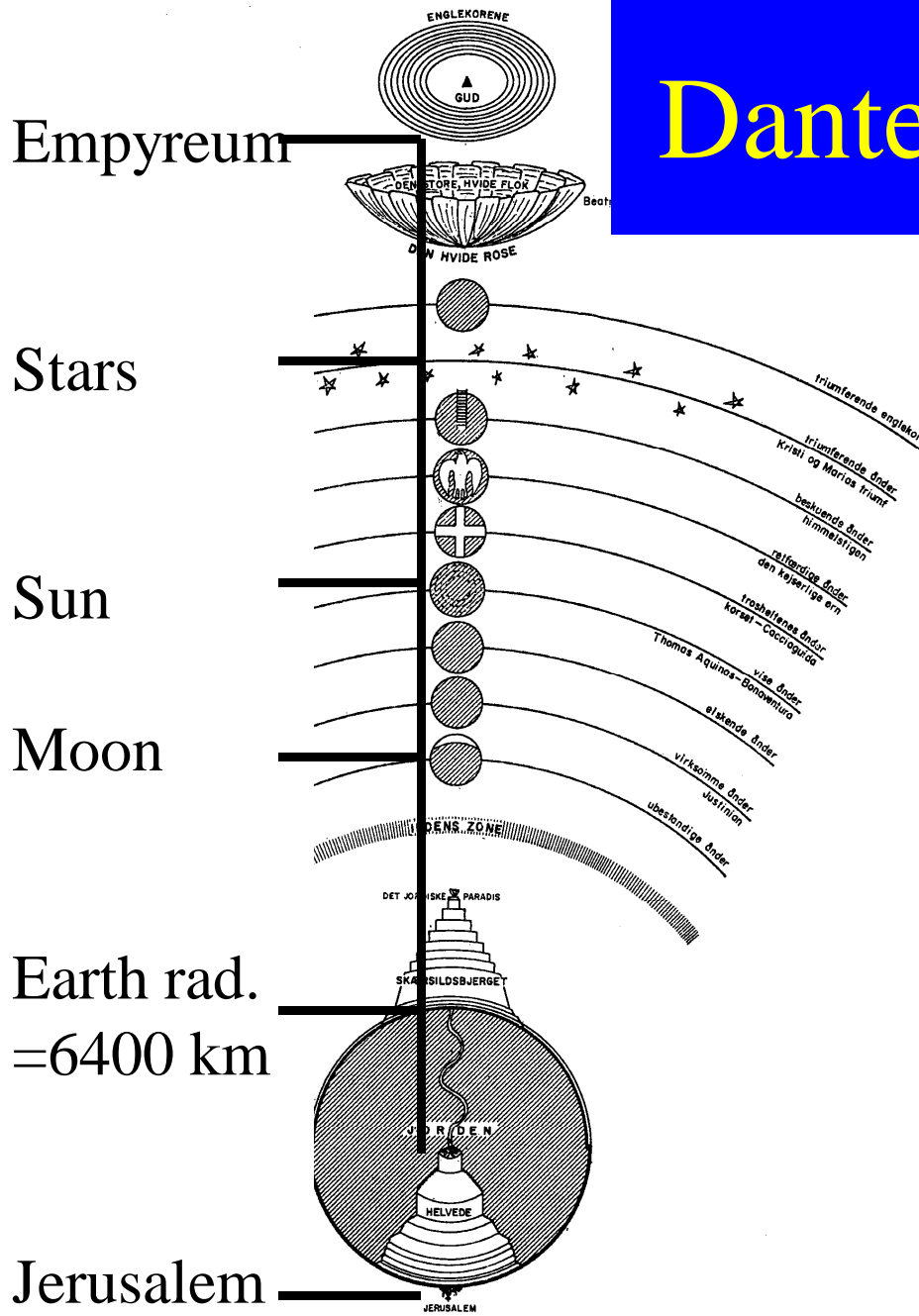
○ *telescopic*

Ptolemy

○ *150 AD*
naked eye



Dante's Universe



	Ptolemy	True value
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Earth radius = 6400 km

The Visible Universe

Year	Radius – light years	What / Who
150-1600	0.000,014	Sphere of stars Ptolemy
1900	30,000	Milky Way Kapteyn
1960	2,000,000,000	Most distant galaxies Palomar 5 meter
2006	14,000,000,000	Visible universe WMAP a.o.

The Visible Universe

is 10^{15} times larger
than Tycho Brahe believed

$10^{15} = 1,000,000,000,000,000 = 1$ million billion times



Tycho Brahe
ca. 1590

Ptolemy
ca. 150 A.D.

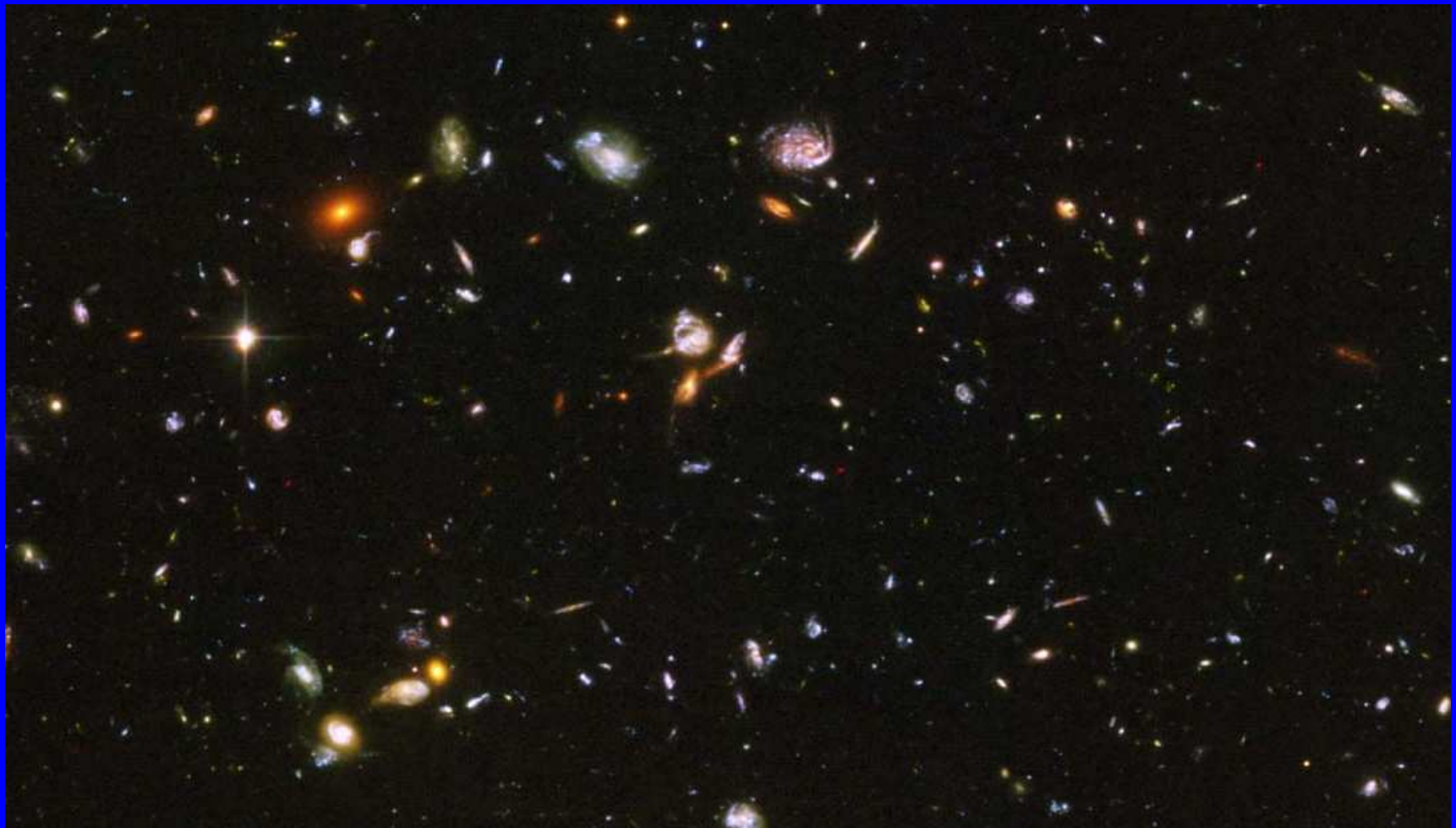
Erik Høg



The whole universe is about 14 billion years

Hubble Space Telescope:

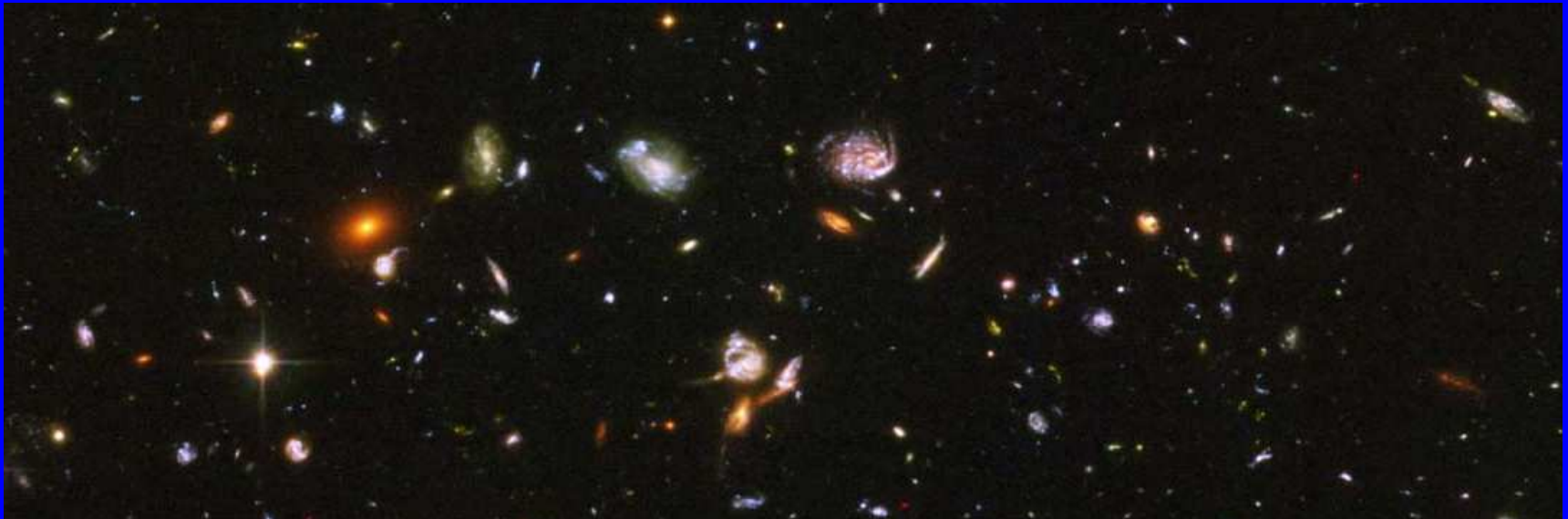
The faintest galaxies are seen 13 billion years back



The whole universe is about 14 billion years

Hubble Space Telescope:

The faintest galaxies are seen 13 billion years back



Website: www.astro.ku.dk/~erik

Read e.g.:

*The depth of heavens ... during 2500 years, and:
The age of the world from the highest authorities*