A Short History of Physics

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References: Most of the following is copied from Wikepedia.

Introduction

Philosophy and Religion aim at Fundamental Truths.

It is my believe that the secured part of this is in Physics.

This happend by Trial and Error over more than 2,500 years and became systematic Theory and Observation only in the last 500 years. This talk collects important events of this time period and attaches them to the names of some people. I can only give an inadequate presentation of the complex process of scientific progress. The hope is that the flavor get over.

Physics

From Acient Greek: "Nature".

Broadly, it is the general analysis of nature, conducted in order to understand how the universe behaves. The universe is commonly defined as the totality of everything that exists or is known to exist.

In many ways, physics stems from acient greek philosophy and was known as "natural philosophy" until the late 18th century.

Ancient Physics: Remarkable people and ideas.

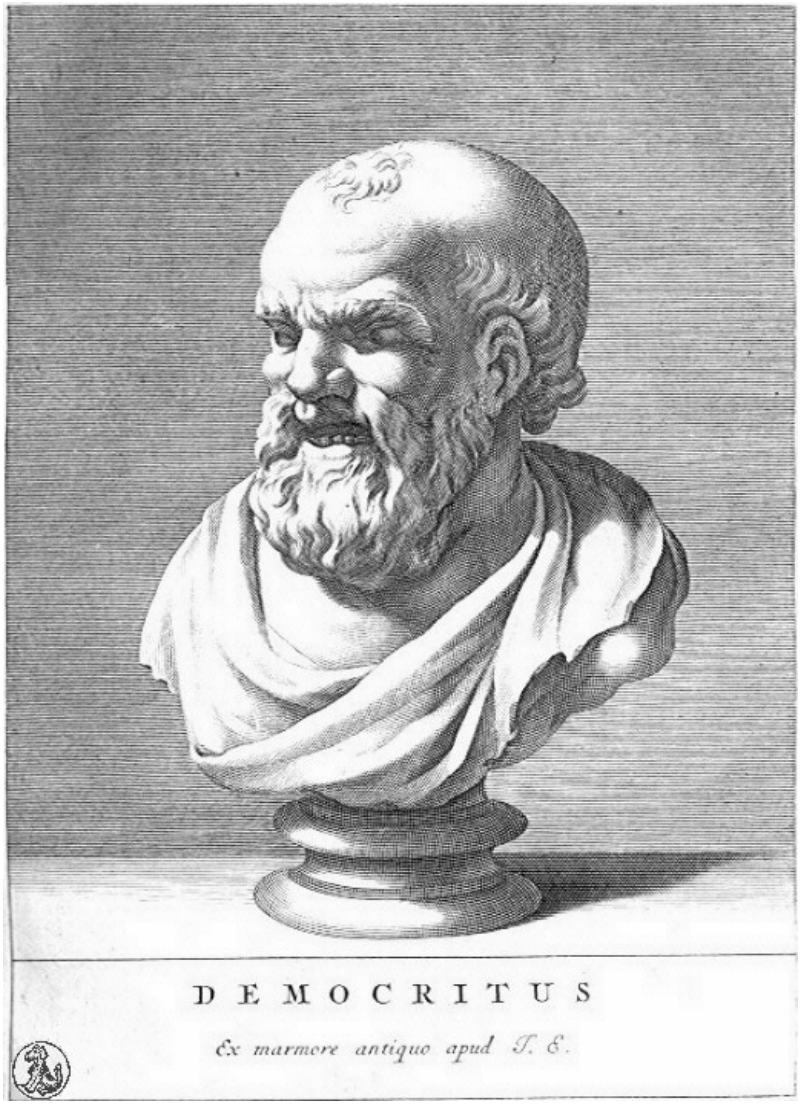
Pythagoras (ca. 570–490 BC):

$$a^2 + b^2 = c^2 \text{ for rectangular triangle.}$$

Leucippus (early 5th century BC) opposed the idea of direct devine intervention in the universe. He and his student Democritus were the first to develop a theory of atomism.

Plato (424/424–348/347) is said that to have disliked Democritus so much, that he wished his books burned. Nowadays, many consider Democritius to be the father of modern science.

Democritus (ca. 460–370 BC)



Aristotle, a student of Plato, promoted the concept of natural laws for physical phenomena, which he attempted to explain with a theory of four elements, earth, water, air, and fire. He had a geocentric view of the universe. Aristotelian physics became enormously popular in Europe with the scientific and scholastic developments of the Middle Ages and remained the mainstream scientific paradigm until the time of Galilei and Newton.

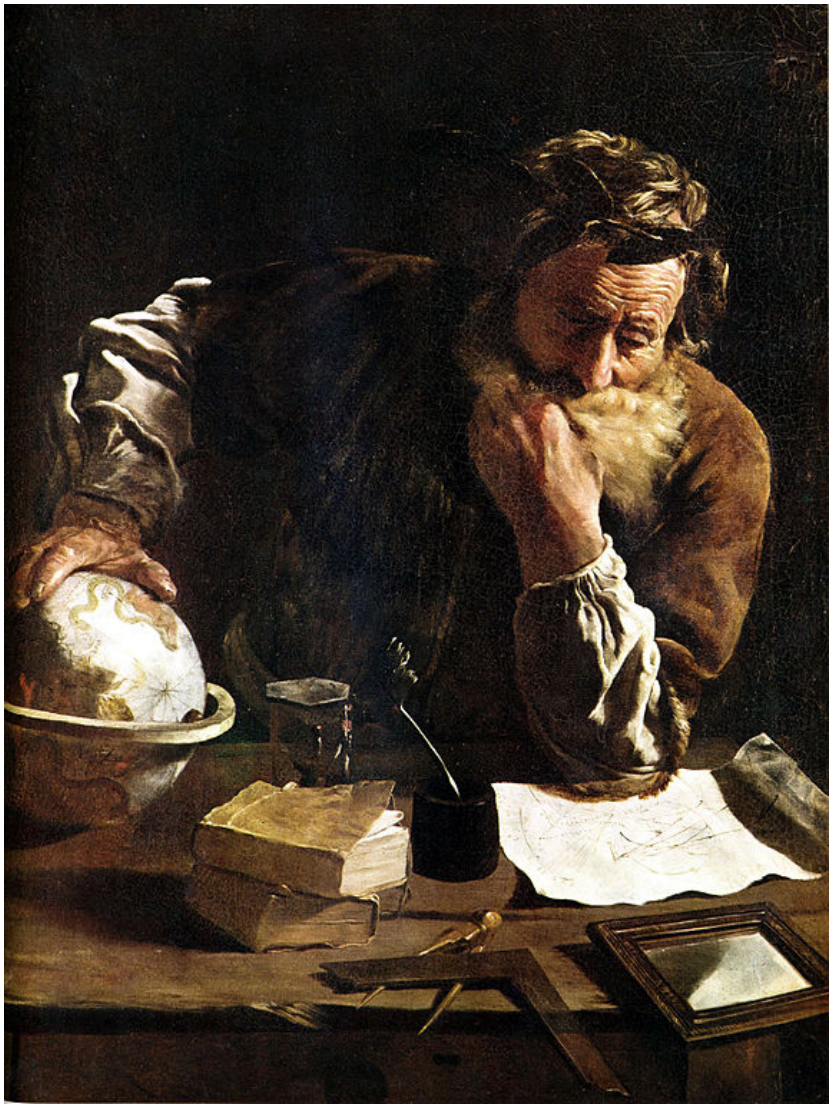
Aristotle 384–322 BC

In contrast to Aristotle's geocentric view Aristarchus of Samos (310 – ca. 230 BC) proposed a heliocentric model of the solar system, but received little support from ancient astronomers, although his student Seleucus was according to Plutarch (historian 46–120 AD) the first to prove the heliocentric system through reasoning. But the argument got lost.

Instead, based on previous work by Hipparchus (190–120 BC), Ptolemy (90–168 AD), one of the leading minds of the Roman Empire, perfected the geocentric system, so that accurate predictions of planetray movements became possible. This was in essence a model with many adjustable parameters.

Archimedes of Syracuse (287–212 BC)

Picture by Domenico Fetti 1620



The Genius of the Antique.

- Foundations of Statics and Hydrostatics
- Mathematics of the lever $F_{\text{in}}\, d_{\text{in}} = F_{\text{out}}\, d_{\text{out}}$.
- Archimedes' Screw (Pump).
- Archimedes' Principle: Law of buoyance.

Writings of Archimedes are also the only source left for the work of Aristarchus: "His hypotheses are that the fixed stars and the Sun remain unmoved, that the Earth revolves about the Sun on the circumference of a circle, ...".

Intermezo

Most of the direct work of the ancient world got lost (for instance, all 14 books of Hipparchus). Major event: Destruction of the Library of Alexandria in 48 BC (about 40,000 books). "Dark" Ages.

– Arabic Scientists (not covered)

– India and China (not covered)

Hindu-Arabic numeral system 0,1,2,3,4,5,6,7,8,9.

– Medieval Years:

Awareness of ancient works re-entered the West through translations from Arabic to Latin.

Scientific Revolution

– Nicolaus Copernicus (1473–1543): Heliocentric.

– Tycho Brahe (1546–1601): Precise planetary data.

– Johannes Kepler (1571–1630):

"Music of the spheres", Phenomenological laws:

1. The orbit of every planet is an ellipse with the sun at one of the two foci (1609).
2. A line joining a planet and the sun sweeps out equal areas during equal intervals of time (1609).
3. $T^2 \propto a^3$, T orbital period, a semi-major axis (1619).

Kepler 1610 by an unknown artist

– Galilei Galileo (1564–1642): Birth of modern science. Use of telescope (Jupiter moons). Inertial frames (Galileo relativity). Tried by inquisition.

– Isaac Newton (1643–1727): Classical Mechanics.

1. Inertia. 2. Acceleration. 3. Action = Reaction.

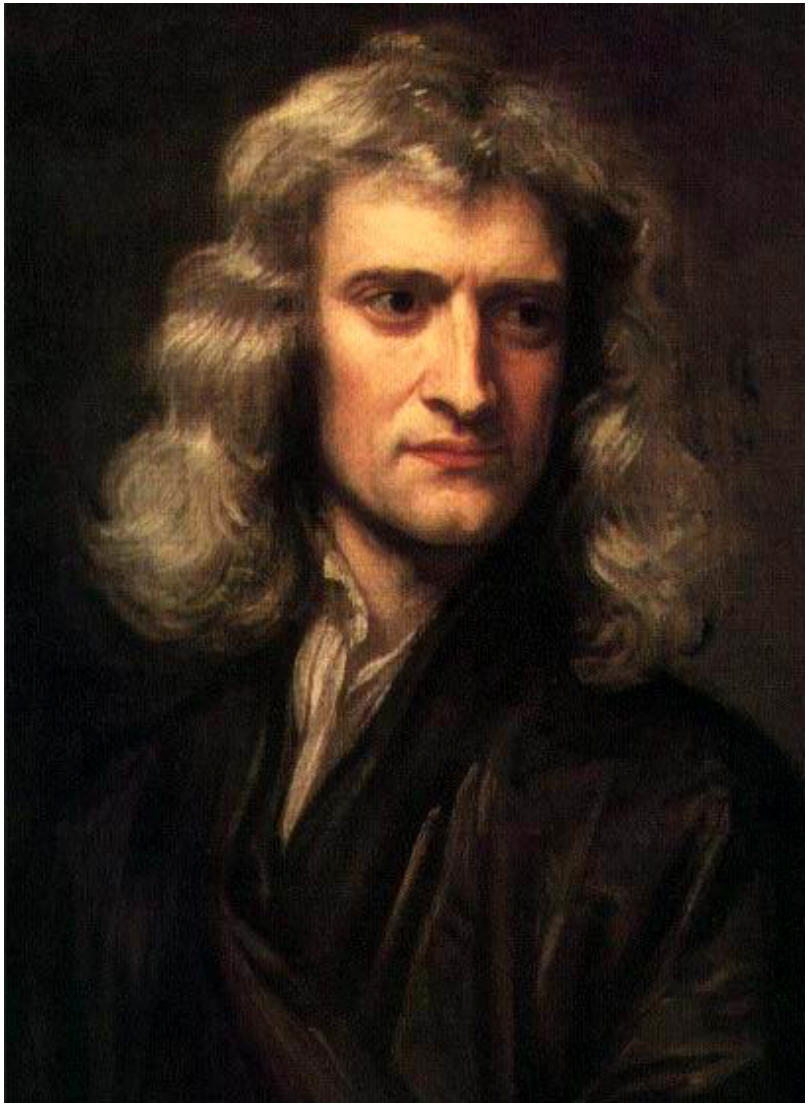
Philosophical Principles of Natural Philosophy (1687).

Planetary motion (Newton's gravity). Calculus (modern form $\int f(x)\,dx$ by Gottfried Leibniz).

– Daniel Bernoulli: Hydrodynamics (1738).

Mathematical Physics: Analytical Mechanics Lagrange (1788), Celestial Mechanics Laplace (several volumes 1799–1825), ...

Newton 1689 painted by Godfrey Kneller



Thermodynamics

Otto von Guerricke (1650): Vacuum (pump).

– Boyle's Law: $V \propto 1/P$ at constant T (1662).

Steam Engines: Thomas Savery (1698), Thomas Newcomen (1711), James Watt (1763) preceeded theoretical developments.

– Joseph Gay-Lussac: $P\,V = N\,R\,T$ (around 1802).

– Carnot Engine (1824).

– Robert Brown (1831): Brownian motion.

– First Law of Thermodynamics (Energy Conserved):

Developed 1840–1850 (Mayer, Joule, Thomphson).

– Second Law of Thermodynamics: (Kelvin 1851, Clausius 1854).

Electrodynamics

– Alexandra Volta (1824): Battery.

– Hans Christian Ørsted, André Marie Ampére (1820): Current – Magnetic force, Current – Current force.

– Michael Faraday (1821): Electric motor.
Induction (1831), independently by Henry.

– Hippolyte Fizeau and Léon Foucault (1850):
Accurate measurement of the speed of light c.

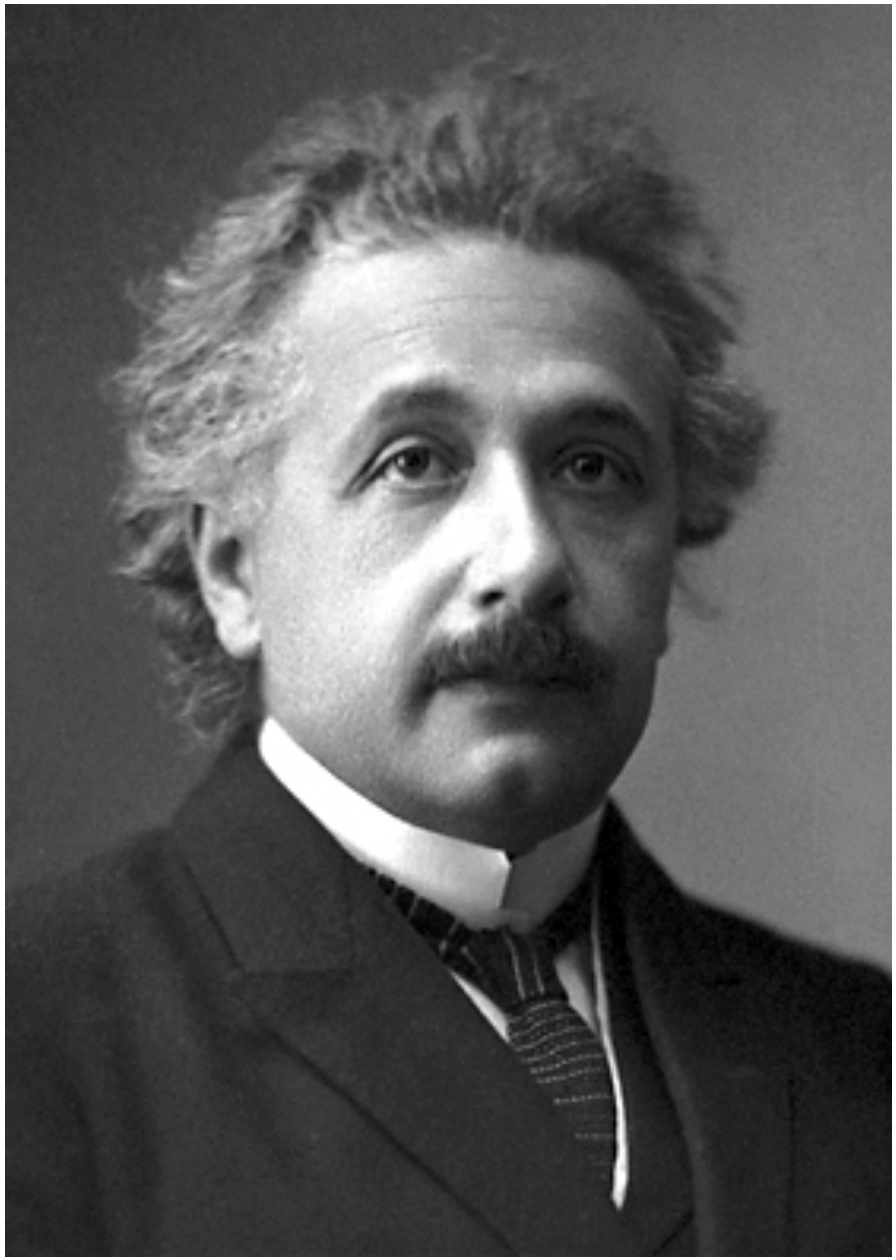
– Maxwell Equations (1864) $\Rightarrow c = 1/\sqrt{\mu_0 \epsilon_0}$.

– Electromagnetic waves, ether (false), radio (1890).

– Michelson-Morley (1887), Einstein (1905):
c is indendent of the motion of its source.

James Clerk Maxwell (1831–1879)

Albert Einstein (1879–1955) in 1921



Birth of Modern Physics

- Wilhelm Röntgen (1895): X-Rays.
- Henri Becquerel (1896): Natural radioactivity.
- Joseph John Thomson: Electron (1897), Isotopes.

Marie Sklodowska-Curie and Piere Curie isolated radioactive elements radium and polonium.

- Einstein (1905): Special Theory of Relativity. (Electrodynamics of moving bodies).
- Einstein (1906): $E = m\,c^2$.
- Rutherford Scattering (1911): Atom structure.
- Einstein (1916): General Relativity (Gravity).

Cosmology (2011): Perlmutter, Schmidt, Ries, ...

Marie Sklodowska-Curie (1867–1934)

Quantum Mechanics

Max Planck (1900), Bohr model (1913), Heisenberg Picture (1925), Schrödinger Picture (1926). With contributions by Einstein, de Broglie, Born, Jordan, Pauli, Dirac, Bose.

– Relativistic Dirac Equation (1928): Antimatter.

– Carl David Anderson (1932): Positron.

– Birth of Quantum Field Theory.

QED (1950), QCD (1973), Standard Model (1975).

Among many others: Fermi, Bethe, Feynman, Schwinger, Tomonaga, Gell-Mann, Higgs (Brout, Engler, Kibble, Guralnik, Hagen, Kibble), Glashow, Salam, Weinberg, Gross, Wilczek, Politzer, ...

Dirac's Grave in Tallahassee

Summary and conclusions

It was a long journey with a 1,400 years intermission. Much had to be omitted (either by space or because the speaker does not know any better).

Could we ever fall back into "dark ages"? This is scary. Even

Leucippus is still disputed.

And how could one ever proof what he assumed?