*EPFL Master course*
*Philosophical perspectives on the exact sciences and their history*

# Introduction & Newton on natural philosophy

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# What you are expected to do

- **submit an essay plan, defend your plan in November-December and work out the essay by 1 May**
- **essay plan (ca. 3 pages): a brief introduction to your topic & situating the topic in the field of philosophy of science, a clear statement of your research question, an outline of how you intend to address that question**
- **final essay:**

a) **an introduction in which you spell out your research question, tell the reader why this question is interesting and put it into a general framework**

b) **a main part in which you develop your argument, give examples, discuss possible objections**

c) **a conclusion that sums up your results and contains an assessment**

# Teaching staff

- Professor

Michael Esfeld, michael.esfeld@unil.ch

- Assistant
- Amine Rusi, amine.rusielhassani@unil.ch
- Postdoc

Cristian Lopez, cristian.lopez@unil.ch

# Schedule autumn

- **Wed 10 Sept.: Michael Esfeld: Newton on natural philosophy & Cristian Lopez: Physics and philosophy**
- **Wed 17 Sept.: Amine Rusi: Philosophy of space and time & Michael Esfeld: What is a law of nature?**
- **Wed 24 sept.: Michael Esfeld: Quantum physics: non-locality and the measurement problem & the ontology of quantum physics**
- **Wed 1 Oct.: Amine Rusi: Philosophy of artificial intelligence and consciousness &**
- **Wed 8 Oct.: Michael Esfeld: Mind and free will & Cristian Lopez: Mathematical structure and ontology**
- **Wed 15 Oct.: Amine Rusi: How to write an essay & definite fixing of the groups and essay subjects**

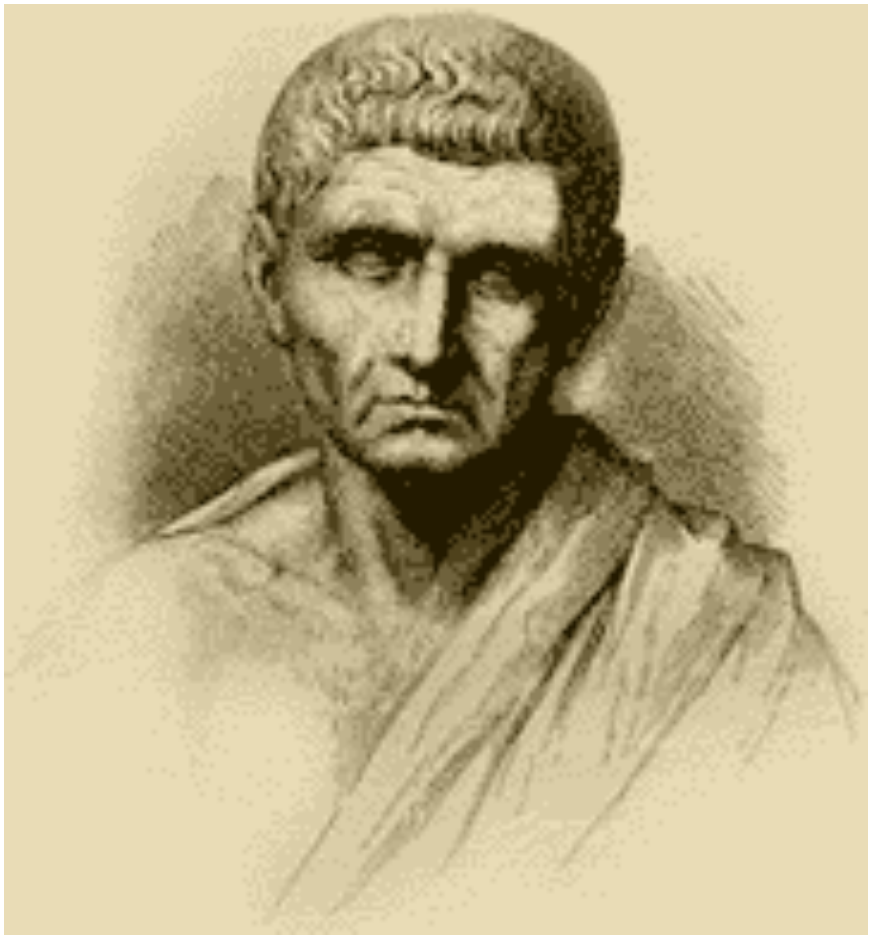
# Schedule autumn

- **Work on essay plan, at least one meeting with supervising assistant (scheduled via moodle); submit essay plan to supervising assistant one week before the oral discussion**
- **Wed 26 Nov., 3, 10, 17 Dec.: discussion of essay plan in class, 15 minutes presentation, 15 minutes discussion**

# Schedule spring

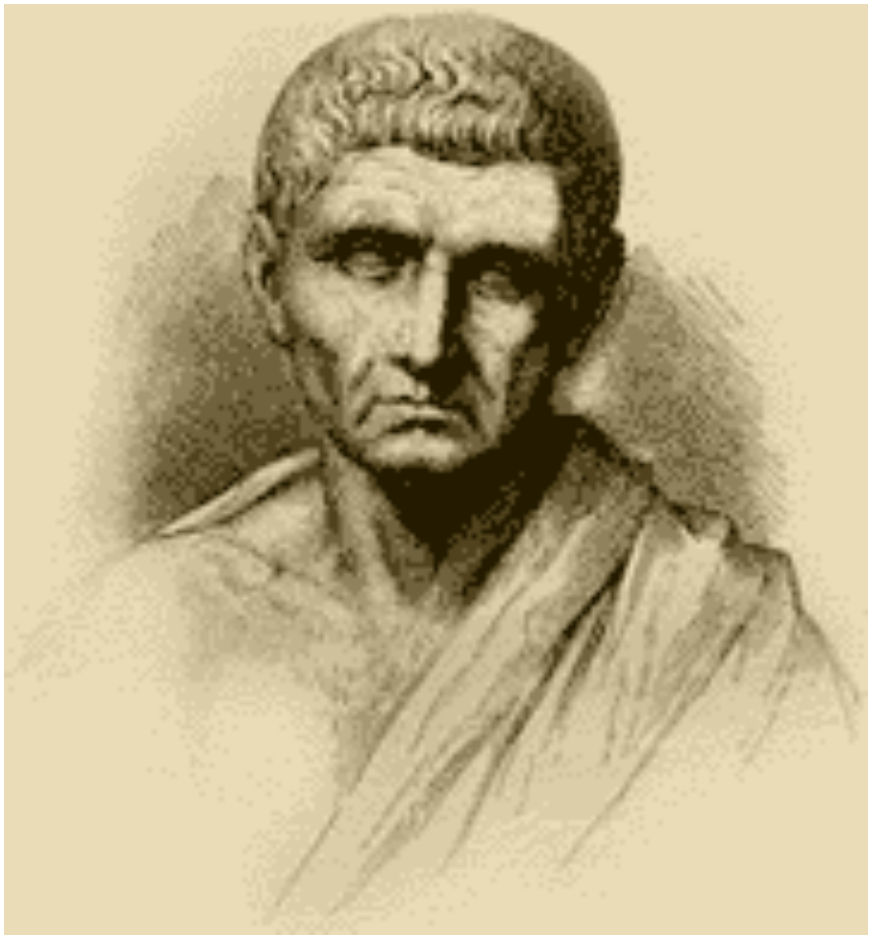
- **Work on essay, at least one meeting with supervising assistant in February**
- **by 1 May: submit essay**
- **by 1 June: submit final version of essay, if changes requested**

# Aristotle (384-322 B.C.)
## *Metaphysics*



- observation
- memory
- experience
- laws
- knowledge: science (epistémé)
- philosophy (théoria)

# Aristotle (384-322 B.C.)
## *Metaphysics*



- ***physis*: the domain of what exists in itself, by contrast to *techné* = the artefacts created by us**
- **physics: the science of that domain**
- **metaphysics: what comes after physics, general principles of being**

# Modern science / Natural philosophy

- science and philosophy inseparable: physics on the basis of a reflection on fundamental concepts

  Descartes, Leibniz, Newton, Einstein
- search for universal laws in mathematical expression

  objectivity, separate facts from norms and values

  systematicity

  experimental method, methodological scepticism

# Three questions

1) What is matter? What is space and time?
2) What are the laws of nature?
   What is a law of nature?
3) How does matter in space and time, being subject to certain laws, explain the observable phenomena?

# First Presocratic philosophers

Thales (about 640 before J.C.)

Anaximander (about 611-549 before J.C.)

Anaximenos (about 600-550 before J.C.)

- matter as stuff ("gunk") stretching out throughout space

  four elements: water, fire, earth, air

# Democritos (about 460-370 before J.C.)

"There is an infinite number of impenetrable atoms, without qualities and indestructible, which move in the void where they are distributed. But when they come close to each other or collide, their aggregation results in water, in fire, in a plant, or in a human being."

# Newton, *Opticks* (1704)

**"… it seems probable to me, that God in the Beginning form'd Matter in solid, massy, hard, impenetrable, moveable Particles … the Changes of corporeal Things are to be placed only in the various Separations and new Associations and motions of these permanent Particles."**

# Richard Feynman
## *Feynman Lectures* (1963)

**"If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generations of creatures, what statement would contain the most information in the fewest words? I believe it is the *atomic hypothesis* (…) that *all things are made of atoms – little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another*. In that one sentence, you will see, there is an *enormous* amount of information about the world, if just a little imagination and thinking are applied."**

# The attractiveness of atomism

- proposal for an ontology that is most parsimonious & most general and that explains the familiar macroscopic world
- macroscopic objects composed of indivisible particles
- all the differences between the macroscopic objects – at a time as well as in time – accounted for in terms of the spatial arrangement of the particles and its change
- atoms: relative positions & change (motion)

# Change / Laws I

- change of position of the particles

→variable of velocity (= first temporal derivative of position $dq / dt = v$)

- initial velocity → certain motion of the particles
- initial velocity explains motion of particles
- initial velocity conserved → inertial motion

→Newton's first law:

"Every body perseveres in its state either of rest or of uniform motion in a straight line, except insofar as it is compelled to change its state by impressed forces."

# Change / Laws II

- change in the relative positions of the particles such that is also change in their state of motion = change of velocity

→ more variables necessary than velocity

- parameters that determine the temporal development of velocity (acceleration, second temporal derivative of position) → forces

→ Newton's second law:

"The change in motion is proportional to the impressed motive force and is made along the straight line on which the force is impressed."

→ Newton's third law:

"To every action there is always opposed an equal reaction: or, the mutual actions of two bodies upon each other are always equal, and directed to contrary parts."

# Change / Laws II

- particles: mass
- in virtue of possessing mass, the particles attract each other (gravitational mass) as well as resist to acceleration (inertial mass)
- distribution of the particles in space at $t$ = distribution of the masses in space at $t$, initial velocities at $t$, gravitational constant → change of velocity (acceleration) of the particles at $t$ determined
- What is mass?
- Where is the force?

# What are the atoms?

- **Ernst Mach (1838-1916):** mass introduced through its dynamical role = how it changes the state of motion of the particles

→ no intrinsic difference between constants of nature (e.g. gravitational constant, Planck's quantum of action) and dynamical parameters attributed to the particles (mass, charge)

→ all these introduced through their function for the particle motion

→ positions as characterizing & discerning the particles

→ mass, charge, constants, forces, fields, energy, etc: dynamical structure; function for evolution of configuration of matter

→ particles as occupying space: primitive ontology, simply there, no function

# Action at a distance

Newton : forces act

- without medium
- instantaneously at any spatial distance (although their action goes down with the square of the distance)

→action at a distance: the mass of an object at *t* changes the state of motion of all the other objects in the universe at *t*

# Bas van Fraassen (1991)

**"To speak of instantaneous travel from *X* to *Y* is a mixed or incoherent metaphor, for the entity in question is implied to be simultaneously at *X* and at *Y* – in which case there is no need for travel, for it is at its destination already."**

# Newton to Bentley 25 Feb. 1692

"That gravity should be innate inherent & essential to matter so that one body may act upon another at a distance through a vacuum without the mediation of anything else by & through which their action or force may be conveyed from one to another is to me so great an absurdity that I believe no man who has in philosophical matters any competent faculty of thinking can ever fall into it."

# Envoi

- Aristotle's distinction between experience and knowledge
- natural philosophy & modern science: physics on the basis of a conceptual reflection about nature, objectivity
- the guiding idea of atomism
- the need for laws of motion
- the distinction between primitive ontology and dynamical structure
- Newton's three laws
- interaction as "action at a distance"