Gestalting Structures in Physics

Tuomo Suntola

Basic questions for human conception

The scope of physical theories

From antique metaphysics to empirical sciences

The picture of reality, the empiricists' puzzle

Concluding remarks

Gestalting Structures in Physics

Basic questions for human conception: What? – Where? – When?

The SI base quantities: mass, length, time (units: kilogram, meter, second)

In search for a deeper understanding we may ask:

Why does anything exist? Where is the universe coming from?

How does nature function?

What determines the structures in material world?

Gestalting Structures in Physics

Aristotle (384–322 BC):

”ALL men by nature desire to know.”

“… and the most exact of the sciences are those which deal most with first principles; for those which involve fewer principles are more exact than those which involve additional principles …”

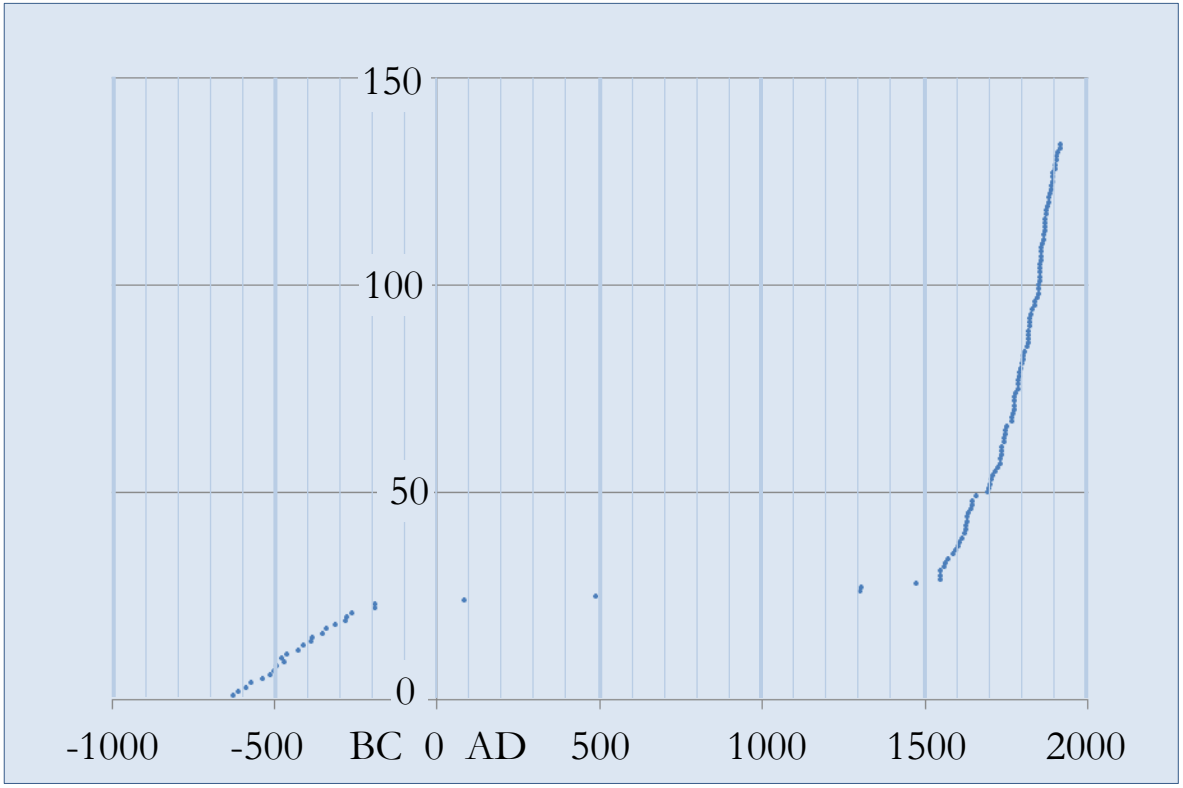
The second statement is generally known as Occams’s razor:

“A principle urging one to select from among competing hypotheses that which makes the fewest assumptions.”

William of Ockham (c. 1288 – 1348)

Outlining of the historical development in Physics

Search for the laws of nature and understanding of space, matter, and motion



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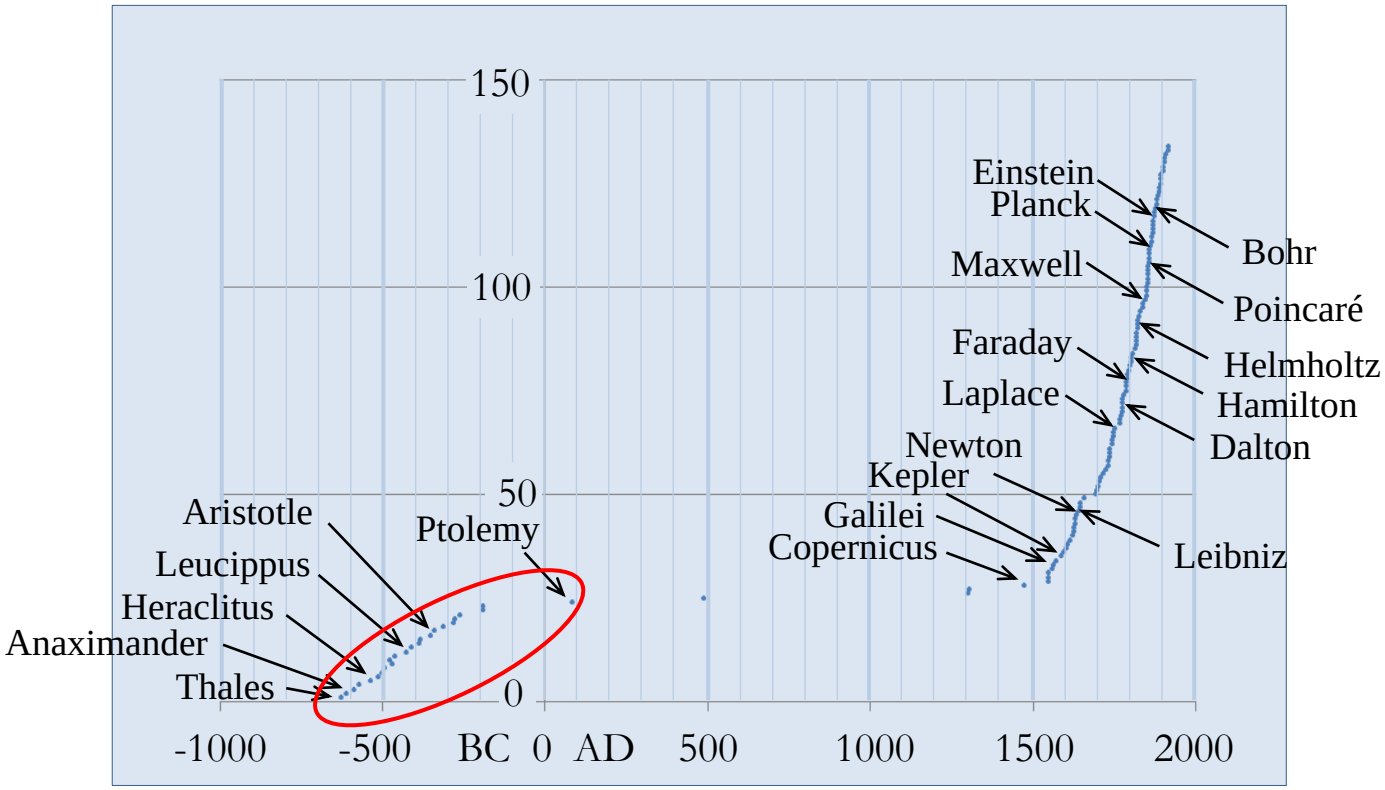
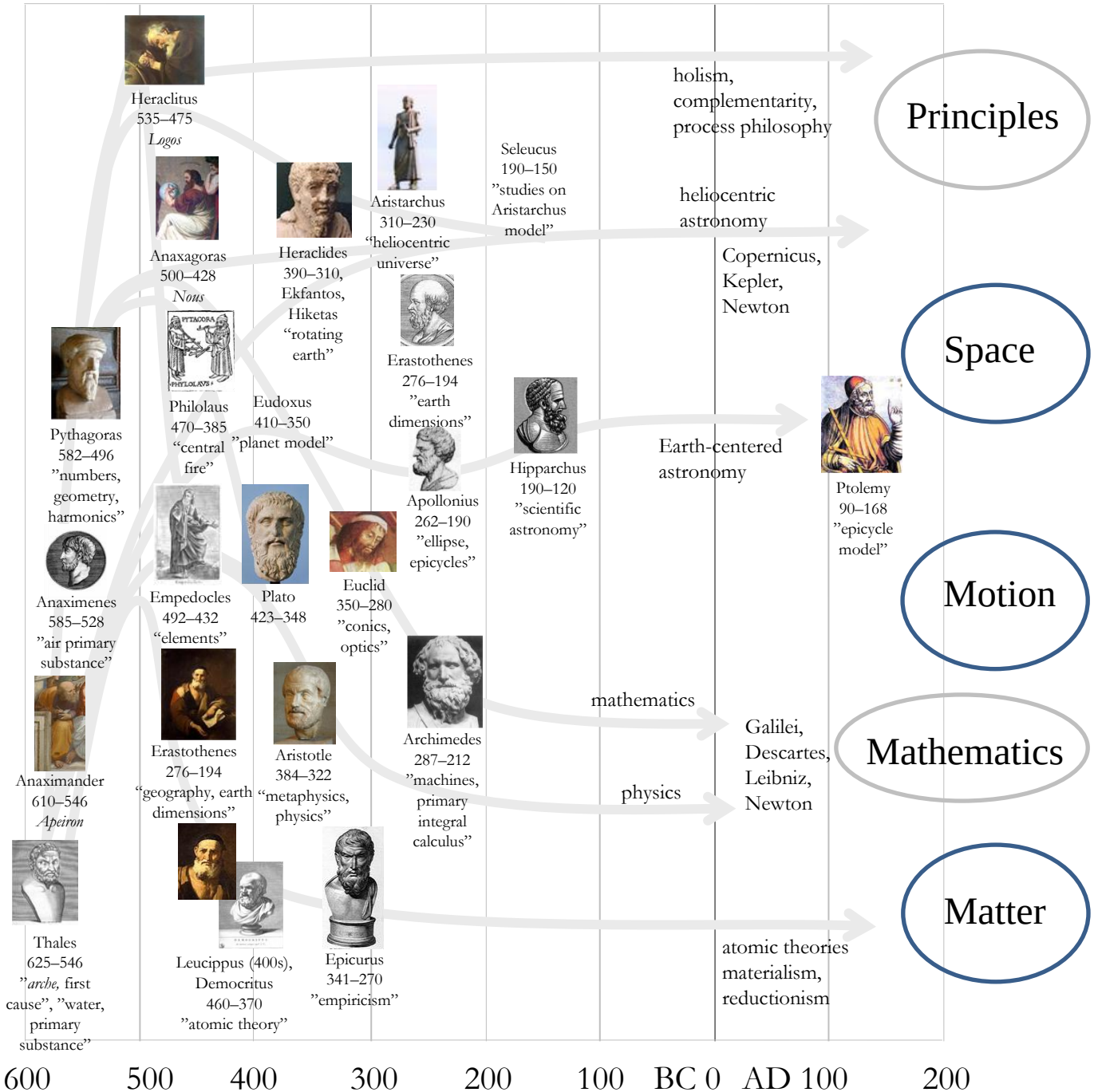
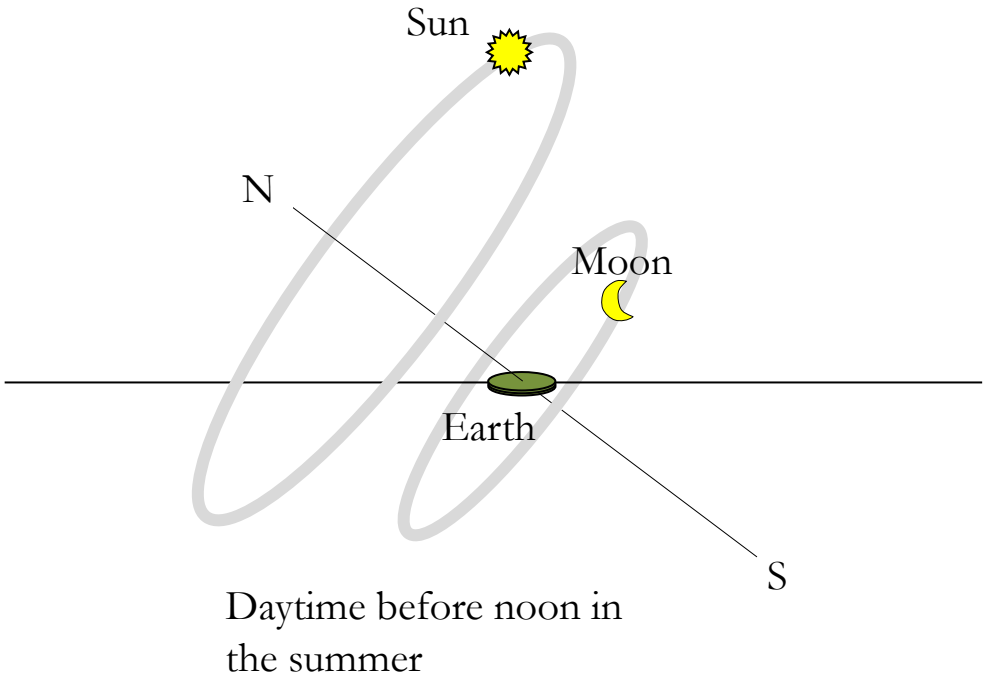


Antique inheritance

Search for the laws of nature and understanding of space, matter, and motion

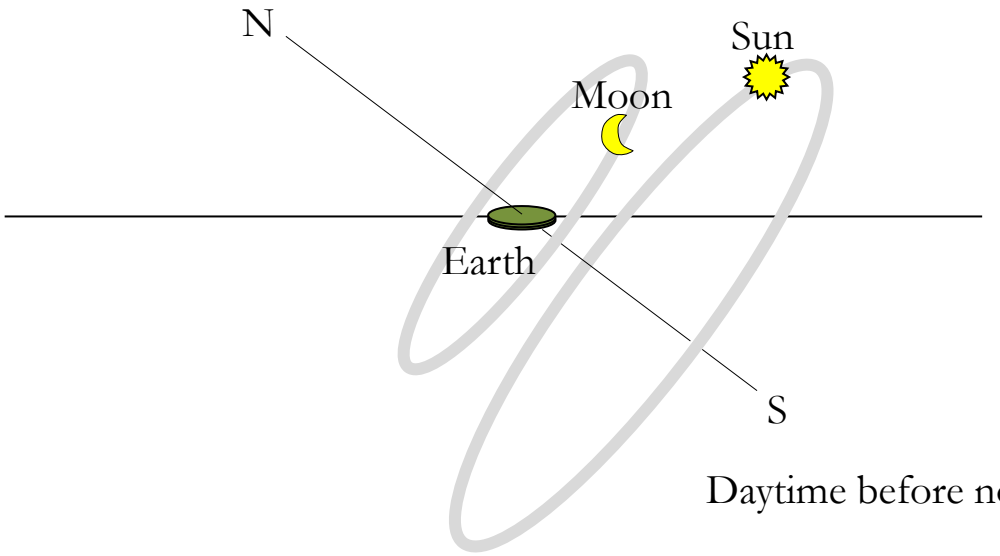


Gestalting skies and space



Anaximander's Earth centered universe.

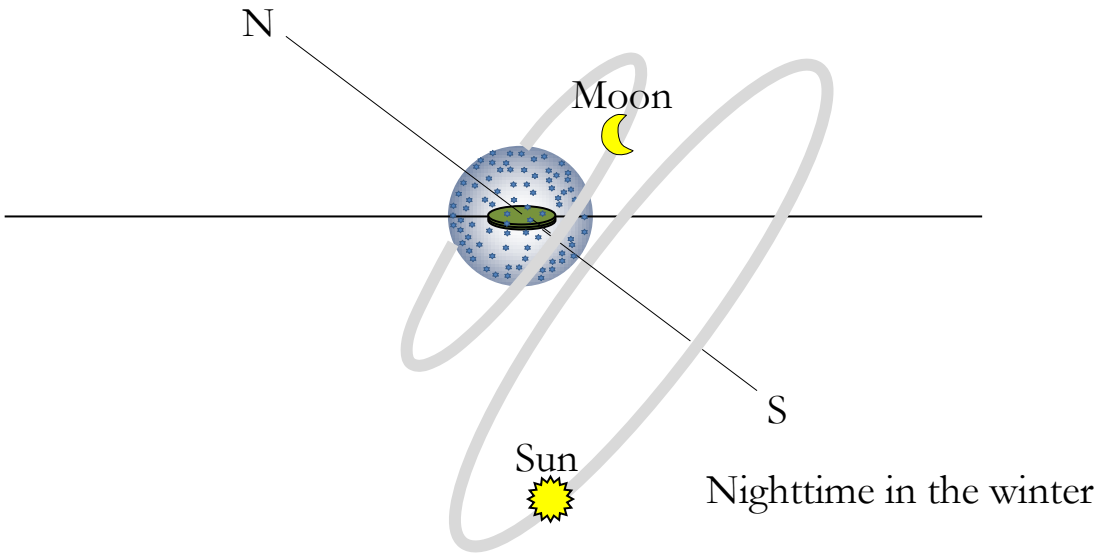
Gestalting skies and space



Daytime before noon in the winter

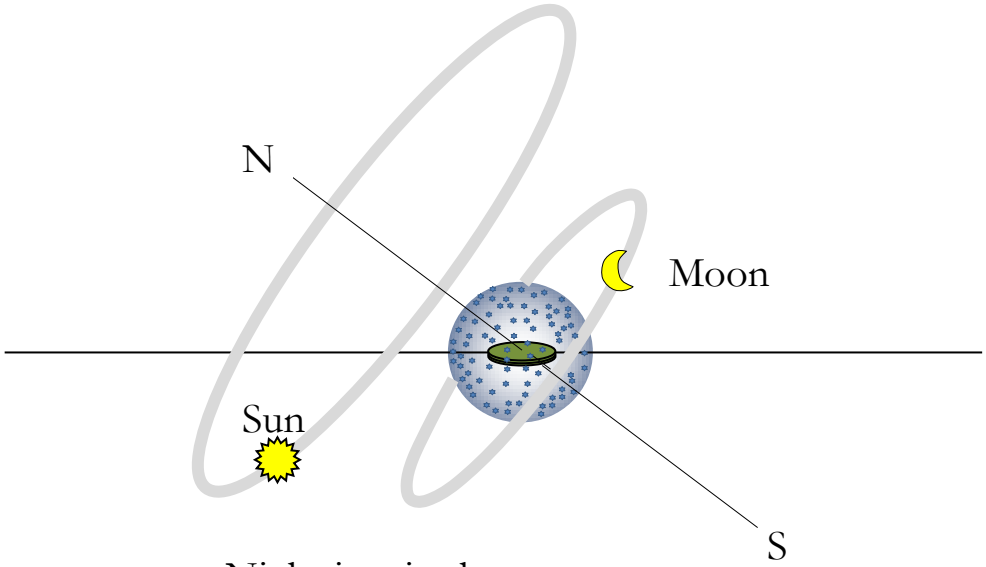
Anaximander's Earth centered universe.

Gestalting skies and space



Anaximander's Earth centered universe.

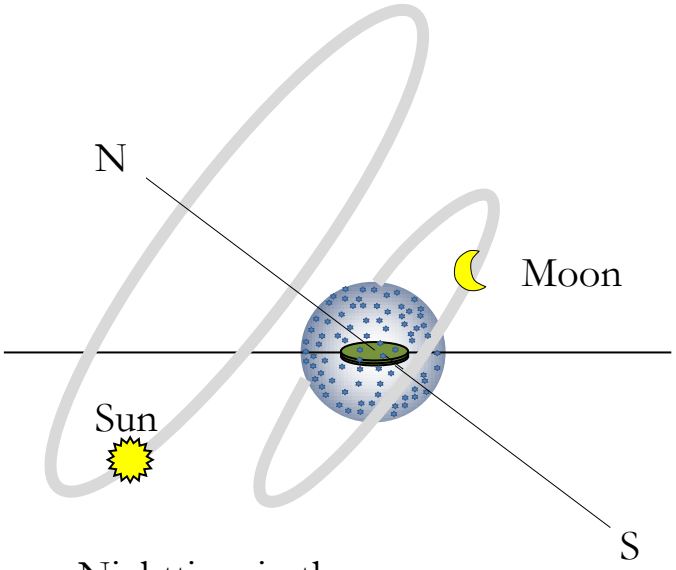
Gestalting skies and space



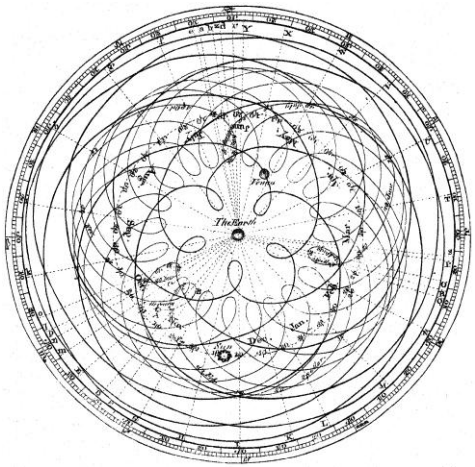
Anaximander's Earth centered universe.

Gestalting skies and space

500's BC → Ptolemy's epicyclic system (100's AD)



Nighttime in the summer

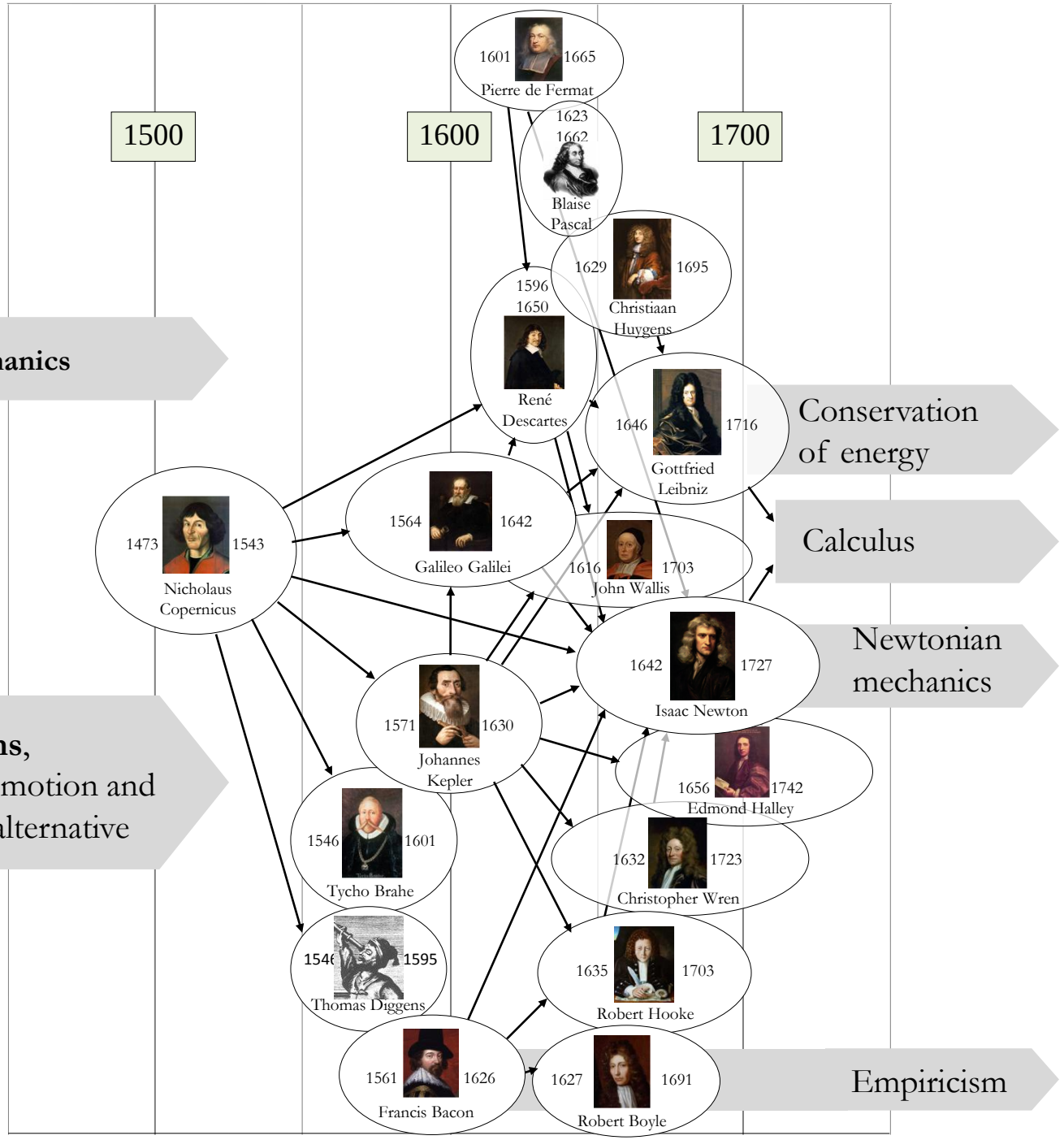


Planetary orbits in the Earth centered system

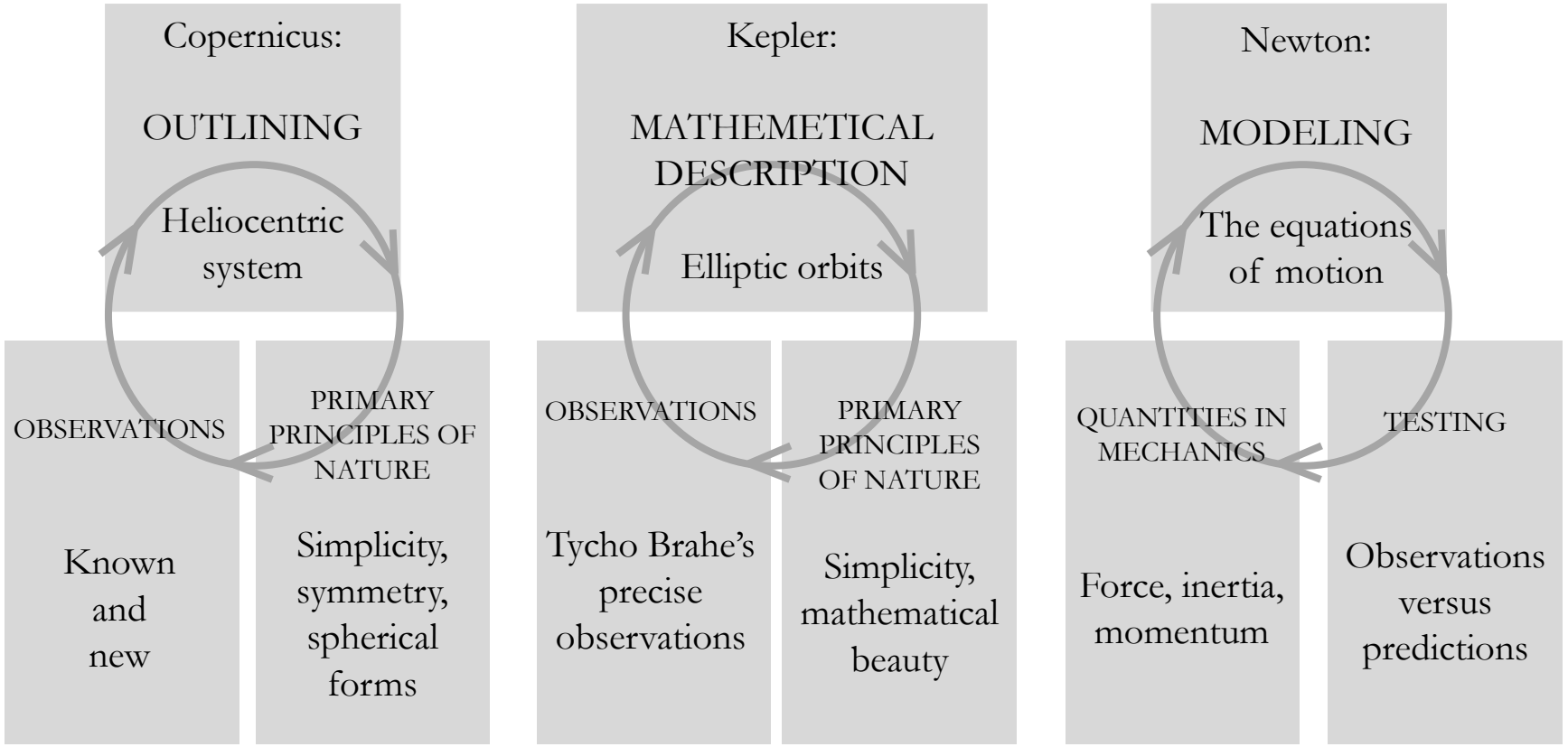
Anaximander's universe was constructed of a flat Earth surrounded by the sphere of fixed stars. The wheels for the Moon and the Sun were behind the sphere of stars.

The Copernican – Newtonian revolution

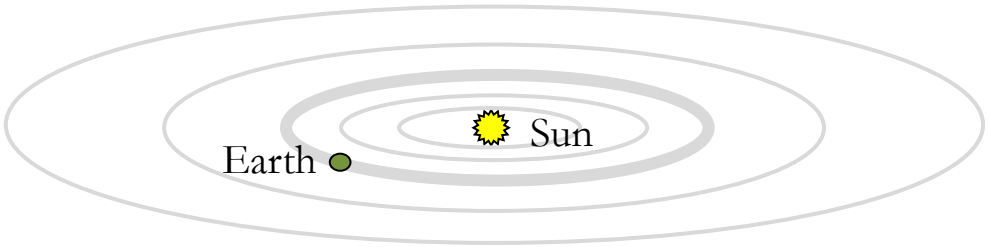
The dawn of mathematical physics

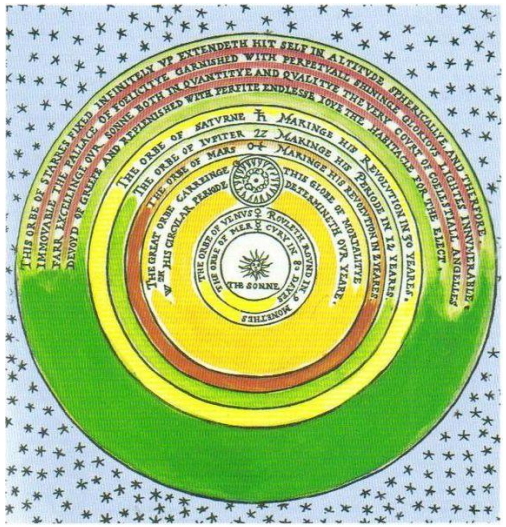


Gestalting of celestial mechanics



Gestalting skies and space



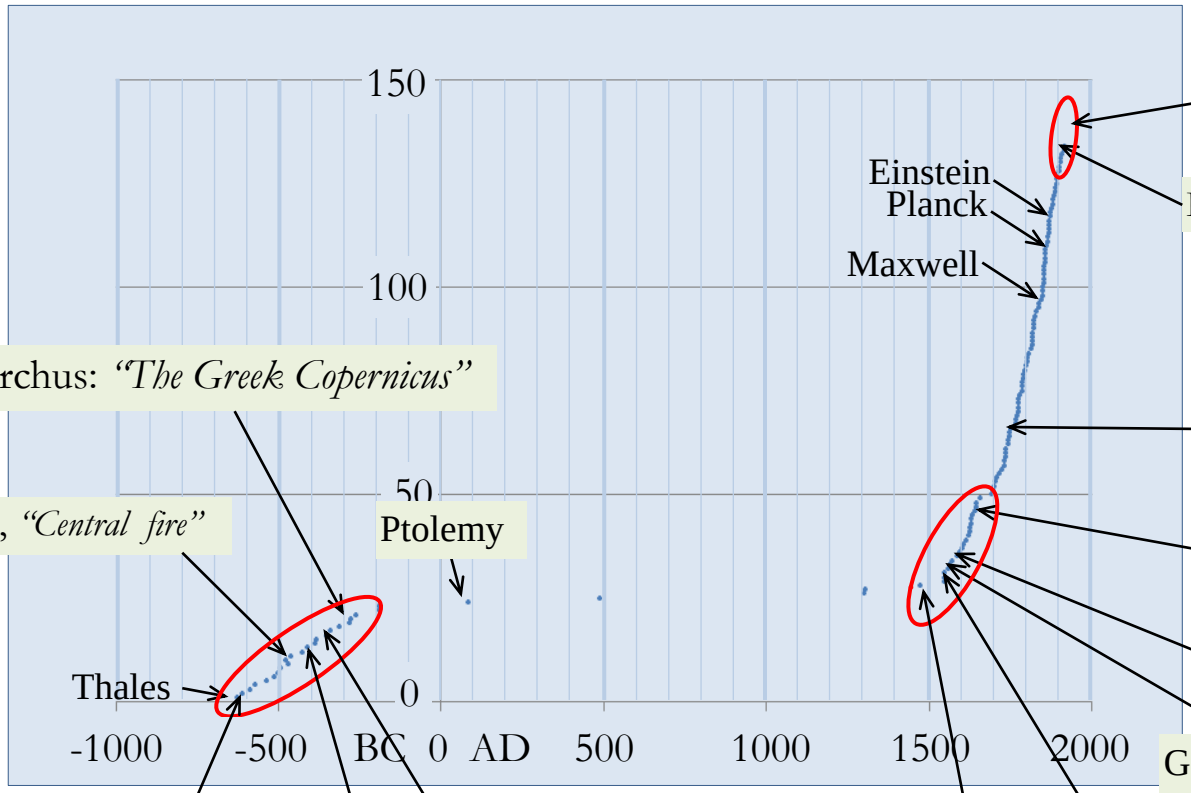


The first Chapter of Kopernicus' *De Revolutionibus,* is titled "***The Universe is Spherical***":

"First of all, we must note that the universe is spherical. The reason is either that, of all forms, the sphere is the most perfect, ... or that wholes strive to be circumscribed by this boundary ...

Thomas Digges's (1546–1595) view of the Copernican system. Fixed stars are spread to unlimited space.

Gestalting space



FLRW cosmology
1916 - 1940

Einstein: General relativity

Einstein
Planck
Maxwell

Laplace: Refinement of celestial mechanics

Newton: Mathematical solution for Kepler's orbits

Kepler: Elliptic orbits, Kepler's laws

Galilei: Force and acceleration, observations with telescope

Brahe: Precise measurement of planetary orbits

Copernicus: Heliocentric system

Aristarchus: *"The Greek Copernicus"*

Philolaus, *"Central fire"*

Ptolemy

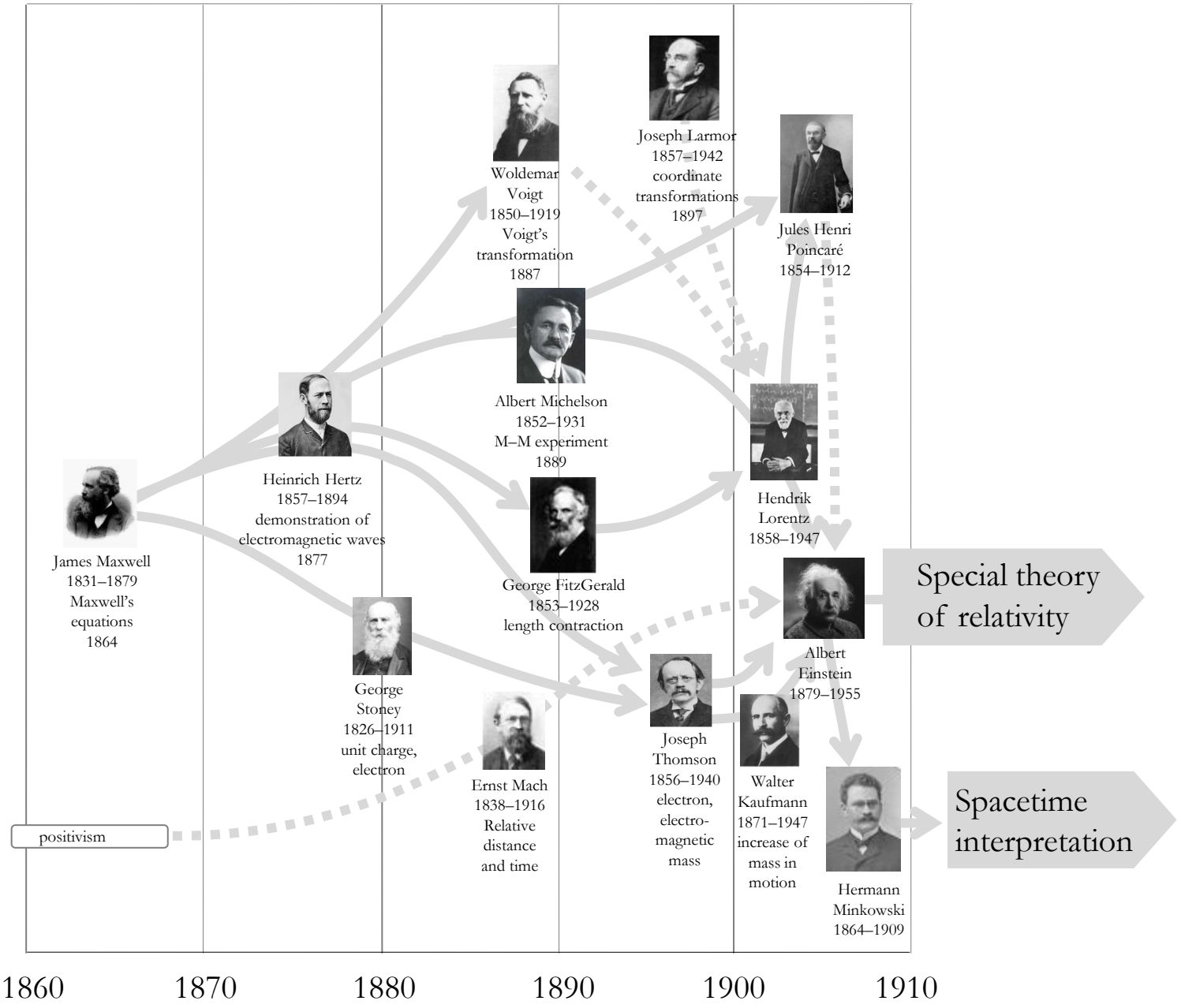
Thales

Aristotle: Eudoxus's system

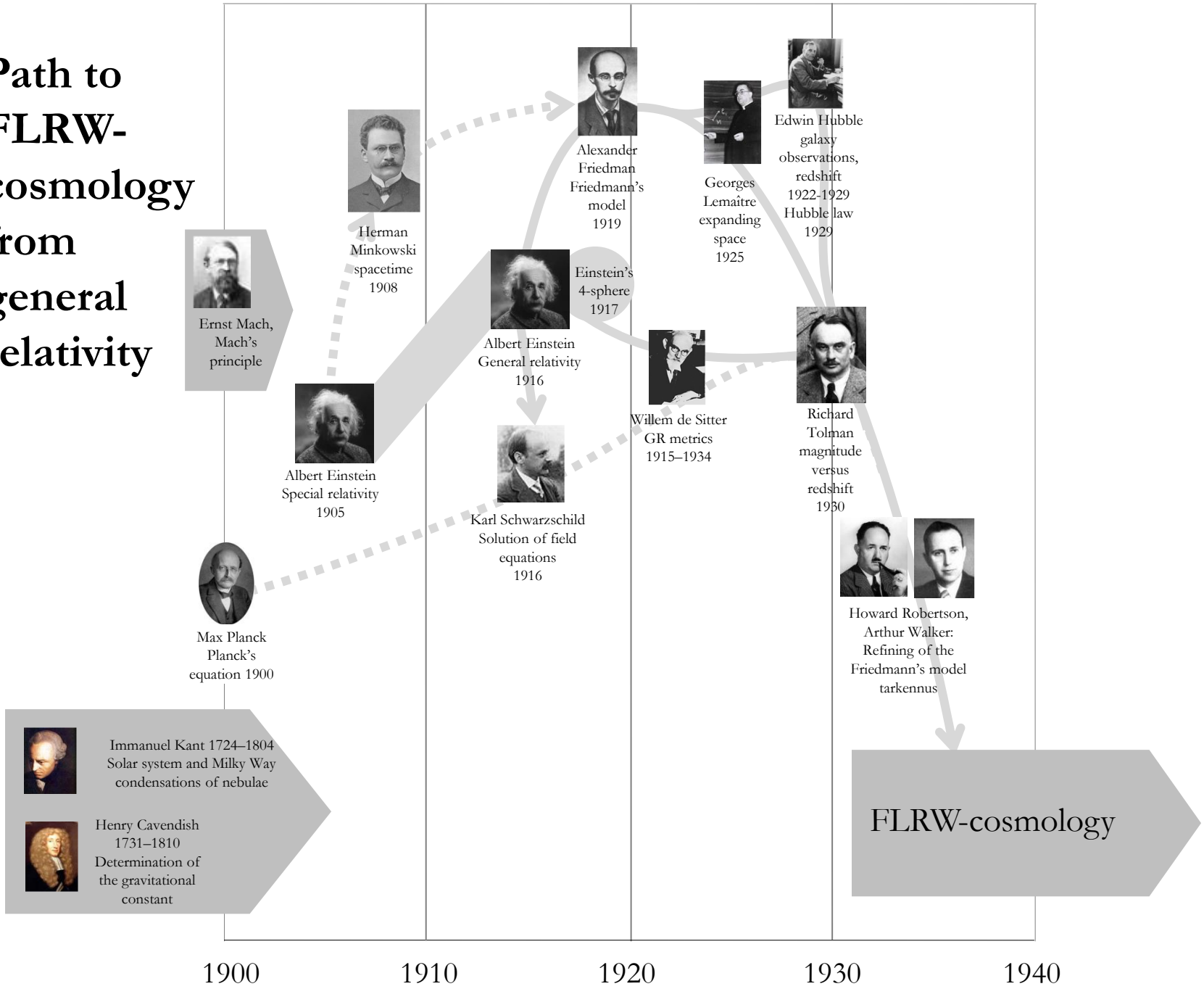
Anaximander's skies around the flat Earth

Eudoxus, planetary spheres around spherical Earth

Path to special relativity



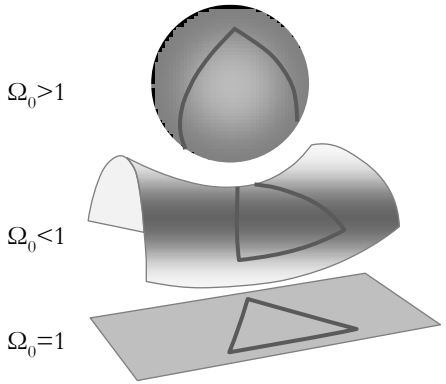
Path to FLRW-cosmology from general relativity

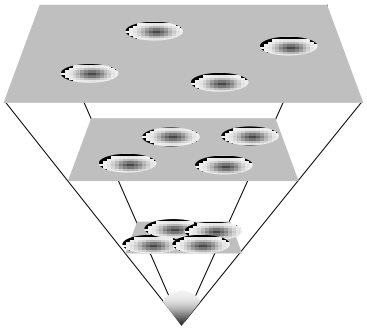


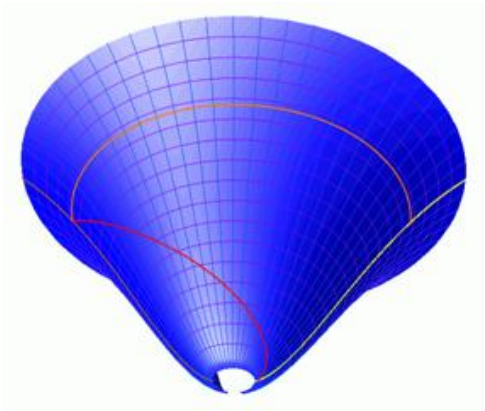
Gestalting skies and space

Gestalting modern cosmology is challenging

Space: FLRW – cosmology (Friedman, Lemaître, Robertson, Walker)







Outlining of spacetime geometry in FLRW – cosmology.

The antiquity question of infinite/finite space is unanswered by the FLRW cosmology.

Gestalting matter

Quantum mechanics: Material structures described in terms of wave functions

Leucippus, Democritus: *"Both matter and void have real existence. The constituents of matter are elements infinite in number and always in motion, with an infinite variety of shapes, completely solid in composition"*

Bohr's atomic model (1913)

Boltzmann: Statistical mechanics, kinetic theory of gases: strong support to atomic theory

Heraclitus, *"Everything is a part of the same whole"* or *"everything has its share of wholeness"*.

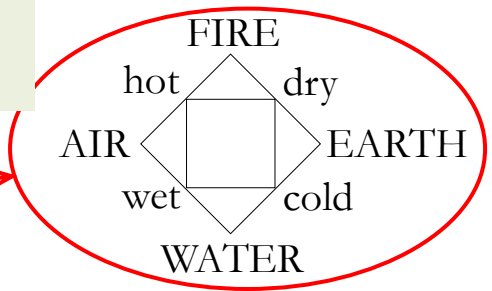
Dalton: Atomic and molecular hypothesis concluded from the ratios of elements in chemical reactions (1808)

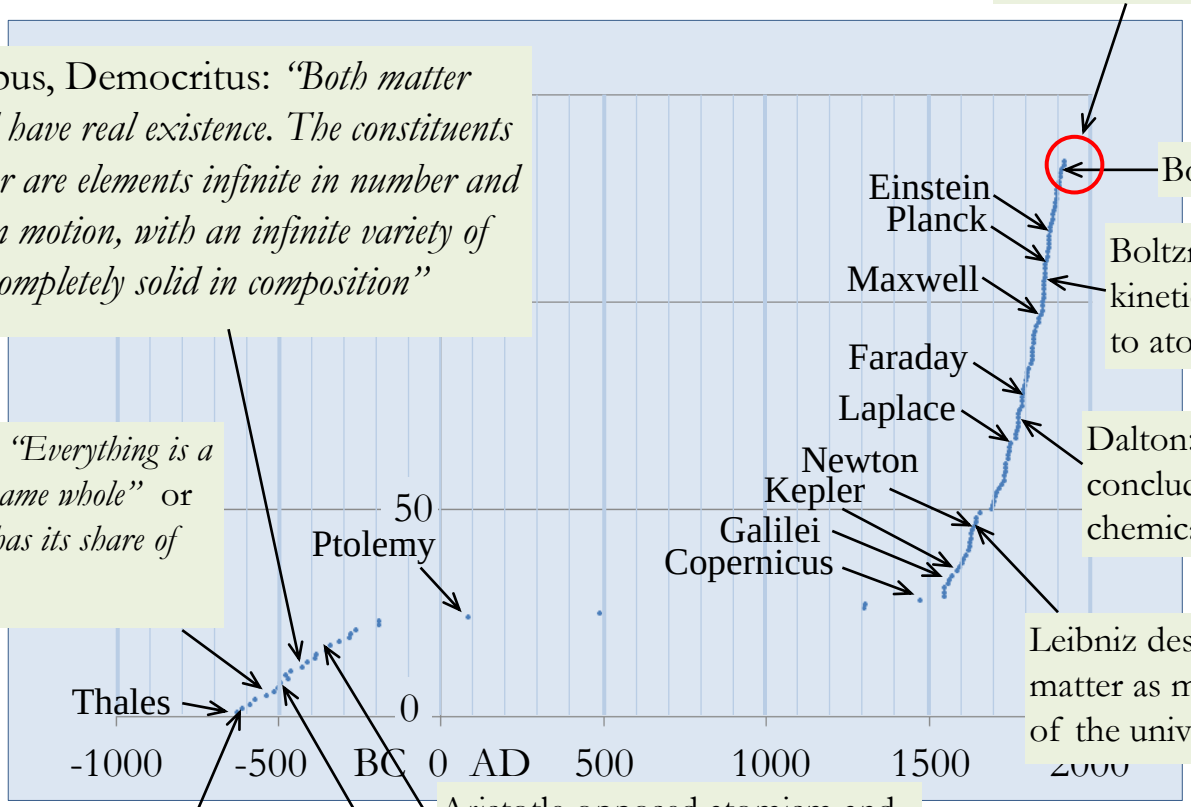
Leibniz described the elementary parts of matter as monads – "perpetual living mirrors of the universe"

Anaximander:
Apeiron is an abstract endless, unlimited principle and primary substance for all material expressions.

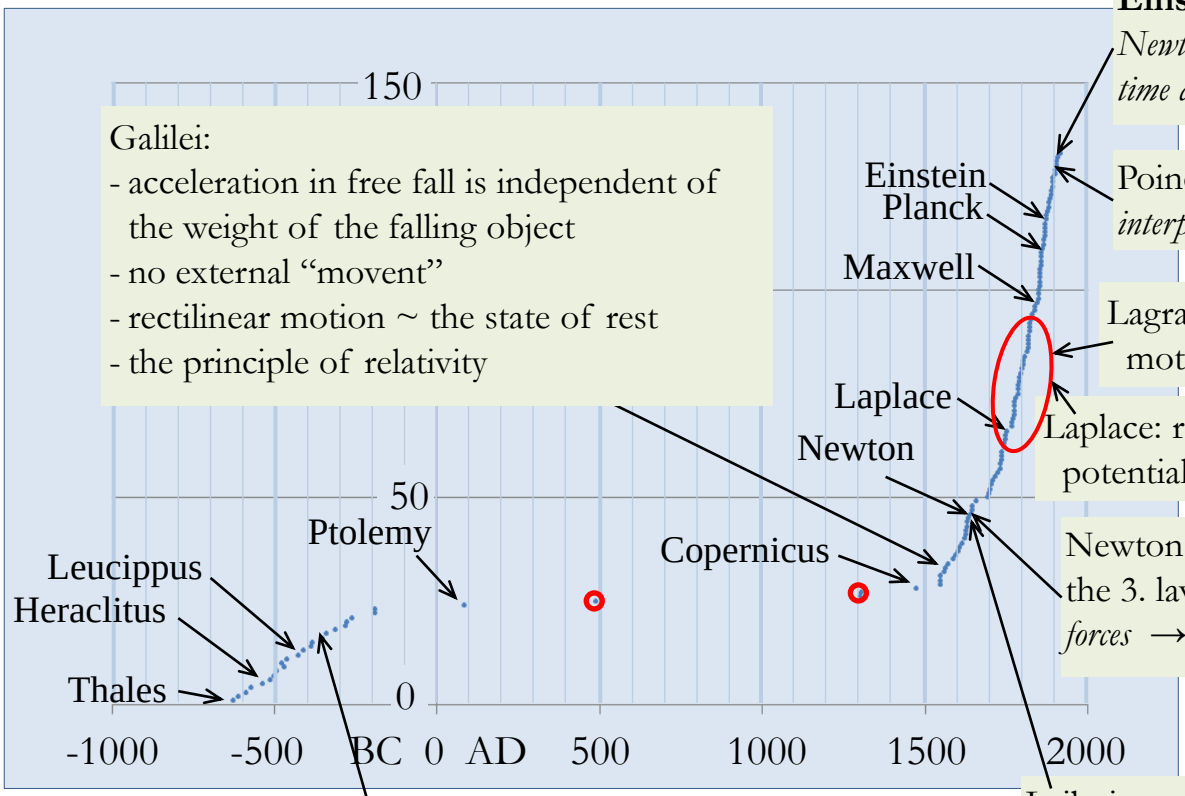
Aristotle opposed atomism and infinite apeiron; supported Empedocles's system.

Empedocles, the system of four elements.





Gestalting of motion



Einstein's special relativity (1905): *Newton's laws modified by redefinition of time and distance.*

Poincaré: *"Everything can be seen as interplay of kinetic energy potential energy"*

Lagrange, Hamilton : equations of motion in generalized coordinates

Laplace: refinement of celestial mechanics, potential theory

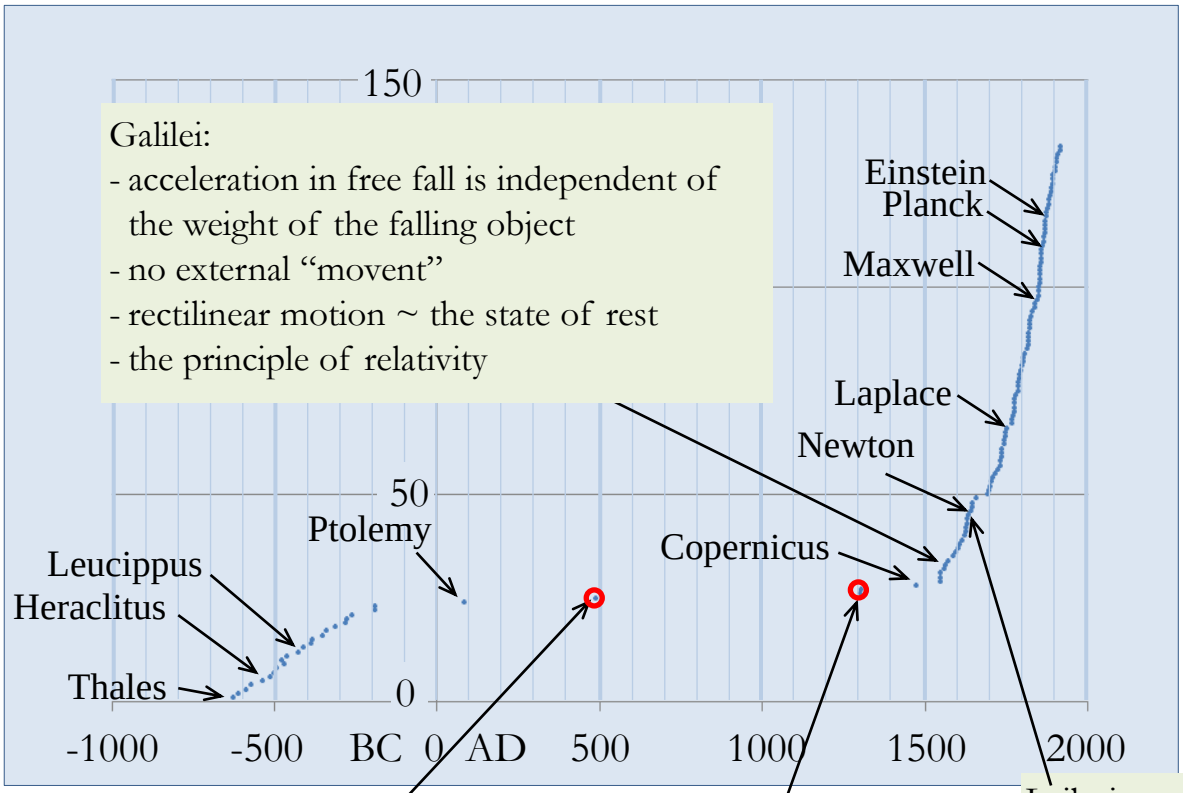
Newton: The 2. law of motion $F = m \cdot a$, the 3. law of motion, *balance of opposite forces → equivalence principle*

Galilei:
- acceleration in free fall is independent of the weight of the falling object
- no external "movent"
- rectilinear motion ~ the state of rest
- the principle of relativity

Aristotle:
- natural motion (free fall): the velocity is proportional to the weight of the object and inversely proportional to the resistance of the medium,
- forced motion (horizontal motion) requires an external movent

Leibniz:
- Living force (kinetic energy), *vis viva* is obtained against release of dead force (potential energy) *(vis mortua)*
- the amount of all living force in space is equal to the dead force released

Gestalting of motion



John Philoponus: *Motion is maintained by the energy, impetus, given to the object by the mover*

Jean Buridan: *Impetus and the concept of momentum*

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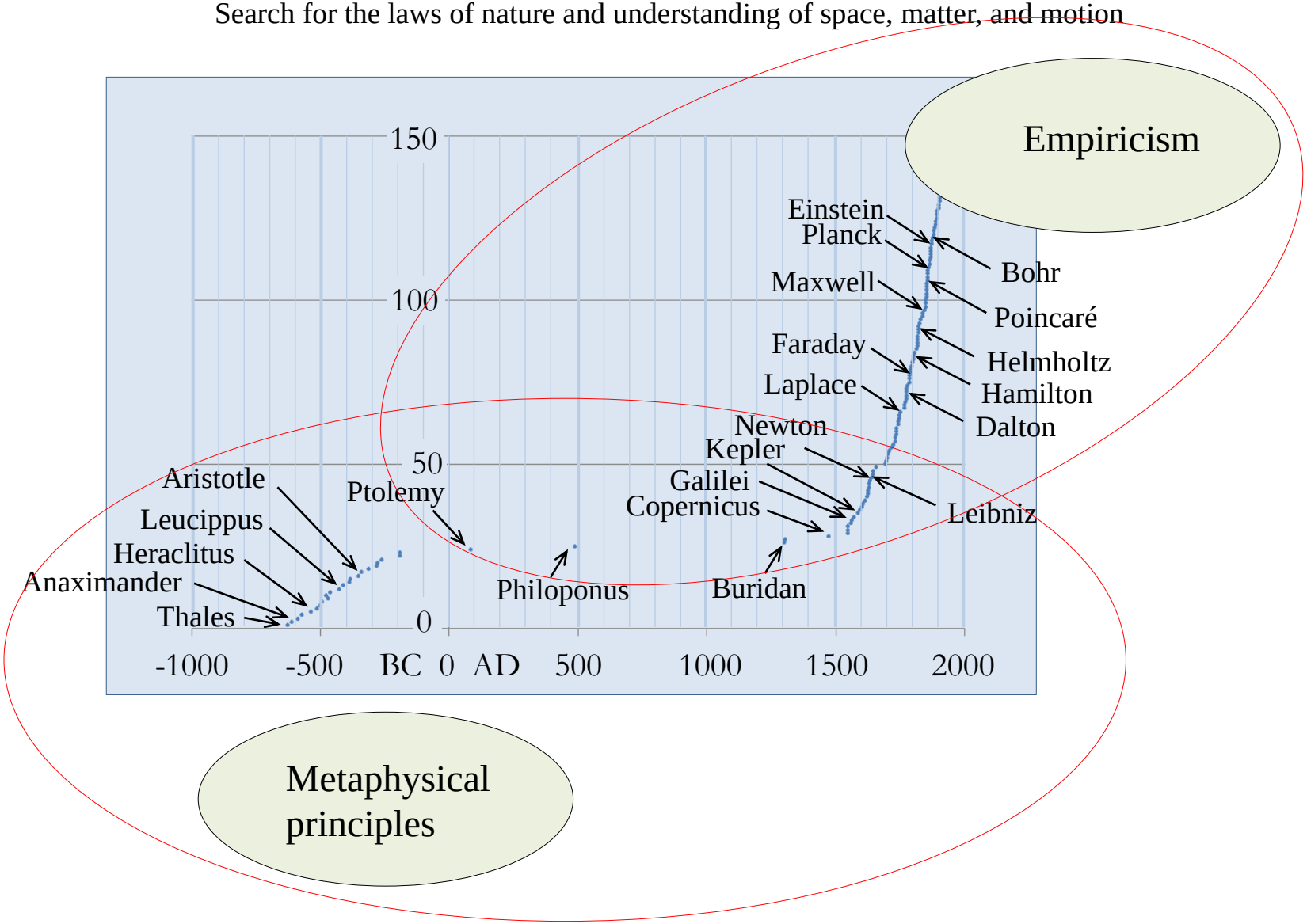
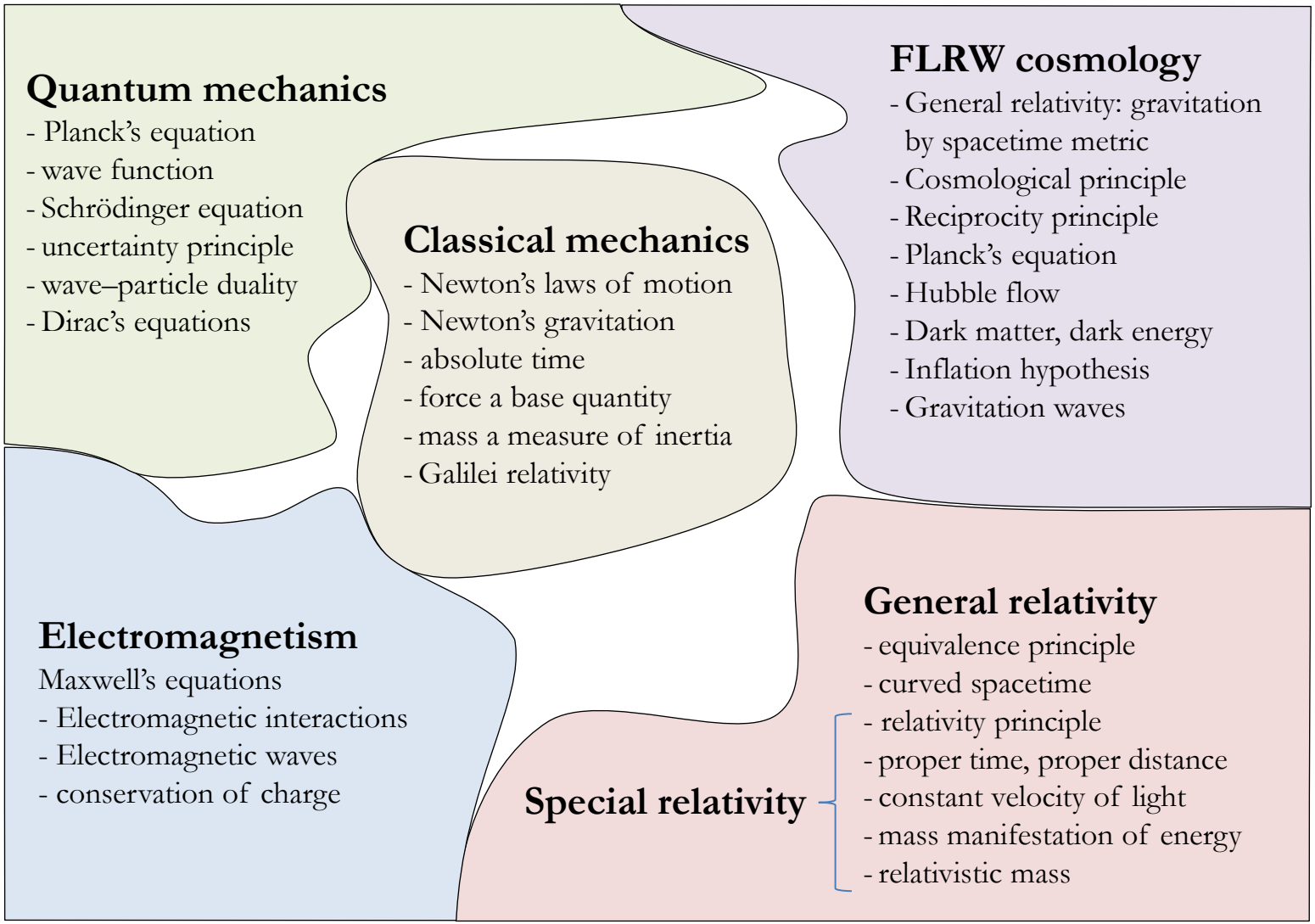


The empiricists' puzzle

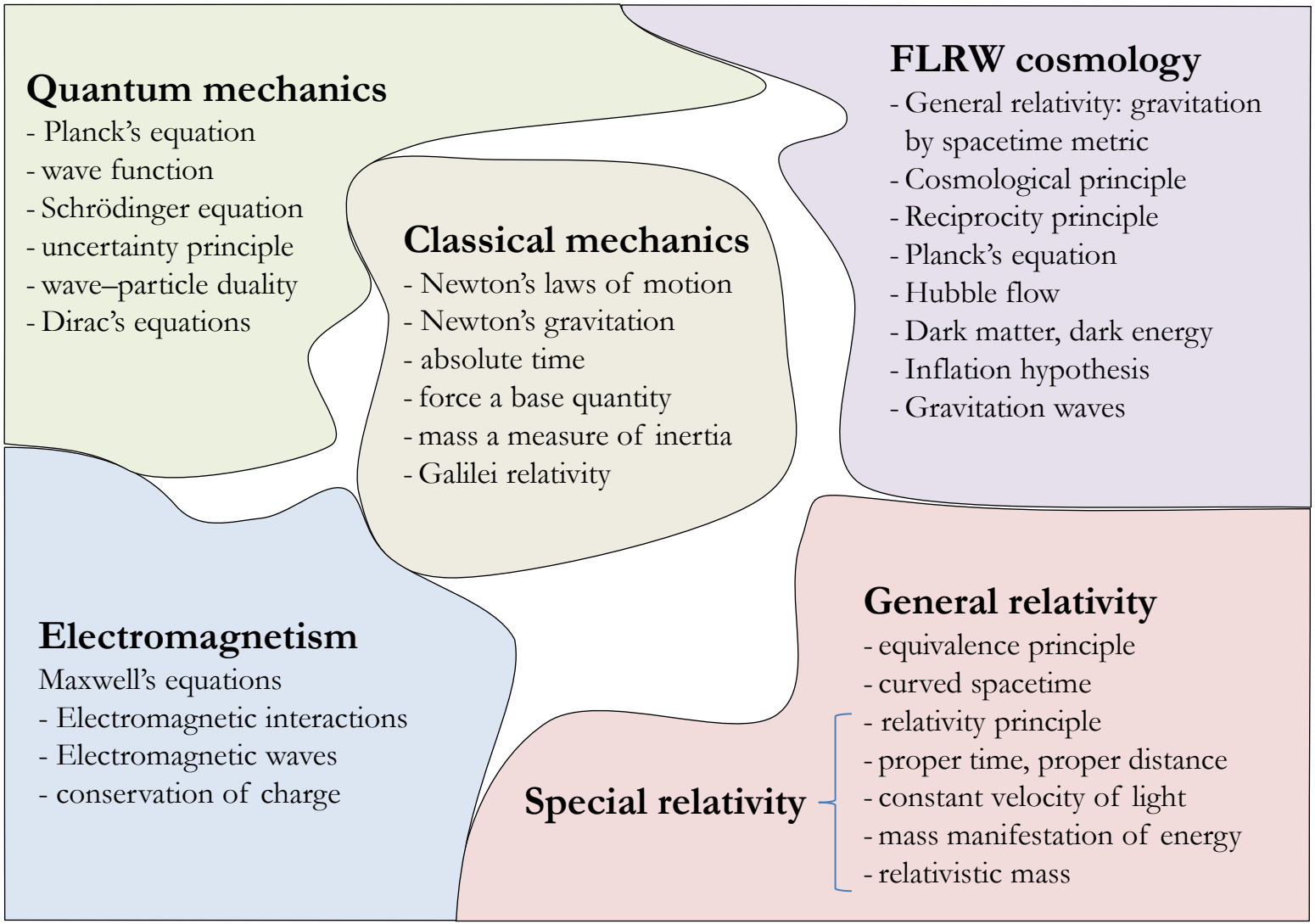


The empiricists' puzzle

Essence of the wave function?

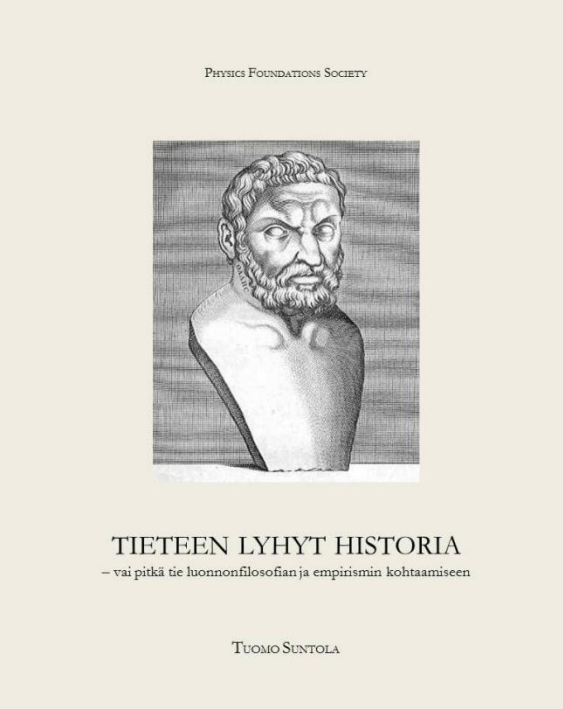
Gestalting curved spacetime ?

How to apply Occam's razor ?



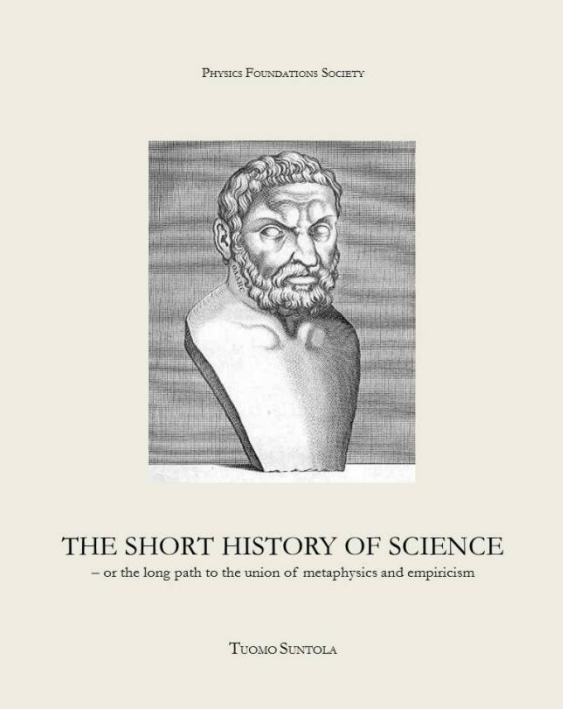
Gestalting relative time and distance ?

Books available at cafeteria (Tiedekahvila)



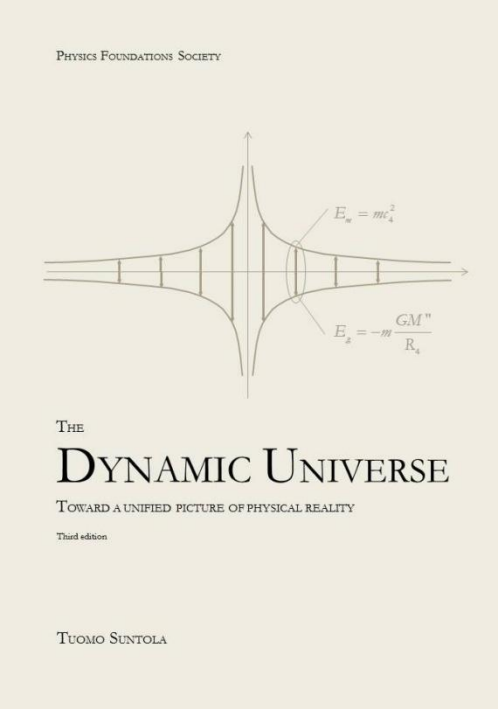
Tieteen lyhyt historia

- vai pitkä tie luonnonfilosofian ja empirismin kohtaamiseen
2012



The Short History of Science

- or the long path to the union of metaphysics and empiricism
2012



The Dynamic Universe

Toward a unified picture of physical reality

2011