

# Paradigma

s. m. [dal lat. tardo paradigma, gr. parádeigma, der. di paradéiknymi "mostrare, presentare, confrontare", comp. di para- "para-2" e déiknymi "mostrare"] (pl. -i). - 1. [ciò che costituisce un termine generale di riferimento, che ha valore esemplare:...

Nel linguaggio filos., termine usato da Platone per designare le realtà ideali concepite come eterni modelli delle transeunti realtà sensibili, e da Aristotele per indicare l'argomento, basato su un caso noto, a cui si ricorre per illustrare uno meno noto o del tutto ignoto.

Con altro sign., il termine è stato recentemente introdotto nella sociologia e filosofia della scienza per indicare quel complesso di regole metodologiche, modelli esplicativi, criteri di soluzione di problemi che caratterizza una comunità di scienziati in una fase determinata dell'evoluzione storica della loro disciplina: a mutamenti di paradigma sarebbero in tal senso riconducibili le cosiddette «rivoluzioni scientifiche».



# Una breve introduzione di storia della fisica ed epistemologia

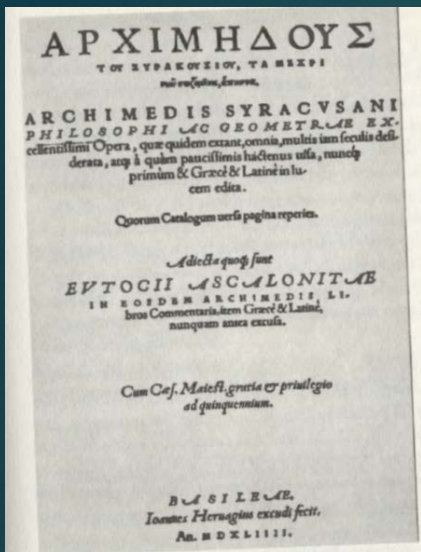
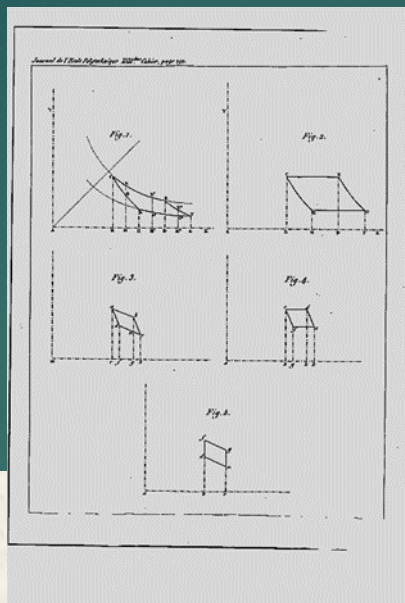
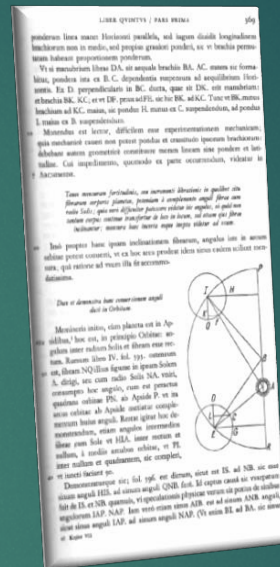


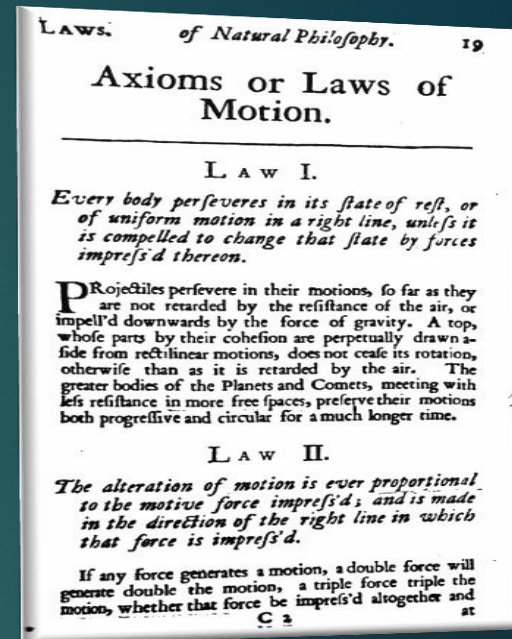
Fig. 18 Frontespizio della prima edizione moderna di Archimede, pubblicata a Basilea nel 1544. Essa conteneva tutte le sue opere note fino a quel momento in greco con il commento tardo-antico di Eutocio e una traduzione completa in latino. Da quel momento i lettori di Archimede in tutta Europa poterono moltiplicarsi e formarono in pochi anni una comunità scientifica fortemente innovativa.



Clapeyron (1834): *Mémoire sur la puissance motrice de la chaleur*. Journal de l'École royale polytechnique Vol. XIV: 153–190 (and 191)



(KGW ([1618-1621]1937–2009) *Epitome Astronomiae Copernicanae*, VII, Book V, p. 369)

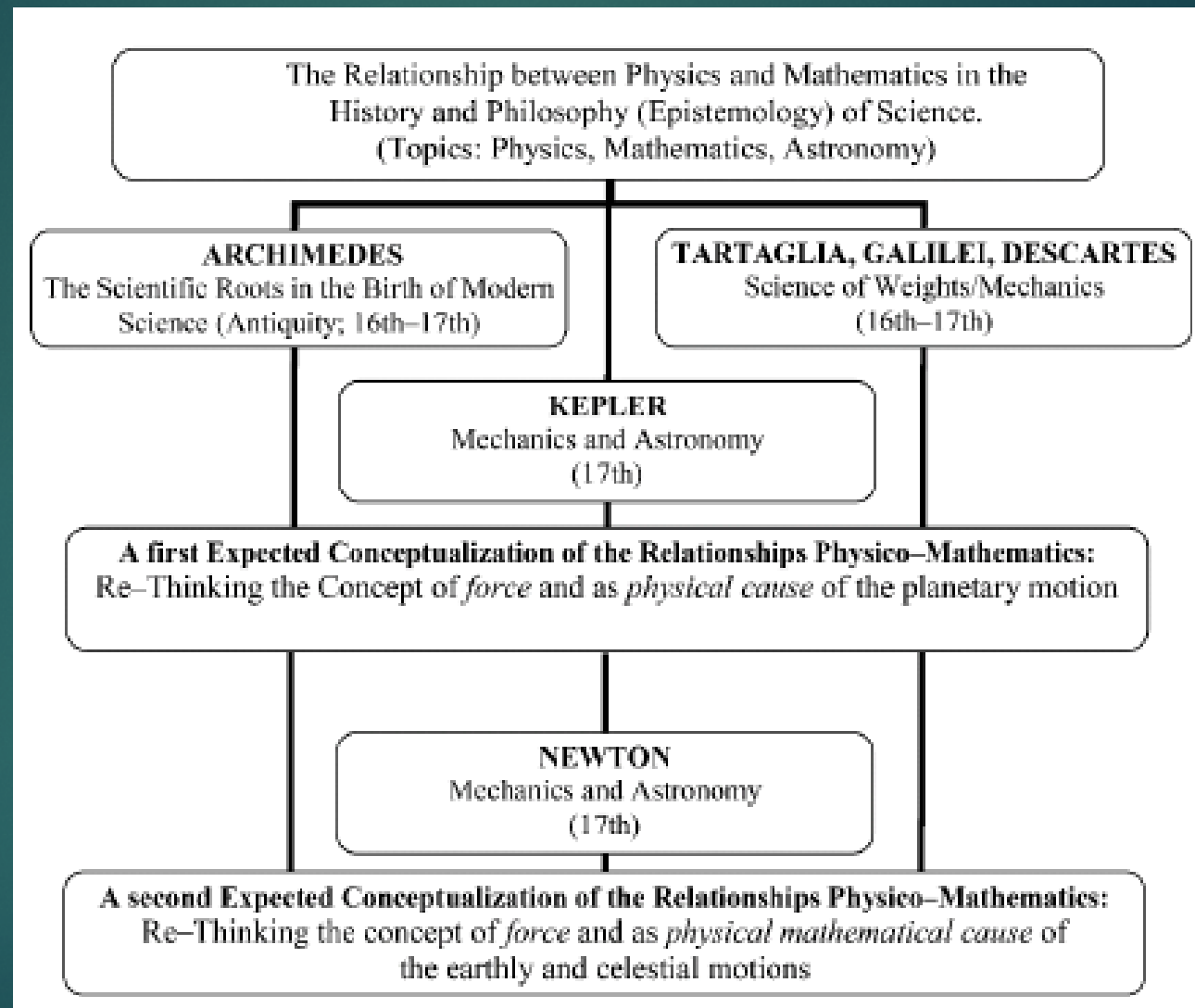


Newton ([1687]1803) *Principia*, I, p. 19

Per la redazione di questo PT ho attinto liberamente da un seminario di storia della fisica esposto dal

Prof. Raffaele Pisano, Lille University, France |

# The Relationship between Physics and Mathematics





# Why History and Philosophy of science (physics)????



Ernst Mach (1838 – 1916)

È stato un fisico e filosofo austriaco, nonché un neuroscienziato ante litteram. Mach fu positivista. Assertore della pura sperimentazione.

Thomas Samuel Kuhn (1922-1996)

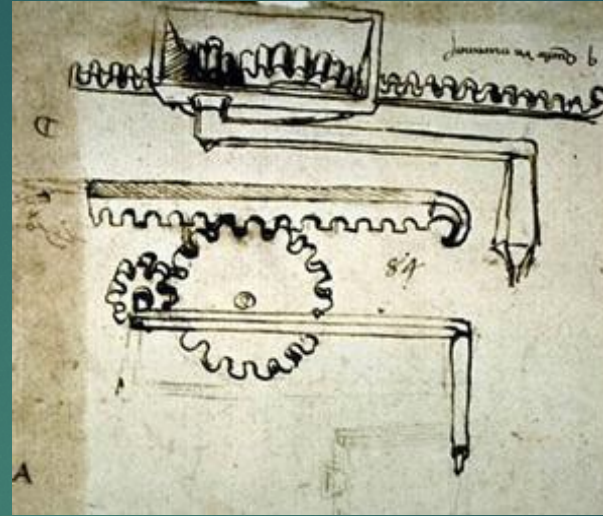
È stato un fisico, storico e filosofo statunitense. Epistemologo, scrisse diversi saggi di storia della scienza, sviluppando alcune fondamentali nozioni di filosofia della scienza. Formulò un'epistemologia alternativa a quella del falsificazionismo di Karl Popper,

Aleksandr V. Koyre (Koyré) 1892-1964

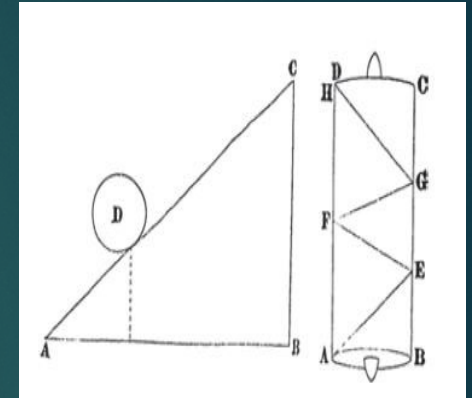
Russo Naturalizzato FR

Koyré divenne uno dei protagonisti dell'epistemologia storica francese.

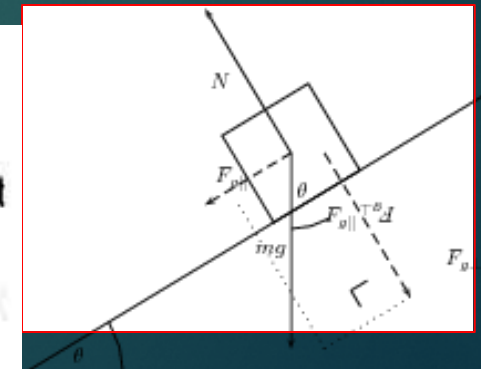
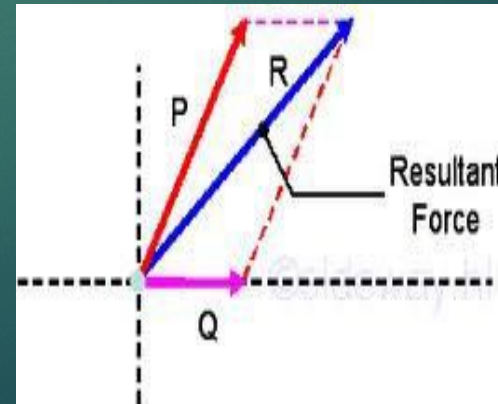
Negli anni Trenta Koyré iniziò la ricerca. Divenne uno dei più eminenti storici del pensiero scientifico del ventesimo secolo. Pubblicò tre volumi degli Studi galileiani. Notevole la sua interpretazione della matematica galileiana non come mero strumento per descrivere la realtà, bensì come matematicismo ontologico. Postumi furono pubblicati gli Studi newtoniani.



The mechanism for the transformation and rotation movement by Leonardo da Vinci.



Geometric representation of the inclined plane as abstract object, and the geometric model by the Galileo screws, *Le mecaniche*, Opere II, p.184







Eduard Jan Dijksterhuis (1892 – 1965 )  
He was a Dutch historian of science.

Alcune opere:

1929 - The Elements of Euclid

1924 - Free Fall and Projectile Motion

1938 - Archimedes

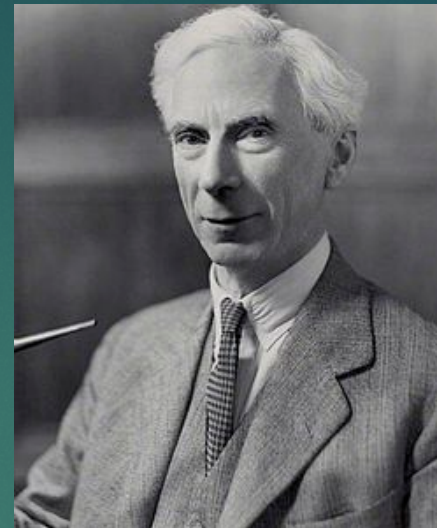
1943 – Simon Stevin (Il 1960)

1952 - Blaise Pascal

1953 – "Christiaan Huygens",

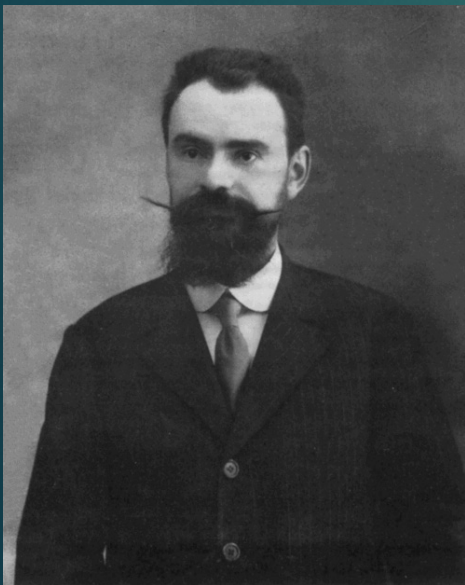
1961 - The Mechanization of the World  
Picture

1963 - (with R. J. Forbes) History of  
Science and Technology



Bertrand A. W. Russell (1872-1970) è  
stato un filosofo, logico,  
matematico, attivista e saggista  
britannico.

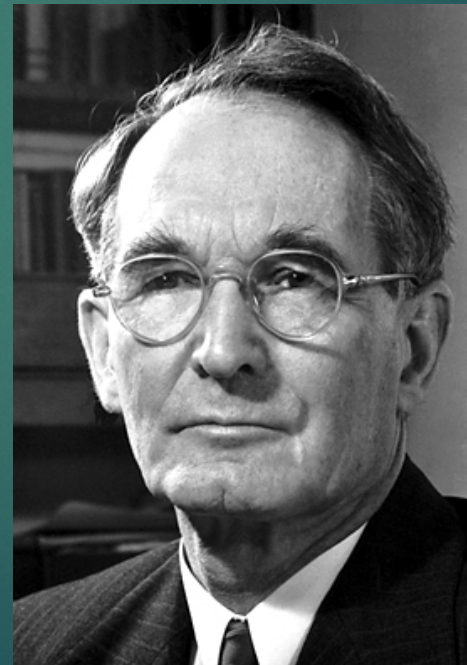
Fu anche un autorevole esponente  
del movimento pacifista e un  
divulgatore della filosofia. In molti  
hanno guardato a Russell come a  
una sorta di profeta della vita  
creativa e razionale; al tempo stesso  
la sua posizione su molte questioni fu  
controversa. Russell è stato  
avvicinato alle correnti filosofiche  
del razionalismo, dell' antiteismo e  
del neopositivismo.[1]



Federigo Enriques (1871-1946)

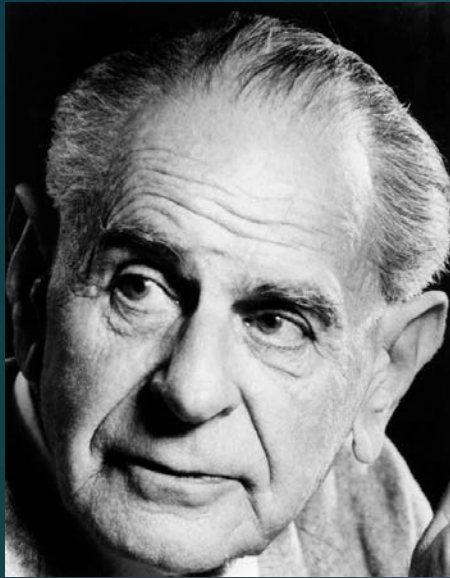
Nelle sue opere sviluppò una  
corrente di pensiero vicina al  
razionalismo. Assieme a  
Giuseppe Peano si può  
considerare uno dei principali  
scienziati italiani che si sono  
dedicati allo studio della logica e  
della filosofia della scienza nella  
prima metà del Novecento.

Fondamentale: Problemi della  
scienza, Zanichelli, Bologna 1906.



Percy W. Bridgman (1882 –1961)  
è stato un fisico e filosofo della  
scienza statunitense. Vinse il  
Premio Nobel per la fisica nel  
1946 «per l'invenzione di un  
apparecchio per la produzione di  
pressioni estremamente alte e  
per le scoperte fatte nel campo  
della fisica ad alta pressione.» Fu  
inoltre un pioniere dell'analisi  
dimensionale.





Karl R. Popper (1902 – 1994) è stato un filosofo e epistemologo austriaco naturalizzato britannico. E' anche considerato un filosofo politico di statura considerevole, liberale, difensore della democrazia e dell'ideale di libertà e avversario di ogni forma di totalitarismo. Egli è noto per la proposta della falsificabilità come criterio di demarcazione tra scienza e non scienza e la difesa della "società aperta".

«Ogni qualvolta una teoria ti sembra essere l'unica possibile, prendilo come un segno che non hai capito né la teoria né il problema che si intendeva risolvere.»

(Karl Popper, Conoscenza oggettiva: un punto di vista evoluzionistico.)

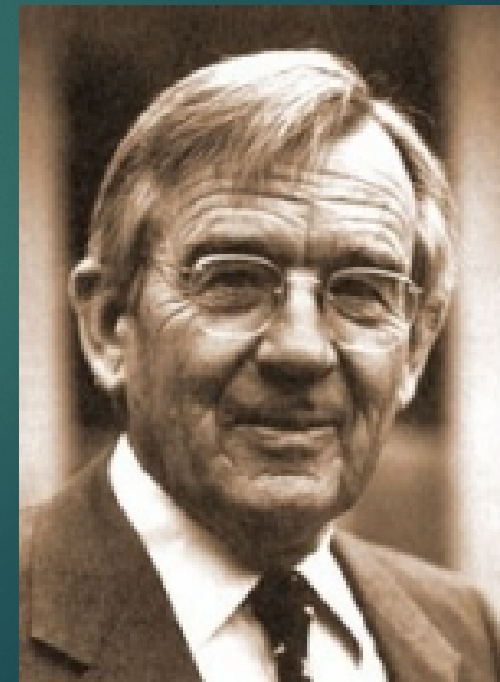


Ludovico Geymonat (1908 – 1991) è stato un filosofo, matematico, storico della filosofia, epistemologo e accademico italiano, uno tra più importanti del Novecento. Ebbe uno stile di pensiero razionalista ateo. La sua opera può essere inquadrata nel filone del neopositivismo da lui rielaborato nell'ottica della tradizione marxista. Interpretò la concezione della matematica di Galileo Galilei come strumento d'interpretazione della realtà. Rimarchevole pure il suo lavoro di alta divulgazione del pensiero scientifico.

Alistair C. Crombie (1915 – 1996) was an Australian historian of science who began his career as a zoologist. He was noted for his contributions to research on competition between species before turning to history.

During his career as a historian of science, Crombie identified thematic threads or "styles" in the development of European approaches to science. He published his ideas in 1994 in a definitive 3-volume work, entitled, *Styles of Scientific Thinking in the European Tradition: The History of Argument and Explanation especially in the Mathematical and Biomedical Sciences and Arts*.

The main argument about six distinct styles of scientific thinking in the history of Western science was also published in the brief 1995 article *Commitments and styles of European scientific thinking*.





# How about Exact Sciences of the Past & and how Write its History ?

## History by *facts* (*vanno interpretati*)

- Historical objective facts, experiments, dates of discoveries
- Primary sources and the early theories
- Birth of new experimental apparatus
- Academic context, societies, academies
- Etc.



## History built by *events* (*teorie*)

- (Foundations of scientific theories)
- Biography and correspondence
- Concepts (e.g.: intuitive and surrogate concepts)
- Mathematical content of a theory
- Etc.

Differenze tra " Fatto" ed "Evento"

# A choice: Inquiring History of Science (Physics)

## Needs

Historical and epistemological structures of a scientific theory

## Inquiring

- By Logic (classical, non-classical),
- By Analogies
- By Mathematic (relationship physics-mathematics, theorems and results, etc.)
- By geometrical figures of speech/styles (figures and describing phenomena, rhetoric, etc.),
- By experimental/theoretical data,
- By impact (paradigms etc.)
- By Context
- By Foundations
- By diagrams



# Archimedean Science: *On the Equilibrium of Planes.*

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ARCHIMEDES

6. If magnitudes at certain distances be in equilibrium, (other) magnitudes equal to them will also be in equilibrium at the same distances.

7. In any figure whose perimeter is concave in (one and) the same direction the centre of gravity must be within the figure."

### Proposition 1.

*Weights which balance at equal distances are equal.*

For, if they are unequal, take away from the greater the difference between the two. The remainders will then not balance [Post. 3]; which is absurd.

Therefore the weights cannot be unequal.

### Proposition 2.

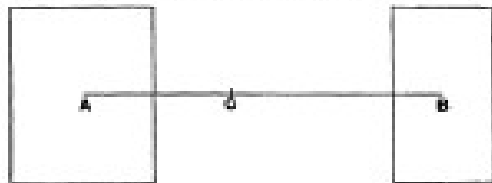
*Unequal weights at equal distances will not balance but will incline towards the greater weight.*

For take away from the greater the difference between the two. The equal remainders will therefore balance [Post. 1]. Hence, if we add the difference again, the weights will not balance but incline towards the greater [Post. 2].

### Proposition 3.

*Unequal weights will balance at unequal distances, the greater weight being at the lesser distance.*

Let  $A$ ,  $B$  be two unequal weights (of which  $A$  is the greater) balancing about  $C$  at distances  $AC$ ,  $BC$  respectively.



Then shall  $AC$  be less than  $BC$ . For, if not, take away from  $A$  the weight  $(A - B)$ . The remainders will then incline

## 1<sup>st</sup> *Supposition* and 1<sup>st</sup> *Proposition*

●1<sup>st</sup> Sup. Equal weights [suspended] at equal distances [from fulcrum] are in equilibrium; equal weights suspended at unequal distances [from fulcrum] are not in equilibrium [state] but [they] incline towards the weight is [suspended] at the greater distance [from fulcrum].

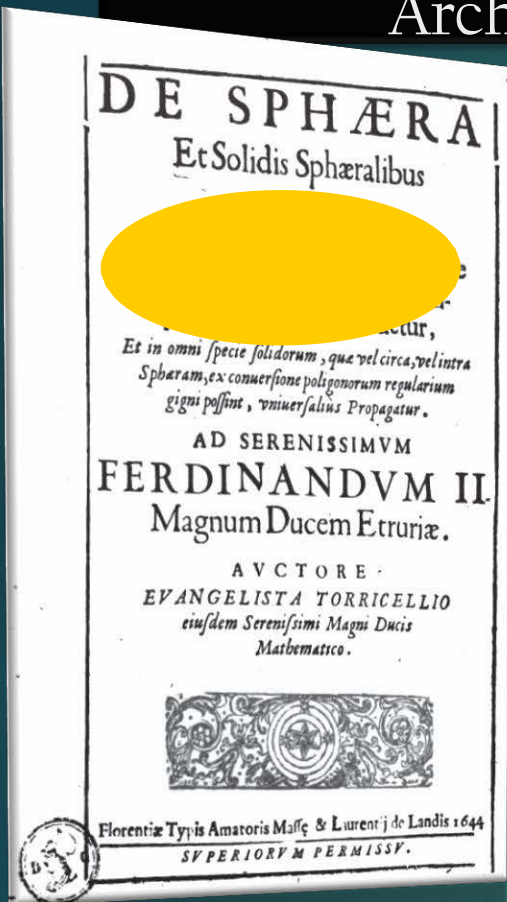
●1<sup>st</sup> Prop. [If] Weights [suspended] at equal distance [from fulcrum] are in equilibrium, [then they are] equal [between them]. [proved by *red. ad ab.* by Supp. 3].

**Archimedes, *On the Equilibrium of Planes*, edited by T. L. Heath. book I, pp. 189-190.**

**"Il grande Archimede", Mario Geymonat, III ed. F.M. Alfani, 2008-)**

**E.J.Dijksterhuis, *Archimedes*, Copenhagen, 1956 (classic Work)**

# Archimedean Approach in Torricelli's Reasoning



Archimedes  
*On equilibrium of  
planes*



Torricelli  
*Opera Goemetrica*

(Early)  
Torricelli Principle of Virtual Work

***Praemittimus. Duo gravia simul coniuncta ex se moveri non posse, nisi centrum commune gravitatis ipsorum discenda.***

*Premise. Two heavy bodies linked together cannot move by themselves unless their common centre of gravity does not descend.*

(Modern) Principle of  
Virtual Work

The necessary and sufficient condition for equilibrium of a mechanical system without friction is that the virtual work done by the externally applied forces  $f$  is zero.

Heath T.L. 2002. "On the Spiral - Proposition 10", 162,.

Galileo G. 1954. *Dialogues Concerning Two New Sciences*, II, 140-146, IV 286-294, op. cit.;

Id., 1890-1909. "Discorsi e dimostrazioni matematiche sopra due nuove scienze", Vol. VIII, II, 176-183; IV, 306 et sgg)

Cavalieri B. 1635. *Geometria Indivisibilium continuo rum nuova quadam ratione promota*, Theorema I-Proposizione I, Libro IV, Ferrone, Bologna, 285

Valerio L. 1606. *Quadratura parabolae per simplex falsum et altera quam secunda Archimedia expeditur*,

Torricelli 1644, *Liber primus De motu gravium naturaliter descendentium*, p. 99, line 4

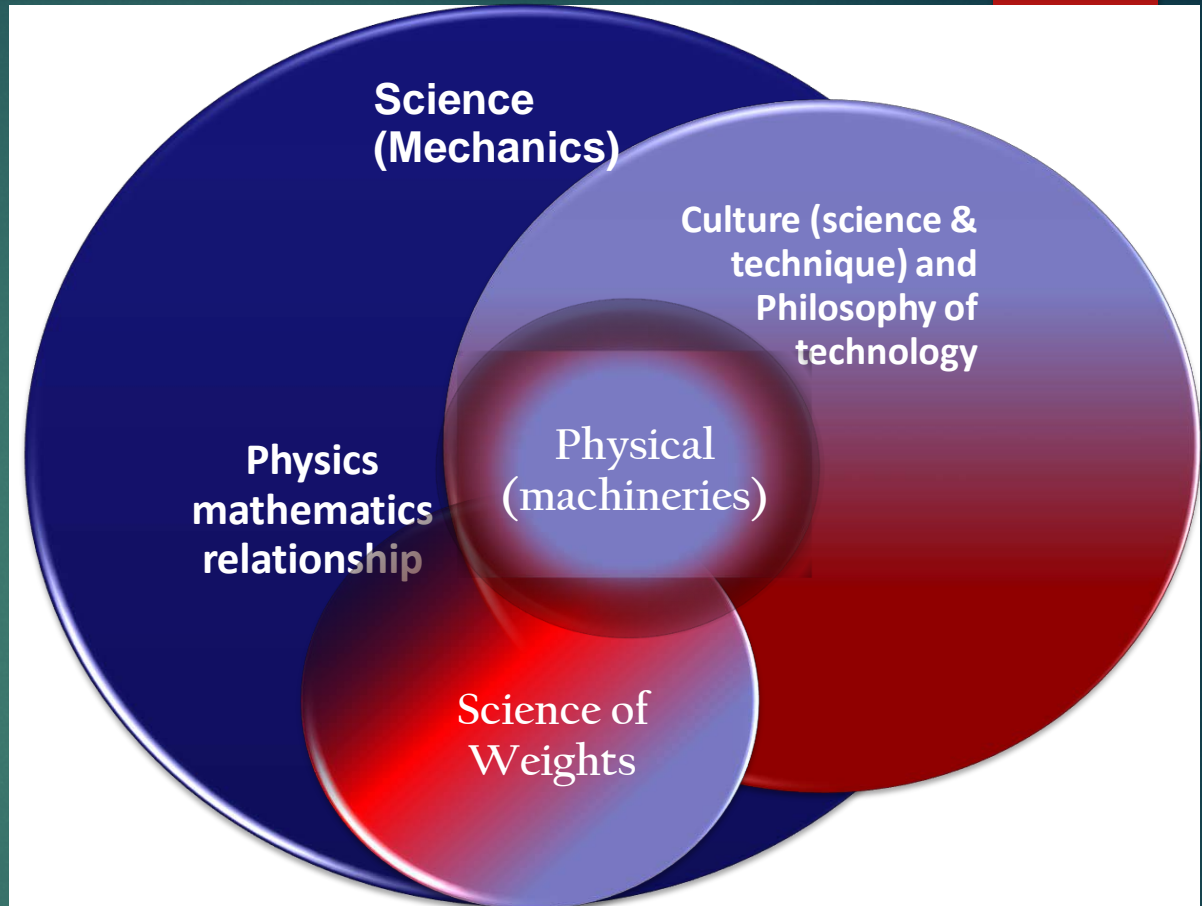


# Lo sviluppo delle macchine



1662. The Frontispieces from  
Georg Andreas Böckler's  
*Theatrum Machinarum Novum*

pubblicato nel 1662 a Colonia da Henrici Schmitz, composto da 154 tavole illustrative a piena pagina con la completa descrizione in lingua latina, completato dal testo della legge tedesca sui mulini in vigore a quel tempo. Le tavole illustrano tutti i possibili sistemi di mulini per i cereali, delle ruote idrauliche per la lavorazione della carta e dei minerali, per le segherie ed altri usi.



Pisano R, Bussotti P (2014) Historical and Philosophical Reflections on the Culture of Machines around the Renaissance. How Science and Technique Work? *Acta Baltica Historiae et Philosophiae Scientiarum* 2/2 [see also 2015 3/1]

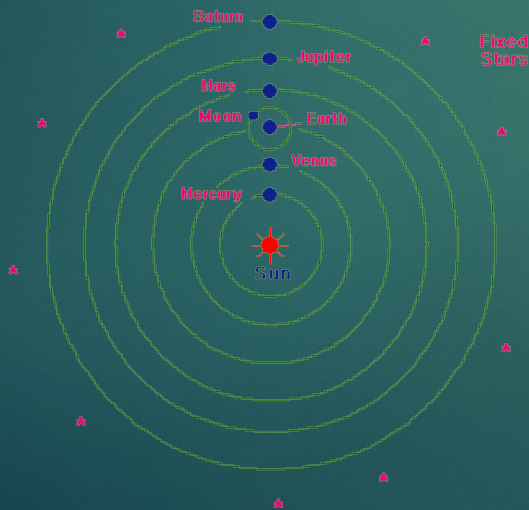
Int. Symposium on History of Machines and Mechanisms  
Proceedings HMM2004  
Edited by Marco Ceccarelli  
Kluwer Academic Publishers



# Nascita della meccanica celeste : NON SOLO CINEMATICA



Stesura: tra il 1507 e il 1512,



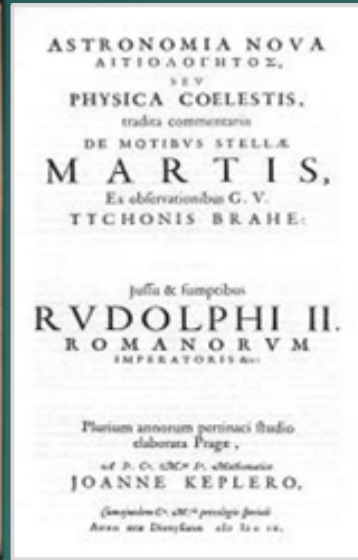
De Revolutionibus Orbium Coelestium, l'oeuvre majeure de Copernic ...



# Kepler Force Conceptualization: an Interplay between Physics, Mathematics and Metaphysics



1596; 1621



1609



1618; 1621



1619

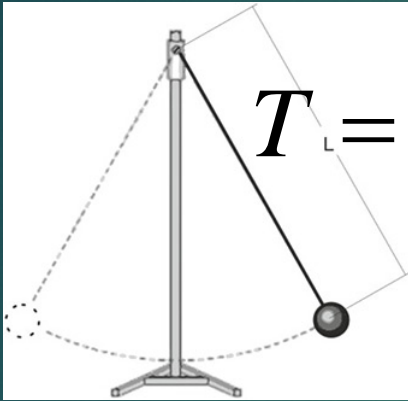
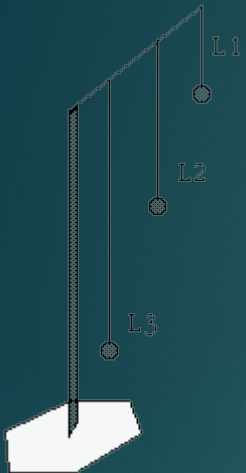
Kepler's relationships between kinematics (motion) and dynamics (force): the forces act as the inverse of the two bodies– distance (KGW III, XXXII, 233-236) and not as inverse-square of the two bodies-distance. Problem of the ellipticity of the orbits.

The main geometrical-mathematical problem to solve and move versus a (sort of) physical astronomy was: What kind of force make the paths elliptical geometrically?

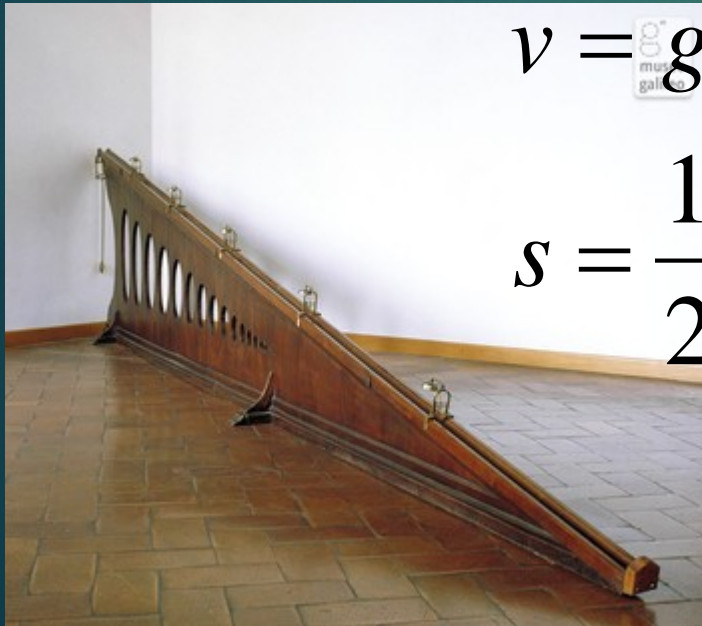
I had then reached the point of ascribing to the same Earth the motion of the Sun, but where Copernicus did so through mathematical arguments, mine were physical, or rather Metaphysical.

(Mysterium, 1596, KGW, I, p. 9, lines 17-19).

# GALILEO: Il moto del pendolo: un fenomeno mai risolto nella fisica aristotelica: UN ENIGMA

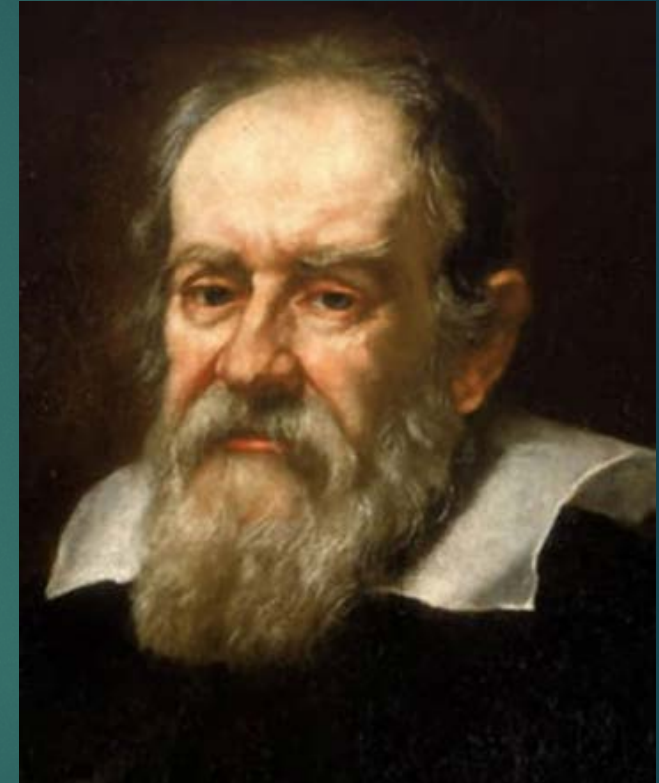


$$T = 2\pi \sqrt{\frac{l}{g}}$$



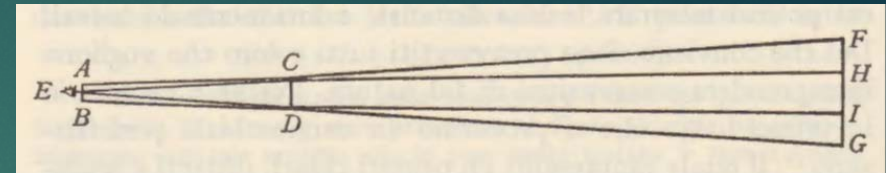
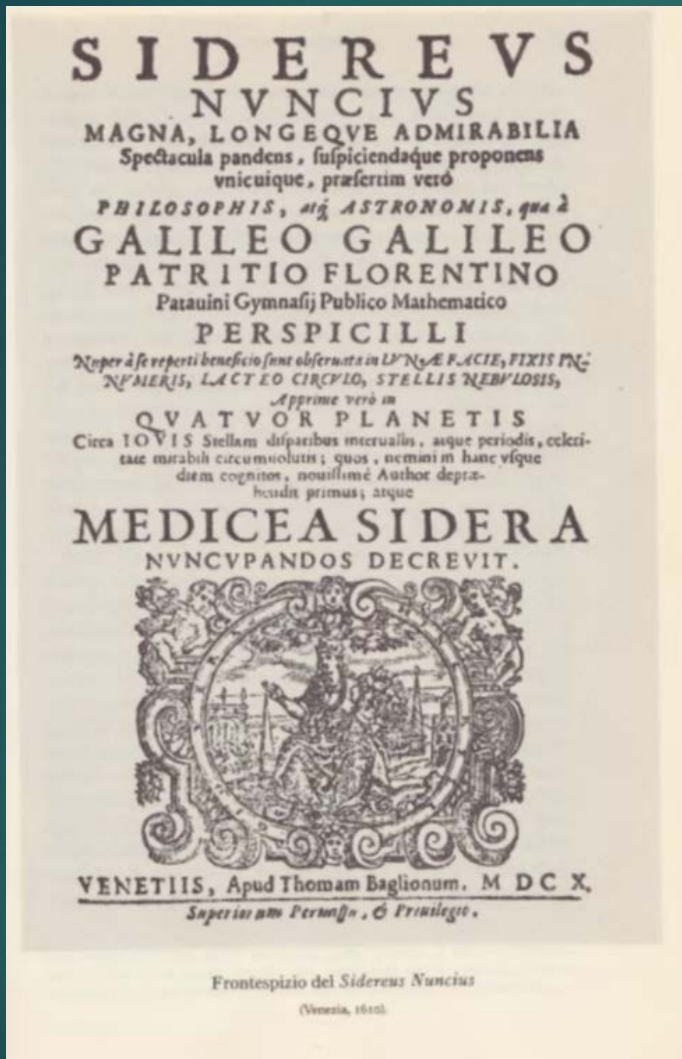
$$v = gt$$

$$s = \frac{1}{2}gt^2$$





-Approfondisce l'osservazione astronomica e costruisce il Cannocchiale (1609)



Sidereus Nuncius (immagini adattate da Galilei-classici-UTET (ed.1996))

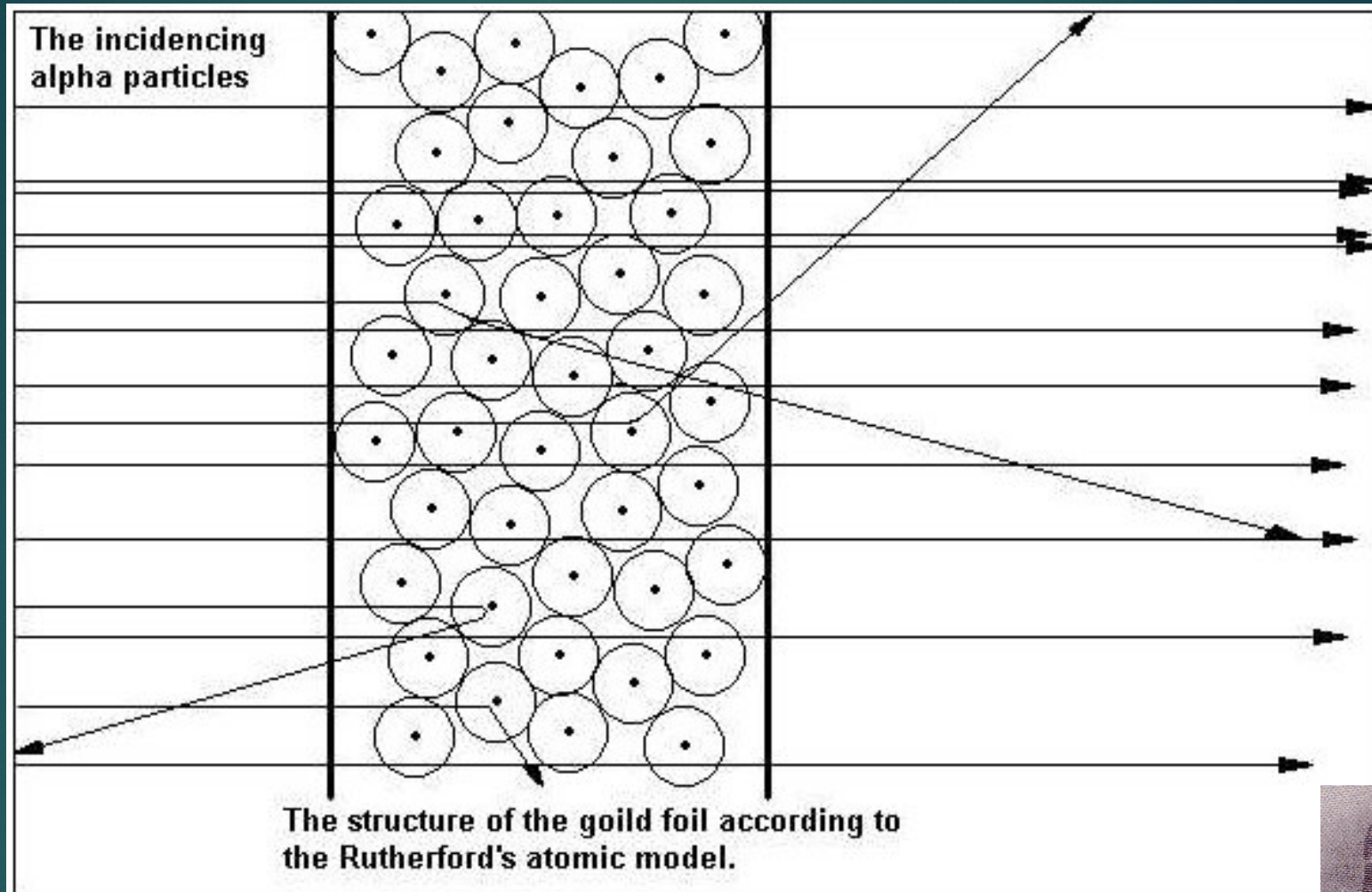






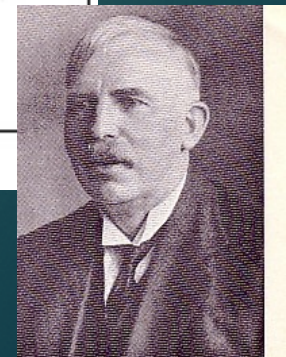


Con il novecento ha inizio la fisica atomica/nucleare



The alpha particles propagated on the atomic nucleuses of the gold foil.

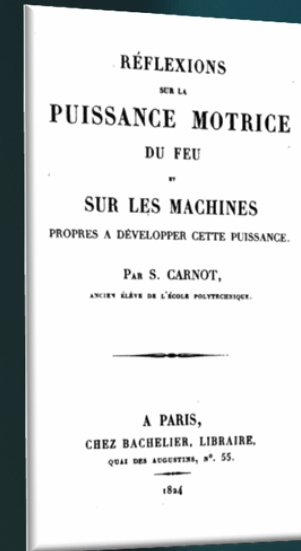
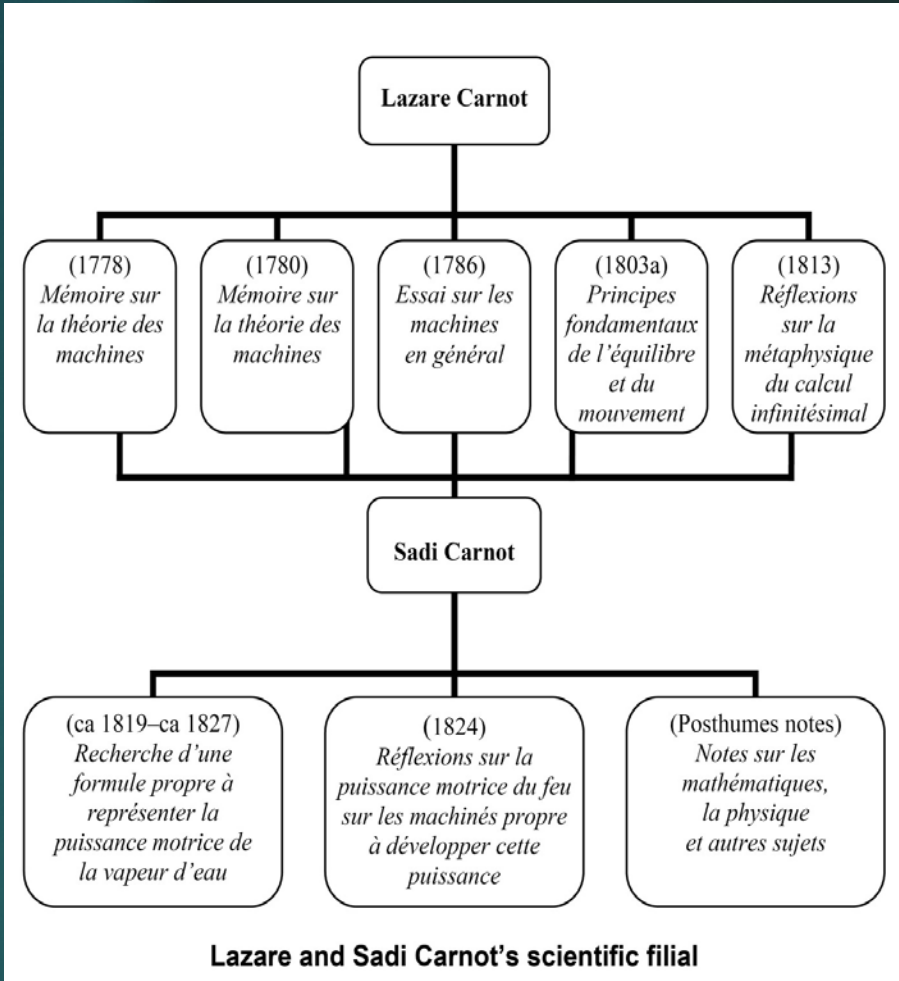
E.Rutherford, Phil. Mag.21,669 (1911)





# Termodinamica

## Lazare and Sadi Carnot. A Filial and Scientific Relationship

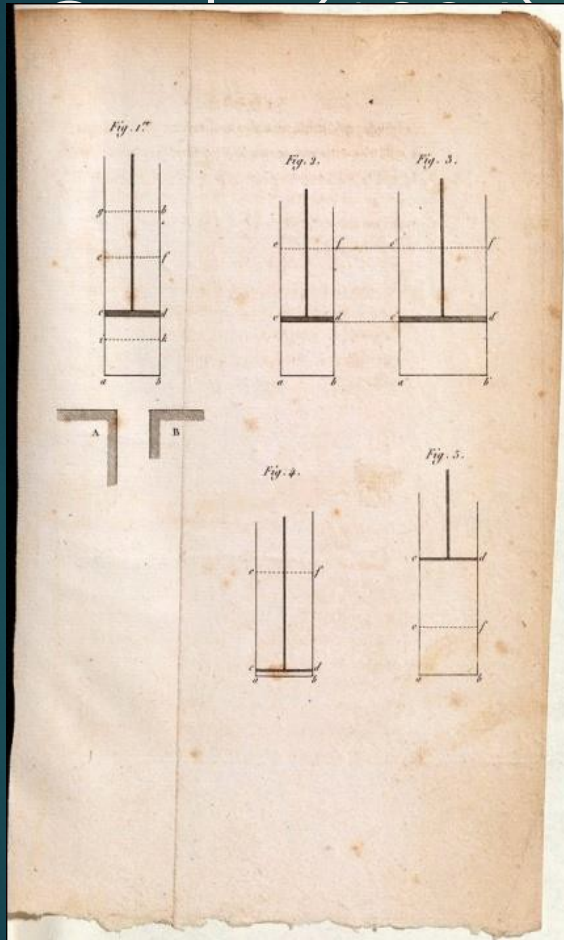


Recherche d'une formule propre à représenter la puissance motrice de la Vapeur d'Eau, in Carnot, S. 1978, *op. cit.*, pp. 223-225, *op. cit.*

Gabbey A. W., Herivel J. W. 1966. « Un manuscrit inédit de Sadi Carnot » In: *Revue d'histoire des sciences et de leurs applications*, Tome 19 n°2. pp. 151-166.



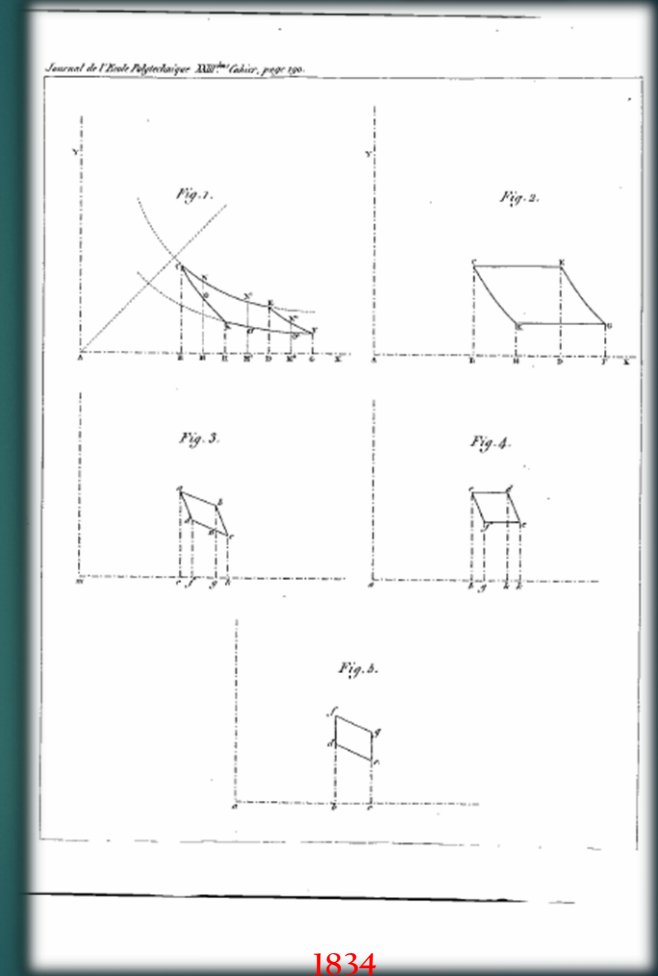
# S. Carnot's Theorem (1824) and the



The *tentative* calculus  
for  $d\eta$  in a footnote (Ivi, pp. 73-79)

- The cycle is composed by two isotherm (as in all of his cycles) and two isochors by  $W=0$ . (Carnot S. 1978. *Réflexions sur la puissance motrice du feu*, pp.39-40)
- The cycle is composed by two isotherm and two adiabatics by  $Q=0$ . (Ivi, pp. 29-38)

$$\eta = \frac{W_{\max}}{Q} = f(\Delta t)$$



1834

Clapeyron: Mémoire sur la puissance motrice de la chaleur, «*Journal de l'Ecole royale polytechnique*» Vol. XIV, 1834, pp. 153-190(-191).



Concepts (mainly)	I. Newton (1642-1727) Newtonian mechanics [paradigm]	L. Carnot (1753-1823) Mechanics / Machines	S. Carnot (1796-1832) Thermodynamics / Machines
Space Time	Infinite and absolute Infinite and absolute	Limited and Relational	Limited and Relational
Bodies	Mathematical points	Global, machines	Global, machines
Inertia	Perpetual	Impossibility of perpetual motion	Impossibility of perpetual motion
Basic- concept	Acceleration	Transformations	Transformations
Interaction	Force-Cause	Work; $\sum_i m_i \vec{W}_i^2 = \sum_i m_i \vec{V}_i^2$	Work [moment-of-activity]
Setting of theory	The law of motion in a dynamics theory, $F=ma$	The laws in <i>Collision theory</i>	Integration of $dq/t$
Techniques	Fluxions... infinitesimal	Geometrical motion; vector calculus	Cycle
Results	Mathematical results...	Invariants; Geometrical motions for mechanical machines	Maximum efficiency of heat machines

# Teoria cinetica dei gas e termodinamica

## Boltzmann's Legacy

At the center of Boltzmann's lifelong struggles in physics and philosophy was the question of the reality of atoms. In the 1870s, when Boltzmann was at the zenith of his intellectual powers, there was no conclusive experimental evidence for the existence of atoms. He had to fight his lonely battle on two fronts: for his belief in the reality of atoms against Mach and the empiricists, and for his statistical interpretation of the second law of thermodynamics, his most revolutionary and lasting contribution to physics, against Loschmidt and others. Boltzmann's struggle on these two fronts was ironic in retrospect, as pointed out by the American theoretical physicist Leo Kadanoff:

Mach was wrong about atoms and wrong in demanding that science only include the immediately visible, but right in demanding a different philosophic outlook for kinetic theory. Boltzmann was right about atoms but utterly wrong in believing that atoms provided a necessary basis for thermodynamics. The second law does not require atoms.<sup>37</sup>

Thermodynamics, in other words, is neutral with respect to models of the microphysical world.

Boltzmann's goal of translating the behavior of the physical world into rigorously defined mathematical entities that obey well-defined rules remains an open game today, one that is still centered upon the second law of thermodynamics, a law that Albert Einstein regarded as an unshakeable and fundamental pillar of the physical world. As he wrote:

A theory is the more impressive the greater the simplicity of its premises is, the more different kinds of things it relates, and the more extended is its area of applicability. Therefore the deep impression which classical thermodynamic made upon me. It is the only physical theory of universal content concerning which I am convinced that, within the framework of the applicability of its basic concepts, it will never be overthrown (for the special attention of those who are skeptics on principle).<sup>38</sup>

As Elliott H. Lieb and Jakob Yngvason have remarked, to derive the second law from statistical mechanics is "a goal that has so far eluded the deepest thinkers."<sup>39</sup>



Fig. 1. Ludwig Boltzmann (1844–1906) as Professor of Mathematics at the University of Vienna in 1875. *Credit:* Courtesy of the Österreichische Zentralbibliothek für Physik.



When the values of all the variables ( $q$ ) are given, the position of each of the moveable pieces is known, and, in virtue of the imaginary mechanism, the configuration of the entire system is determined.

*The Velocities.*

556.] During the motion of the system the configuration changes in some definite manner, and since the configuration at each instant is fully defined by the values of the variables ( $q$ ), the velocity of every part of the system, as well as its configuration, will be completely defined if we know the values of the variables ( $q$ ), together with their velocities ( $\frac{dq}{dt}$ , or, according to Newton's notation,  $\dot{q}$ ).

*The Forces.*

557.] By a proper regulation of the motion of the variables, any motion of the system, consistent with the nature of the connexions, may be produced. In order to produce this motion by moving the variable pieces, forces must be applied to these pieces.

We shall denote the force which must be applied to any variable  $q$ , by  $P$ . The system of forces ( $P$ ) is mechanically equivalent (in virtue of the connexions of the system) to the system of forces, whatever it may be, which really produces the motion.

*The Momenta.*

558.] When a body moves in such a way that its configuration, with respect to the force which acts on it, remains always the same, (as, for instance, in the case of a force acting on a single particle in the line of its motion,) the moving force is measured by the rate of increase of the momentum. If  $F$  is the moving force, and  $p$  the momentum,

$$F = \frac{dp}{dt},$$

whence

$$p = \int F dt.$$

The time-integral of a force is called the Impulse of the force; so that we may assert that the momentum is the impulse of the force which would bring the body from a state of rest into the given state of motion.

In the case of a connected system in motion, the configuration is continually changing at a rate depending on the velocities ( $\dot{q}$ ), so

and the work spent in producing the motion is equivalent to the kinetic energy. Hence

$$T_{pq} = \frac{1}{2} (p_1 \dot{q}_1 + p_2 \dot{q}_2 + \&c.), \quad (13)$$

where  $T_{pq}$  denotes the kinetic energy expressed in terms of the momenta and velocities. The variables  $q_1, q_2, \&c.$  do not enter into this expression.

The kinetic energy is therefore half the sum of the products of the momenta into their corresponding velocities.

When the kinetic energy is expressed in this way we shall denote it by the symbol  $T_{pq}$ . It is a function of the momenta and velocities only, and does not involve the variables themselves.

563.] There is a third method of expressing the kinetic energy, which is generally, indeed, regarded as the fundamental one. By solving the equations (3) we may express the momenta in terms of the velocities, and then, introducing these values in (13), we shall have an expression for  $T$  involving only the velocities and the variables. When  $T$  is expressed in this form we shall indicate it by the symbol  $T_q$ . This is the form in which the kinetic energy is expressed in the equations of Lagrange.

564.] It is manifest that, since  $T_p, T_q,$  and  $T_{pq}$  are three different expressions for the same thing,

$$T_p + T_q - 2T_{pq} = 0,$$

$$\text{or} \quad T_p + T_q - p_1 \dot{q}_1 - p_2 \dot{q}_2 - \&c. = 0. \quad (14)$$

Hence, if all the quantities  $p, q,$  and  $\dot{q}$  vary,

$$\begin{aligned} & \left( \frac{dT_p}{dp_1} - \dot{q}_1 \right) \delta p_1 + \left( \frac{dT_p}{dp_2} - \dot{q}_2 \right) \delta p_2 + \&c. \\ & + \left( \frac{dT_q}{dq} - p_1 \right) \delta q + \left( \frac{dT_q}{d\dot{q}_1} - p_2 \right) \delta \dot{q}_1 + \&c. \\ & + \left( \frac{dT_p}{dq_1} + \frac{dT_q}{d\dot{q}_1} \right) \delta q_1 + \left( \frac{dT_p}{dq_2} + \frac{dT_q}{d\dot{q}_2} \right) \delta q_2 + \&c. = 0. \end{aligned} \quad (15)$$

The variations  $\delta p$  are not independent of the variations  $\delta q$  and  $\delta \dot{q}$ , so that we cannot at once assert that the coefficient of each variation in this equation is zero. But we know, from equations (3), that

$$\frac{dT_p}{dp_1} - \dot{q}_1 = 0, \&c., \quad (16)$$

so that the terms involving the variations  $\delta p$  vanish of themselves.

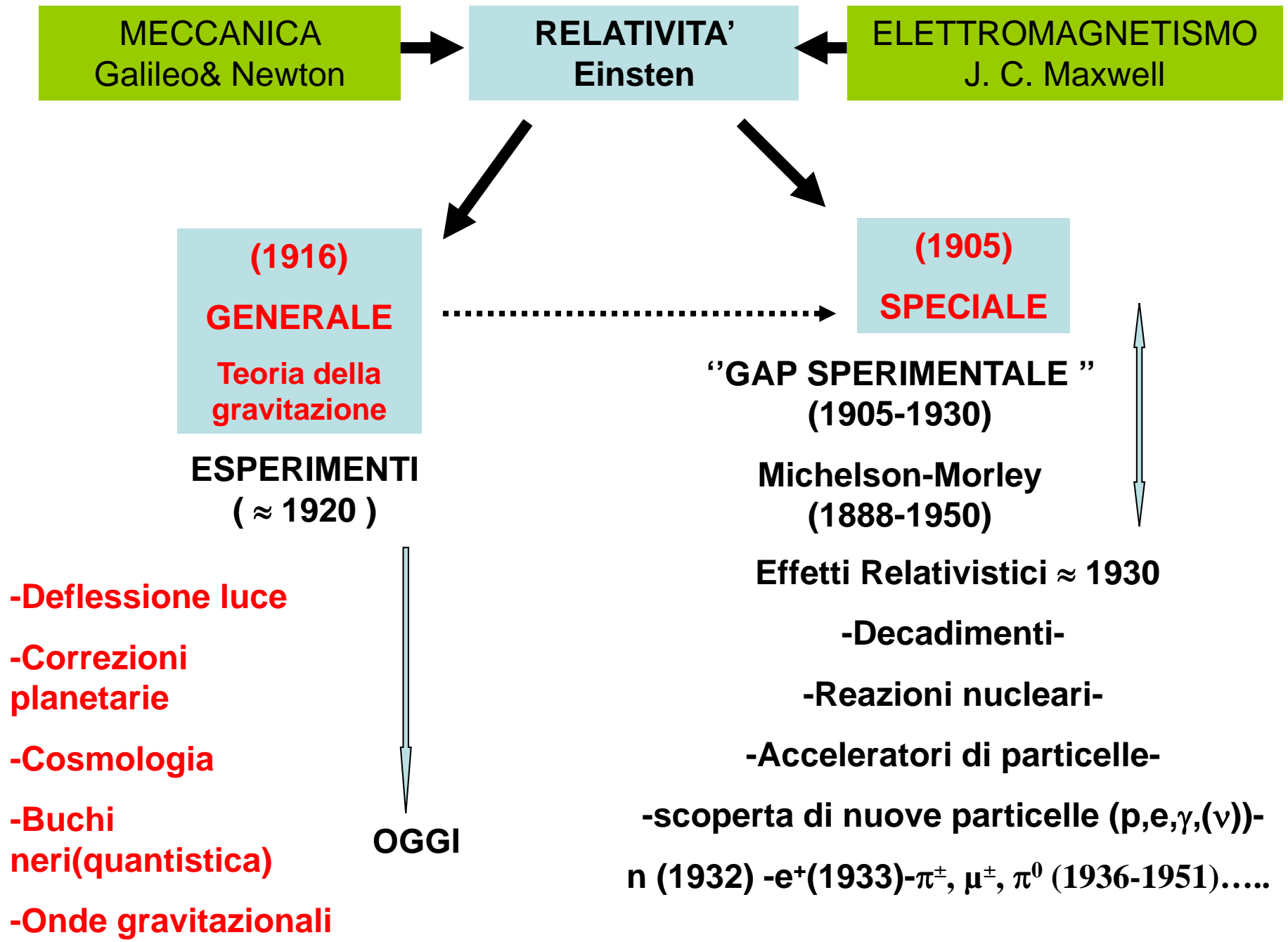
The remaining variations  $\delta \dot{q}$  and  $\delta q$  are now all independent, so that we find, by equating to zero the coefficients of  $\delta \dot{q}_1, \&c.,$

$$p_1 = \frac{dT_q}{d\dot{q}_1}, \quad p_2 = \frac{dT_q}{d\dot{q}_2}, \&c.; \quad (17)$$

In the whole chapter V (Maxwell 1873, II, Pt IV, V, 184–194) - contrary to Newtonian mechanics - Maxwell expressed motion and energy relationships within the system as a whole, rather than in terms of laws of motion governing the actions of forces.

Thus, after several methods proposed, he announced **a third method related with Lagrange.**

Pisano R (2013) On Lagrangian in Maxwell's electromagnetic theory. Scientatum VI. The Federate University of Rio de Janeiro Press, Rio de Janeiro, pp. 44–59





# Gli sviluppi (impressionanti) del '900



## A development

[...]

**1900-1901. Planck:** black body (Einstein ad hoc hypothesis)

**1905-1917. Einstein:** Relativity, etc.

**1913. Bohr:** atomic model, energy, etc.

**1925-1927. Schroedinger:** wave equation and wave develops the processing of quantum mechanics, electron wave.

**1927. Heisenberg:** *the uncertainty principle.*

**1927. Bohr:** *complementarity principle, Copenhagen interpretation*

[...]

**Kuhn:** relation quantitative relationship among electromagnetic fields and matter's properties (electrons and atoms). *What about the use of the Planck's constant in classical physic and in modern physics?*

2. The energy of (classical) harmonic oscillator is quantized (?)

3. Thus, if the energy of harmonic oscillator is quantized (?)...that is out from classical physics ... does it mean that we accept this result ... as an application of modern physics to classical physics ?

Left to right: Max Planck, Albert Einstein, Niels Bohr, Louis de Broglie, Max Born, Paul Dirac, Werner Heisenberg, Wolfgang Pauli, Erwin Schrödinger, Richard Feynman.

# Quantum Mechanics & Shared Cross-References Knowledge

**1923.** Louis de Broglie (1892-1987): On 10 Sept. (Ph.D. thesis on 25 Nov.) proposed his theory concerning wave-behavior of the matter.

**1924.** Satyendra Nath Bose (1894-1974): on 2 July proposed a new analyses statistical procedure

**1924.** Einstein: on 10 July extended Bose's procedure to a set of gas-particles material and mono-atomics. By another reasoning associated energy and frequency making stronger de Broglie's equations.

**1924.** Max Born (1882-1970) called the new theory: *quantum mechanics*.

**1925.** Wolfgang Pauli (1900-1958): on 16 January formulated his *principle of exclusion*.

**1925.** Werner Heisenberg (1901-1976): on 25 July his first article on matrix-interpretation of the mechanics (*Quantum-theoretical interpretation of kinetic and mechanical relations*).

**1925.** Born-Jordan (1902-1980): on 25 Sept. make stronger Heisenberg's theory.



# Quantum Mechanics & Shared Cross-References Knowledge

**1925.** Paul A. M. Dirac (1902-1984): on 7 Nov. generalized and analyzed and make stronger the mathematical form of Heisenberg's theory (he introduced "commentator"  $[p; q]$ ).

**1925.** Born, Heisenberg and Jordan: on 16 Nov. published the first complete treatise of the mechanics using matrix theory.

**1926.** Pauli: on 17 January utilized matrix mechanics to calculate discrete spectrum of the atom of hydrogen.

**1926.** Erwin Schrödinger (1887-1961): on 27 Jan. published open *Quantisierung als Eigenwertproblem* (Quantization as an Eigenvalue Problem) road to wave-mechanical interpretation

**1926.** Enrico Fermi (1901-1954): on 7 Feb. published *Statistic by Fermi-Dirac*.

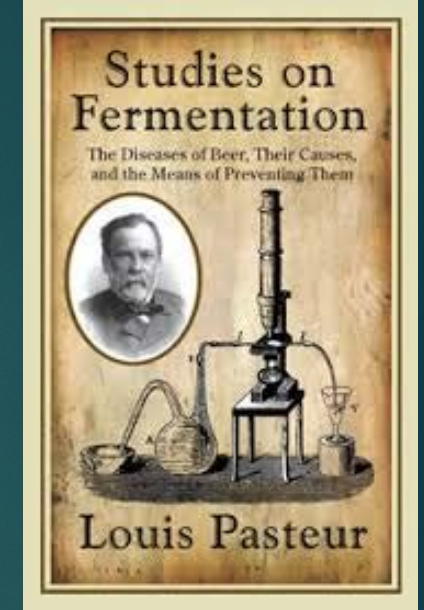
**1926.** Born: on 25 June published a job concerning the statistical interpretation of wave function.

**1926.** Dirac: on 26 August re-interpreted Planck's theory and still obtained by another road...*Statistic by Fermi-Dirac*.

**1927.** Heisenberg: on 23 March presented the relationship of indeterminations within the new mechanics.

# Ma non solo Fisica

Il metodo Galileiano ha fortemente influenzato molte altre disciplina



<<...Queste poche linee che ho tracciato sul corso degli studi da me compiuti nel campo dell'economia politica vogliono solo dimostrare che le mie idee, in qualsiasi modo le si voglia giudicare e per quanto poco esse coincidano con gli interessi delle classi dominanti, sono il risultato di lunghi anni di coscienziose ricerche. Sulla porta della scienza, come sulla quella dell'inferno, deve essere posto questo invito: Qui si conviene lasciare ogni sospetto. Ogni viltà convien che qui sia morta. >>1

Karl Marx, Londra, gennaio

1859 (prefazione a "per la critica dell'economia politica")  
1 (Inferno, Canto III, vv.14-15)



-J. V. Neumann, Un modello di equilibrio economico generale, tradotto in italiano in "L'Industria", n. 1, 1952, pag. 1.