

History of Science

Michael Nauenberg, February 6, 2017

Important scientific discoveries made in
the past

How were these discoveries made?

Start by reading some articles and books
on the subject by historians of Science

Then read the original accounts by the discoverers

But pay also attention to Einstein's
dictum:

"If you want to find out anything from the theoretical physicists about the methods they use, I advise you to stick closely to one principle: don't listen to their words, fix your attention on their deeds."

Ideas and Opinions, 1954 pg. 270

Some historical discoveries I have
considered :

Planck and the discreteness of energy

Einstein and the discovery of photons

Newton and the laws of motion

Huygens, Hooke and atmospheric pressure

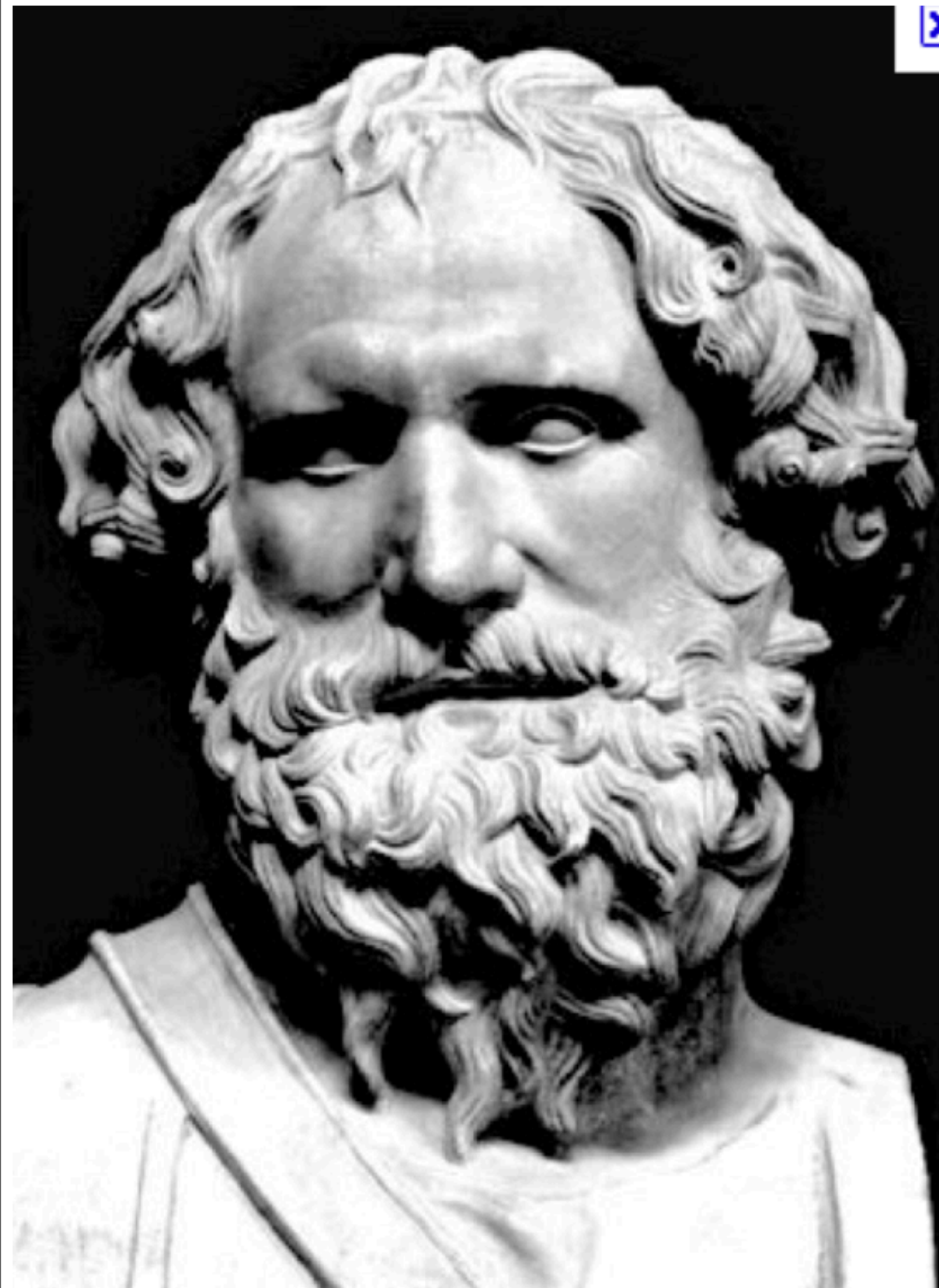
Chandrasekhar, Stoner and the maximum mass of
cold stars

Barrow, Leibniz and the fundamental
theorem of the Calculus

- 1) “Newton's Early Computational Method for Dynamics”,
Archives for History of Exact Sciences, **46**, (1994) 221-252.
- 2) “Newton's Principia and Inverse-Square Orbits”,
The College Mathematics Journal, (May 1994) 212-221
- 3) “Hooke, Orbital Motion and Newton's Principia”,
American Journal of Physics, **62**, (1995) 331-350.
- 4) “Newton and Huygens on Curvature and its Applications to Dynamics”, Special issue on Christiaan Huygens in the Dutch
Journal De zeventiende eeuw. Cultuur in de Nederlanden in Interdisciplinair Perspectief, (Sept. 1996) 215-234.
- 5) “The Mathematical Principles Underlying the *Principia* Revisited”,
Journal for History of Astronomy **29**, (1998) 286-300.
- 6) “Hooke’s and Newton’s contributions to the early development of orbital dynamics and the theory of Universal Gravitation
Early Science and Medicine Vol X No. 4 (2005) 518-528
- 7) “Newton’s unpublished perturbation method for the lunar motion”,
International Journal of Engineering Science **36** (1998) 1391-1405
- 8) “Newton’s curvature measure of force”,
Section 3.9 in I. B. Cohen “*A Guide to Newton’s Principia*” (Univ. of Cal. Press 1999)

- 9) Comment on “An analysis of Newtons Projectile diagram”,
European Journal of Physics **21** (2000) L5-6
- 10) “Newton’s perturbation methods and its application to Lunar motion”, *Isaac Newton’s Natural Philosophy*, edited by I. B. Cohen and J. Buchwald (MIT Press, 2001)
- 11) “Curvature in Newton's Dynamics” (with J. Brackenridge),
Cambridge Companion to Newton, edited by I. B. Cohen and G. Smith (Cambridge, 2002)
- 12) “Kepler's Area Law in The Principia: Filling in some details in Newton's proof of Proposition 1”, *Historia Mathematica* **30** (2003) 441-456
- 13) M. Nauenberg, “Gap in Einstein’s early argument for existence of photons”,
Physics Today, October 2005
- 14) “Hooke’s and Newton’s contributions to the early development of orbital dynamics and the theory of universal gravitation”, *Early Science and Medicine* **X** (2005), 518-528
- 15) “Curvature in Orbital Dynamics”,
American Journal of Physics **73** (2005), 340-348
- 16), “Robert Hooke’s seminal contributions to orbital dynamics”,
Physics in Perspective **7** (2005), 4-34 and Robert Hooke,
Tercentennial Studies,
eds. M. Cooper and M. Hunter (Ashgate, London 2006), 3-32
- 17) “How Einstein discovered the Photon”, *History of Physics Newsletter* **9** (2006) 18-19

- 20) “The early application of the calculus to the inverse square force problem”,
Archive for History of Exact Sciences **64** (2010) 269-300
- 21) “Placing Chandra’s work in historical Context”
Physics Today 64, Issue 7, (2011) 8
- 22) “Proposition 10, Book 2, in the Principia, revisited”,
Archive for History of Exact Sciences **65** (2011) 567-587
- 23) “Comment on ‘Is Newton’s second law really Newton’s?’”,
American Journal of Physics **80** (2012) 931-933
- 24) “Barrow and Leibniz on the Fundamental Theorem of the Calculus”,
Submitted to *Annals of Science* **71** (July 2014) 335-354
- 25) “Orbital motion and force in Newton’s Principia; the equivalence of the
descriptions in Propositions 1 and 6.”
Archive of History of Exact Sciences **68** (March 2014) 179-205
- 26) “My early work in the history of Physics”,
Council of the University of California Emeriti Association Newsletter (October
2013)
- 27) “What happened to the Bohr-Sommerfeld elliptic orbits in Schrodinger’s
wave mechanics?”
Contribution to the centennial volume celebrating the Bohr atom, (to be
published by the Danish Academy of Science , 2015)
- 28) “Solution to the Long Standing Puzzle of
Huygens’ Anomalous Suspension”, *Archives
History of Exact Sciences*, April 2015
(online)
- 29 “John Bell’s major contributions to
Physics and Philosophy”
Royal Irish Academy Annual Review
(2014-15) 23-26
- 30) “Max Planck and the Birth of the
Quantum Hypothesis”
Am. J. Physics 84 (2016) 709-720
- 31 “Recollections of John Bell”, Chapter
in a Tribute to John Bell (Cambridge
Univ Press) (to be published 2017)



ARCHIMEDES 282-212 B.C.

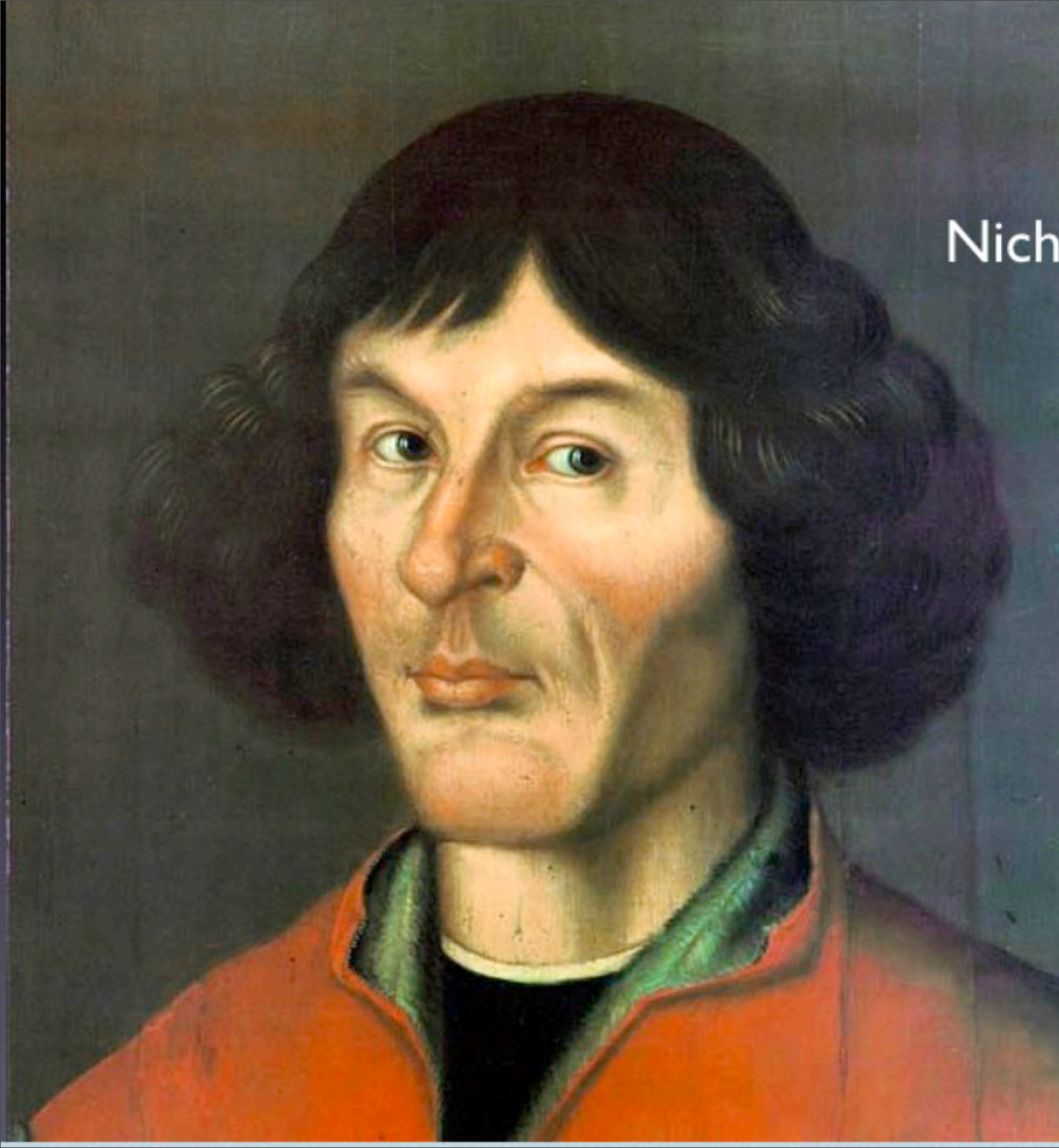


Claudius Ptolemaeus
AD 100-c 170

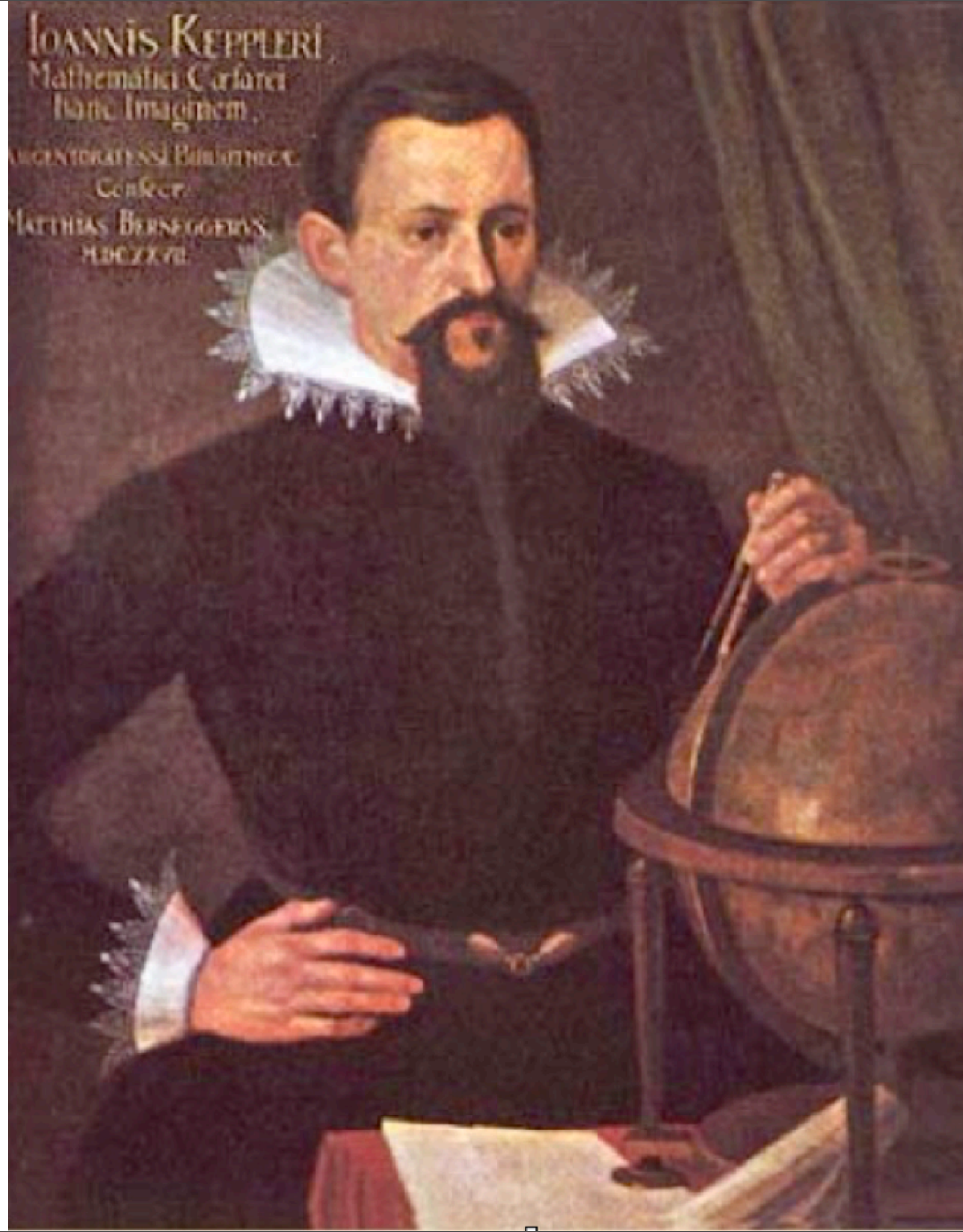
Early baroque artist rendition

Leonardo da Vinci
1452-1519





Nicholaus Copernicus
(1473-1543)



Kepler
1571-1630

Physicists



Galileo Galilei
1564-1642

Galileo



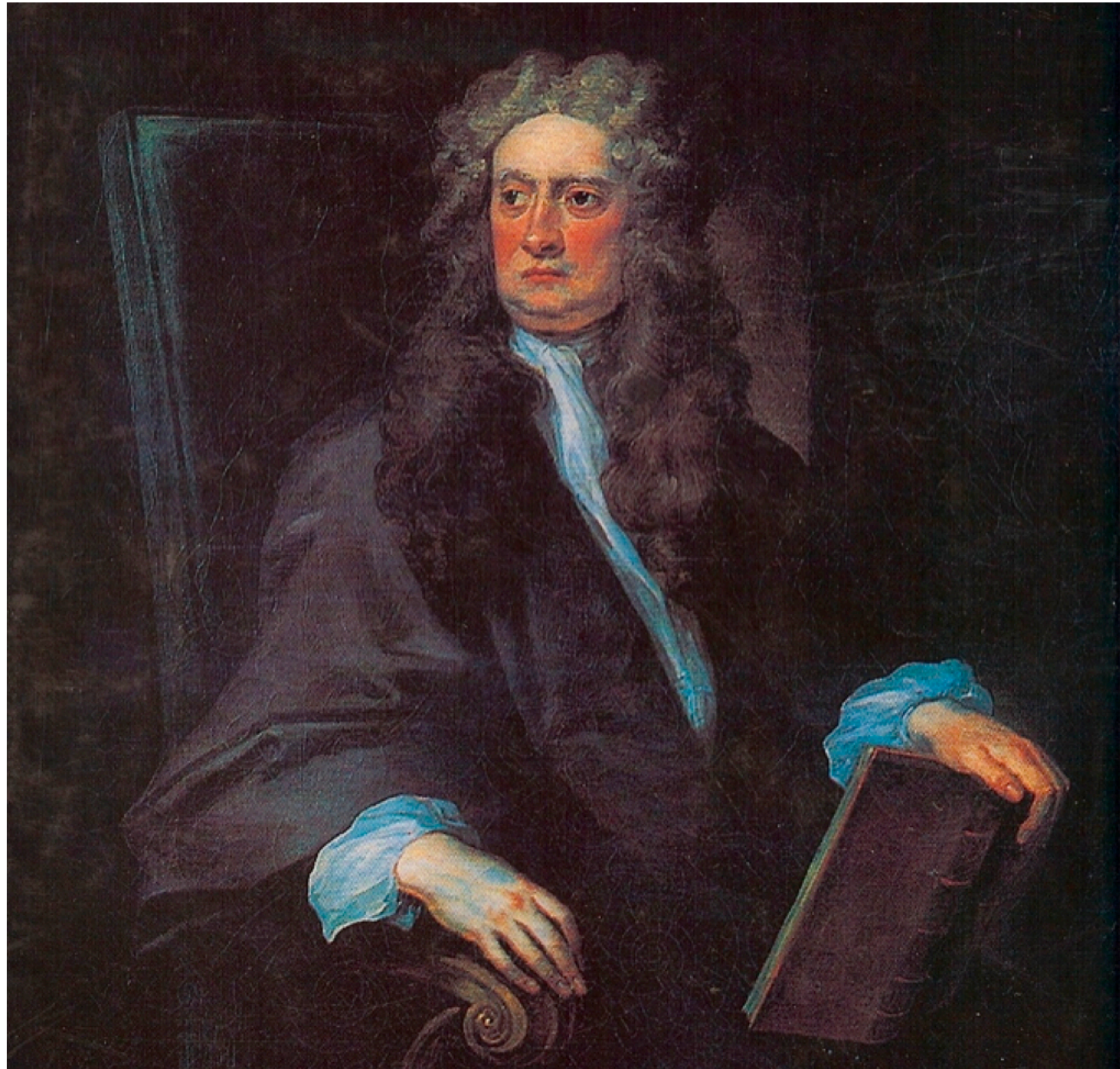


Tycho Brahe
1546-1601

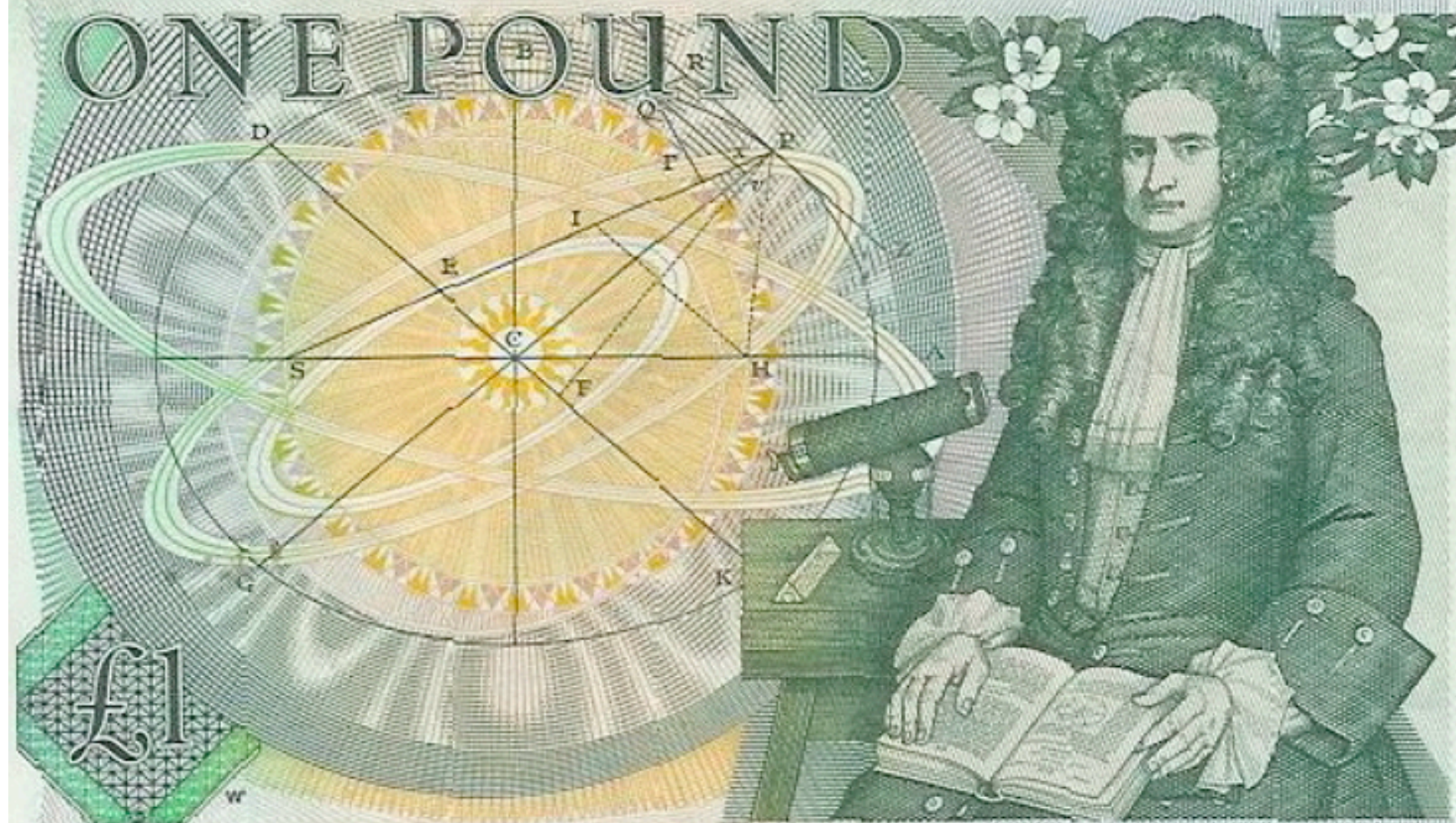


Isaac Newton
1642-1727

Isaacus Newton Eq: Aur.



Isaac Newton






Robert Boyle

The Honourable
Robert Boyle
FRS



Robert Hooke? 1635-1703



A portrait of Joannes Baptiste van Helmont, a 17th-century Dutch chemist and physician. He is depicted from the chest up, wearing a dark, high-collared garment. The background is a textured, brownish-grey. To the left of the portrait, there is a faint, stylized illustration of a plant with long, pointed leaves.

Joannes Baptiste van
Helmont
1580- 1644

The Rules of Mathematicks, or
learning by demonstration do ill
square to Nature. For Man dot
not measure Nature; but she
him.





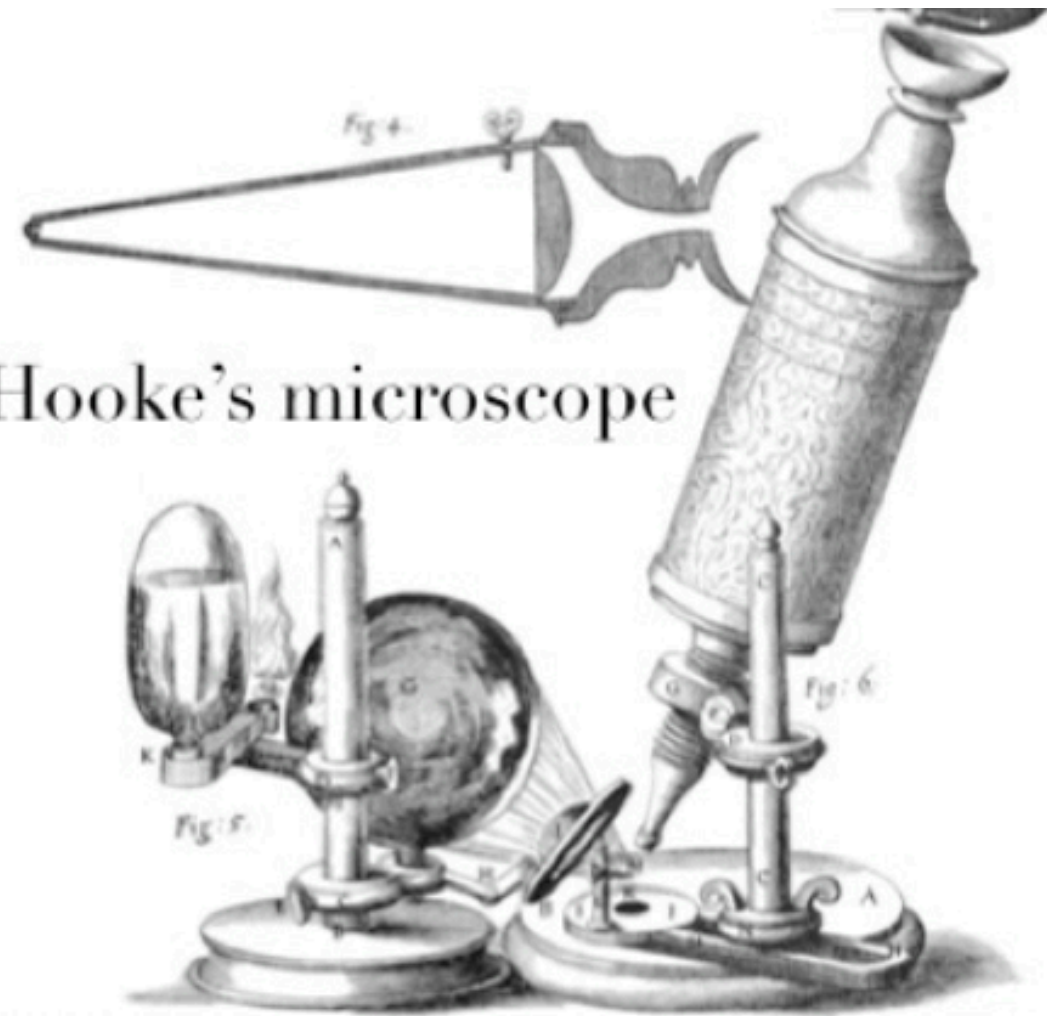
Christiaan Huygens
1629-1695



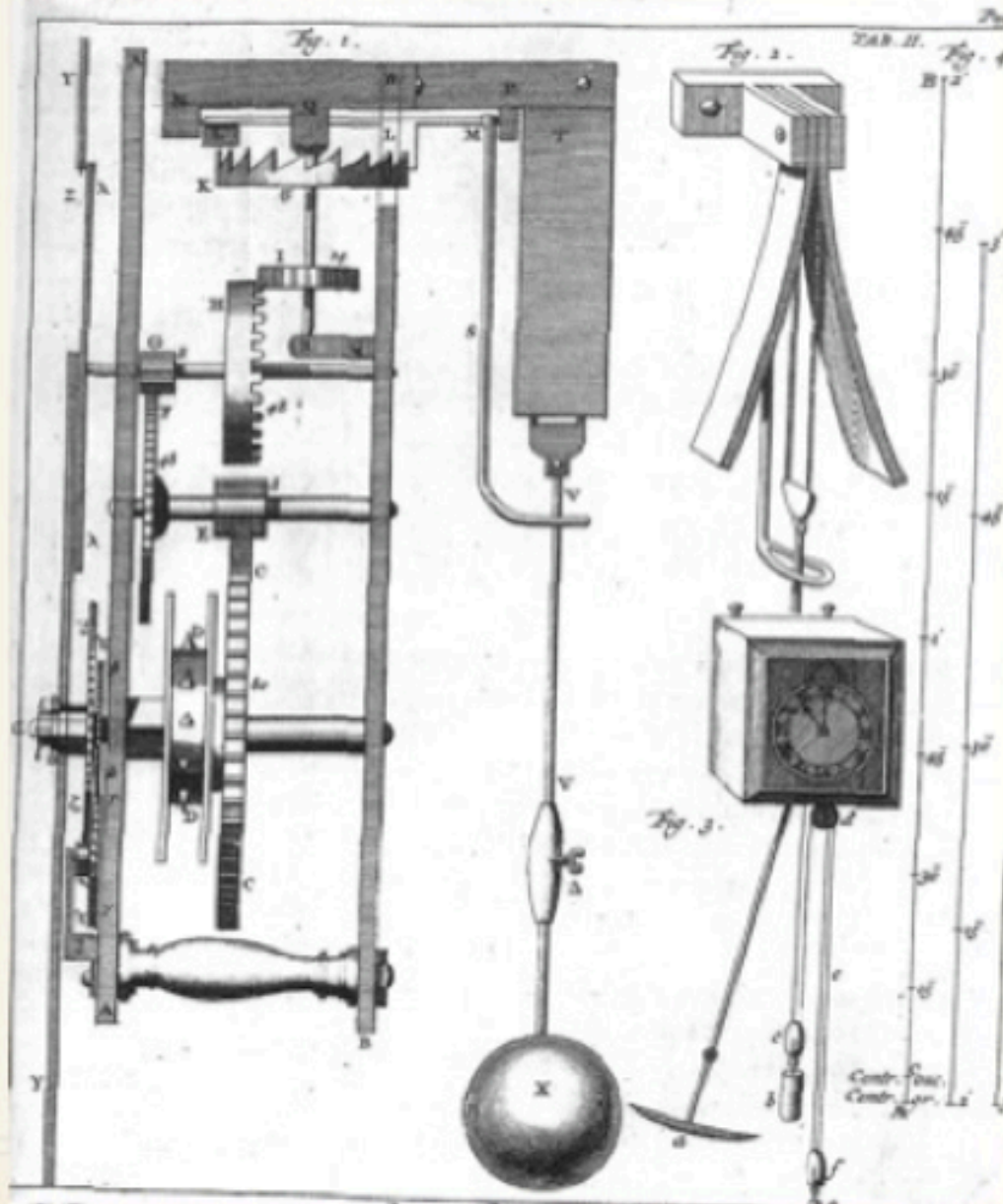
Christiaan Huygens
1629-1695



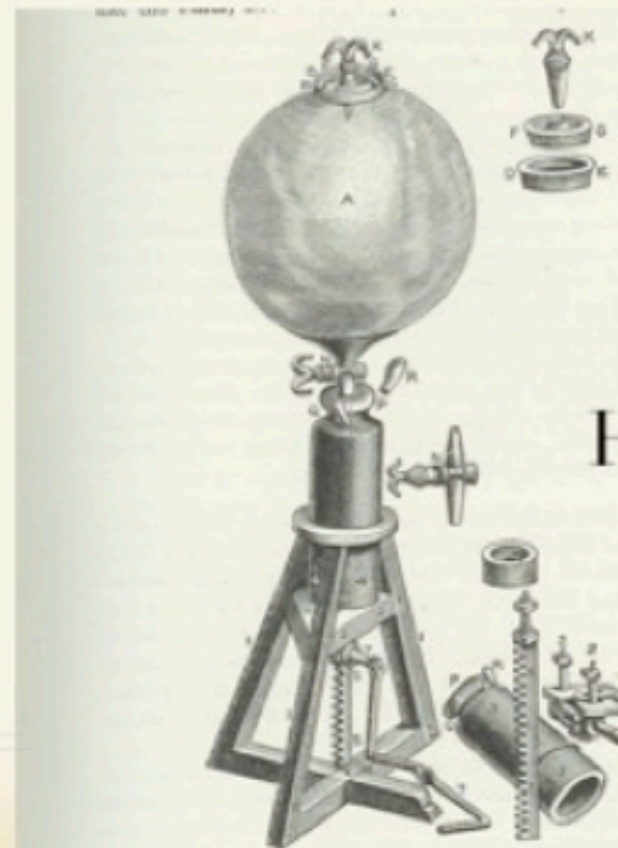
Galileo's telescope



Hooke's microscope



Huygens clock



Hooke's air pump



Pierre-Simon Laplace

1749-1827

Gabrielle Emilie Le Tonnelier, marquise du Chatelet

1706 - 1749

French translation and
commentary on Newton's

Principia

Voltaire to Frederick II
of Prussia

"she was a great man
whose only fault was
being a woman"

Inspired the marchioness
of Algarotti

In 1746, elected to the

Academy of Sciences of Bologna

1706-1749



Laura Mariá Caterína Bassi

1711-1778



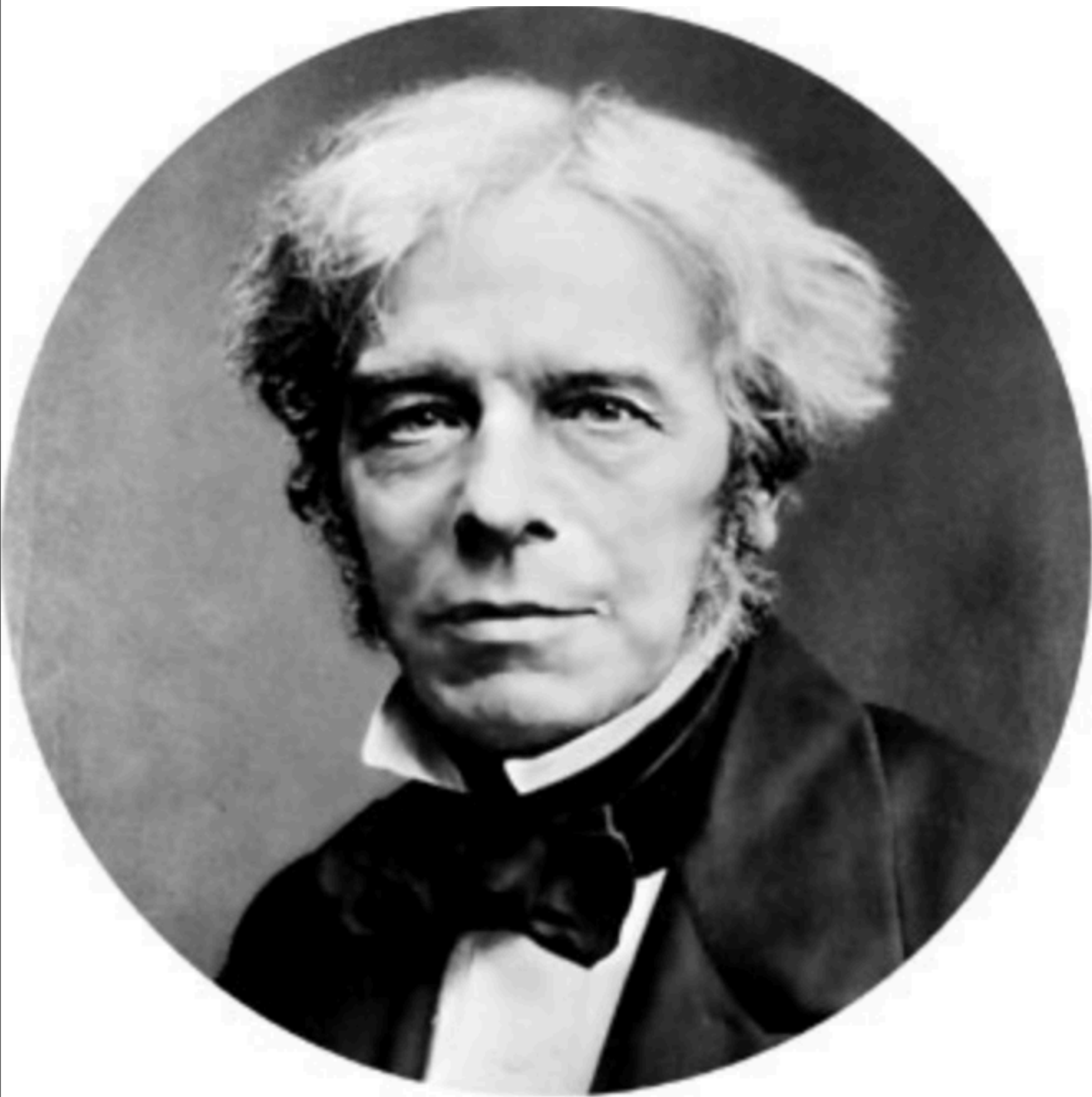
In 1731, appointed to professor
of anatomy at the University
of Bologna, and a year later
to a chair in philosophy

In 1774, appointed by Pope
Benedict XIV

to an elite group of scholars
known as the Benedictini, and
a year later to the chair of
experimental physic

Thomas Young
1773-1829

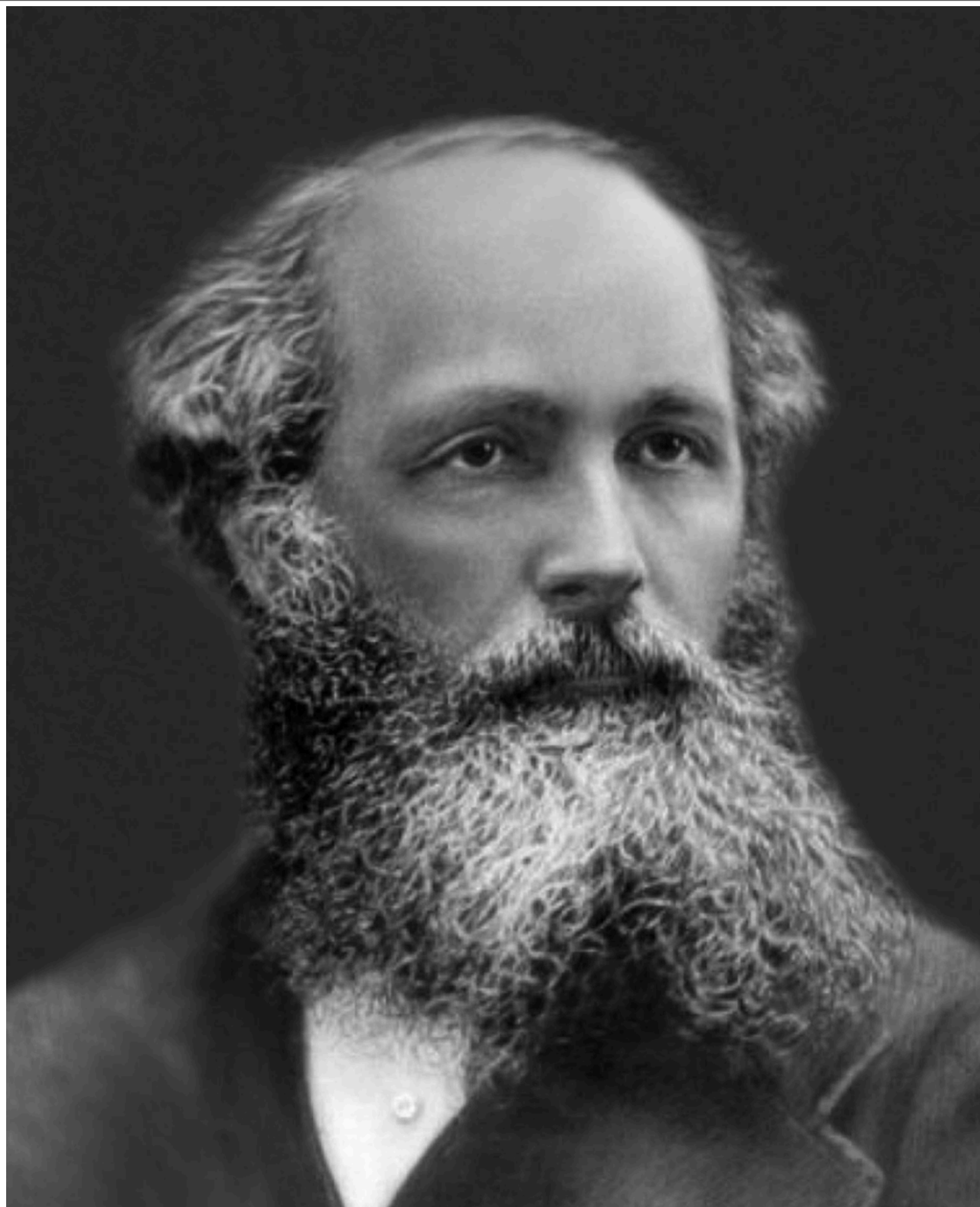




Michael Faraday
1791 1867

Michael Faraday





James Clerk Maxwell
1831 - 1879



LUDWIG BOLTZMANN
1833-1906

$$S = k \log W$$

Ludwig Boltzmann



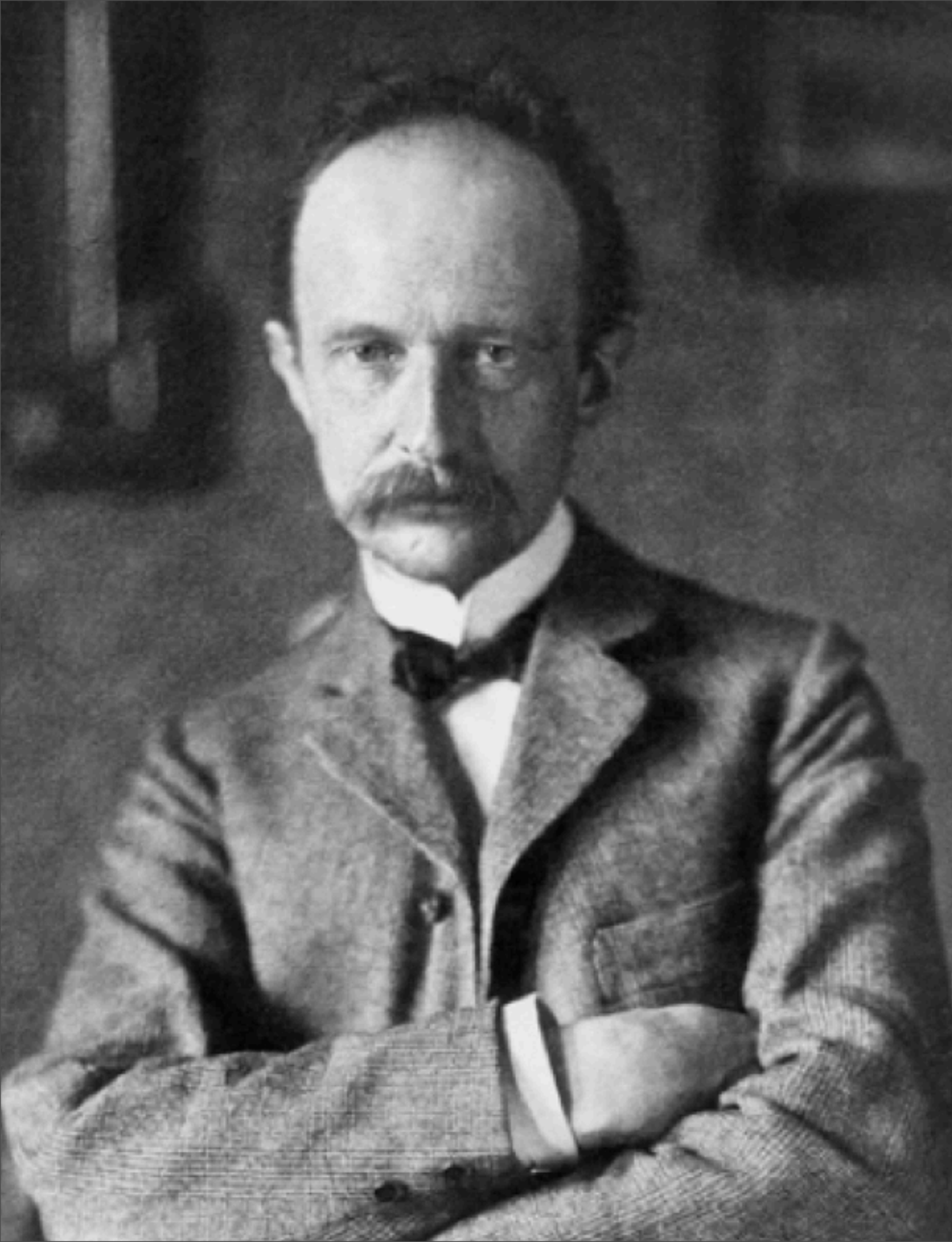
Max Planck
1858-1947

“On the theory of the
Energy Distribution
Law of the Normal
Spectrum”

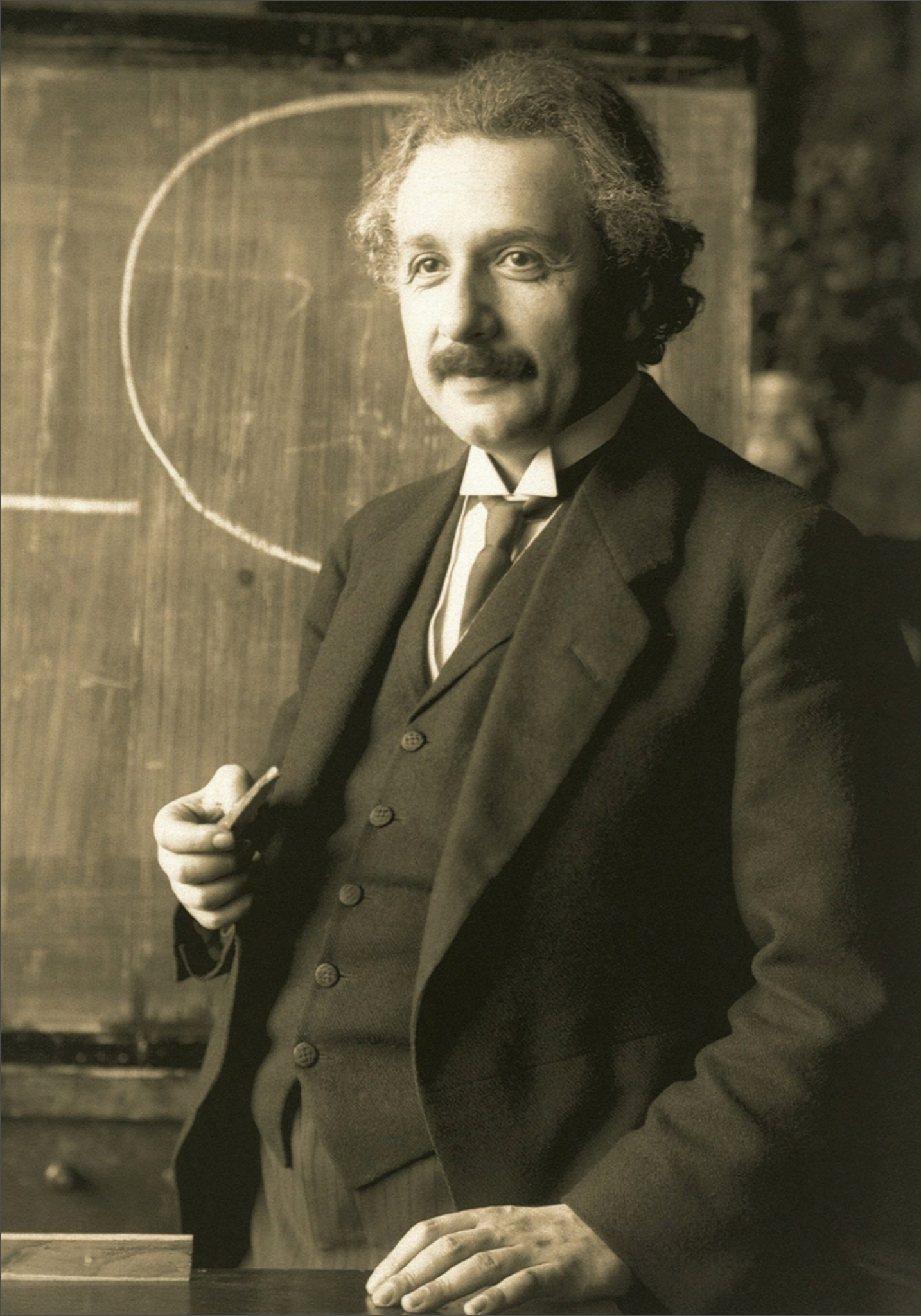
Presented at the
14 Dec. 1900
meeting of the
German Physics
Academy



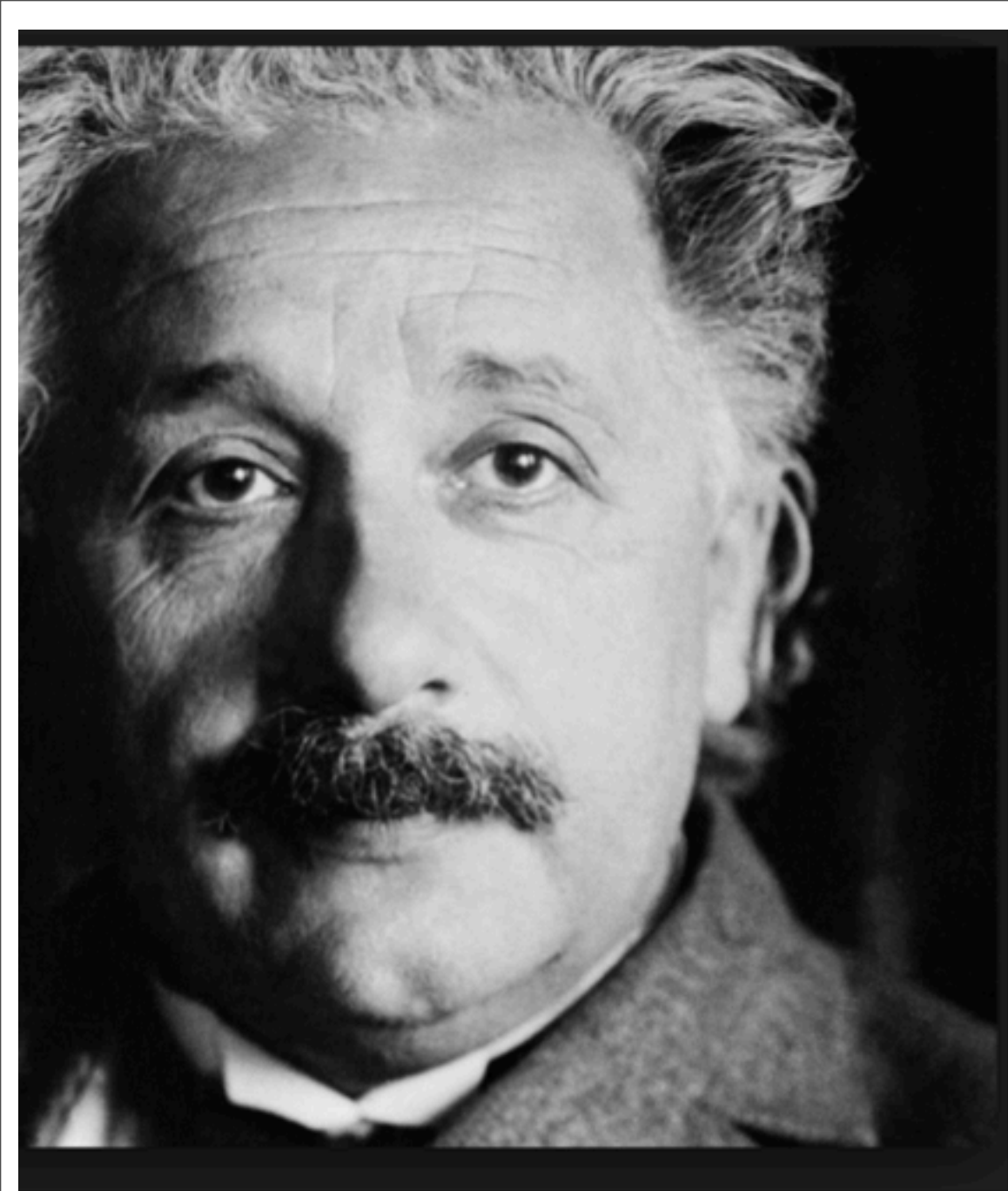
MAX PLANCK



MAX PLANCK



Albert Einstein
1879-1955



Albert Einstein

1879-1955

Quantum mechanics is certainly imposing. But an inner voice tells me that it is not yet the real thing. The theory says a lot, but does not really bring us any closer to the secret of the 'old one'. I, at any rate, am convinced that *He is not playing at dice*.

Einstein in a letter to Bohr:
You believe in a *dice playing God*, and I
in perfect laws in the world of things
existing as real objects ...

Louis de Broglie
1892-1987

$$p = h/\lambda$$

$$\oint dq/\lambda = n$$

or

$$\oint dq \, p = nh$$

Bohr -Sommerfeld
quantization (1916)



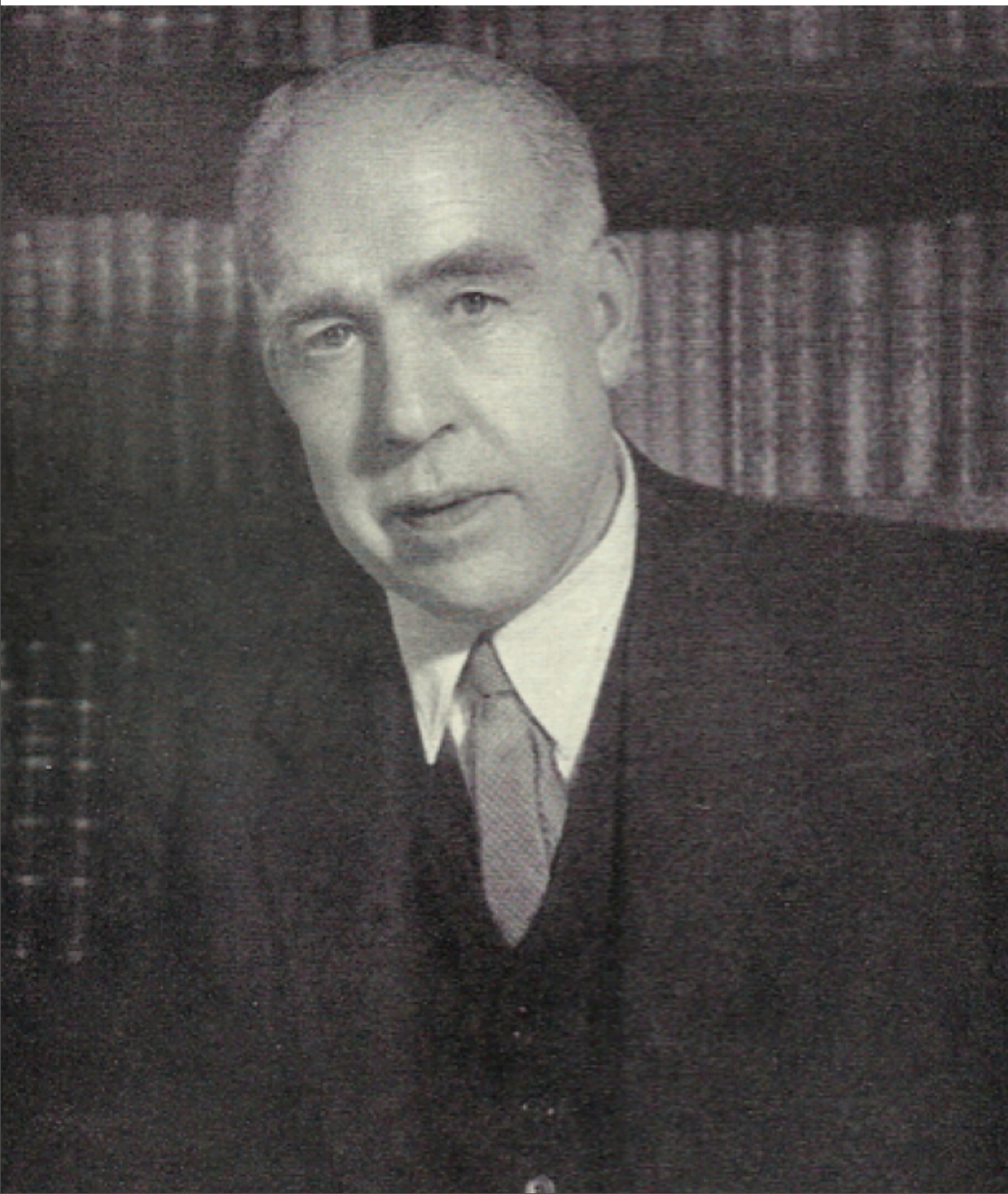


Niels Bohr
1885 - 1962

“On the constitution of
atoms and molecules”

Philosophical Magazine
and
Journal of Science 26
July 1913

Niels Bohr





Peter Debye



Erwin Schroedinger



Writing, April 1924 (CERN)

Wolfgang Pauli 1900-1968

On the connection of
the completion of the
electronic group in the
atom with the complex
structure of the
spectrum”

Zeitschrift für Physik
31 765-783 (1925)

.. an essential advance by
the
reflections of E.C. Stoner
p. 773

Wolfgang Pauli





Wolfgang Pauli



Arnold Sommerfeld
1868-1951

Atomic Structure and
Spectral Lines

“bible of the old
quantum theory”



English: Photograph of participants of the first Solvay Conference, in 1911, Brussels, Belgium.

Seated (L-R): [Walther Nernst](#), [Marcel Brillouin](#), [Ernest Solvay](#), [Hendrik Lorentz](#), [Emil Warburg](#), [Jean Baptiste Perrin](#), [Wilhelm Wien](#), [Marie Curie](#), and [Henri Poincaré](#).

Standing (L-R): [Robert Goldschmidt](#), [Max Planck](#), [Heinrich Rubens](#), [Arnold Sommerfeld](#), [Frederick Lindemann](#), [Maurice de Broglie](#), [Martin Knudsen](#), [Friedrich Hasenöhl](#), [Georges Hostelet](#), [Edouard Herzen](#), [James Hopwood Jeans](#), [Ernest Rutherford](#), [Heike Kamerlingh Onnes](#), [Albert Einstein](#), and [Paul Langevin](#).



Paul Adrien Maurice Dirac
1902-1984

“On the theory of
Quantum Mechanics”

Proceedings of the
Royal Society of
London A 112, 661-677
(1926)



Landau in 1936

Lev Landau

1908-1968

**“On the theory of
stars”, Physikalische
Zeitschrift der
Sowjetunion, 1 (1932),
285–288.**



Lev Landau

1908- 1968



Enrico Fermi

Enrico Fermi

“Quantization of the
ideal atomic gas”

Z. Physik 36, 902-912
(1926)

... Pauli, in connection with
the work of E.C. Stoner,
establish the rule that when
an atom has fixed quantum
numbers, there cannot be
any further electrons in the
shell that is characterized by
these quantum numbers.



Eugene Wigner
(1902-1995)
Nobel Prize in Physics
1963

Wigner's friend and
Consciousness in
quantum mechanics

“Remarks on the Mind
Body Question”, in
The Scientist speculates,
I.J. Good, ed. (1961) pp.
284-302

. . . the quantum mechanical description will be superceded. In this it is like all theories made by man. But to an unusual extent its ultimate fate is apparent in its internal structure. It carries within itself the seeds of its own destruction. (Bell and Nauenberg 1966)



“Does quantum mechanics carry the seeds of its own destruction”

Kurt Gottfried
Physics World
1991

John Stewart Bell (1928-1990)



The New York Review of Books

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Steven Weinberg and the Puzzle of Quantum Mechanics

N. David Mermin, Jeremy Bernstein, Michael Nauenberg, Jean Bricmont, and Sheldon Goldstein, et al. (Tom Banks, Murray Gell-mann, Jim Hartle, Robert Griffiths)

APRIL 6, 2017 ISSUE

In response to:

The Trouble with Quantum Mechanics from the January 19, 2017 issue

Mathematicians

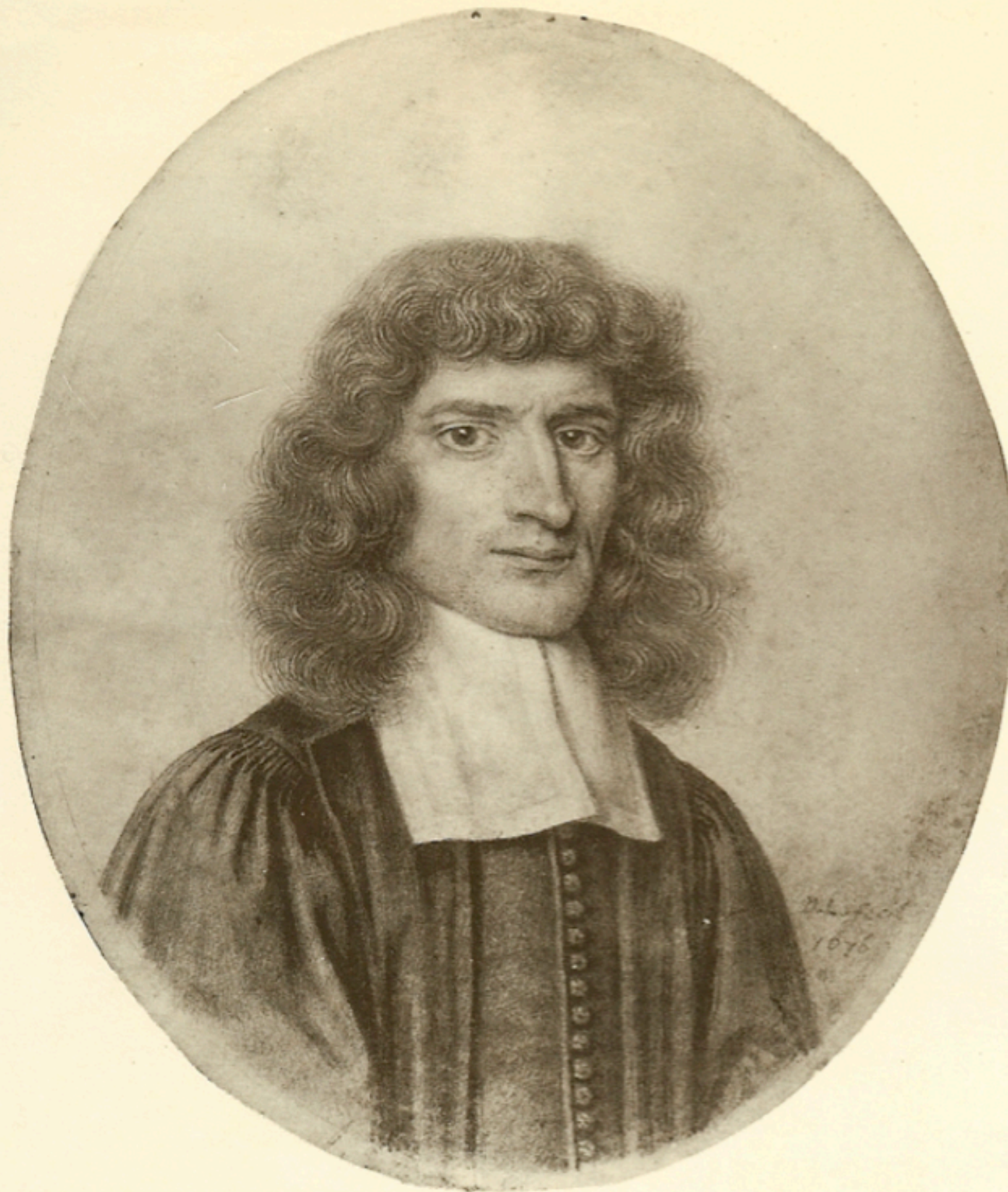
Bonaventura Cavalieri 1598-1647





PIERRE DE FERMAT 1601 - 1665

Lawyer at the Parlament of Toulouse,
France. According to Wikipedia, he was
an “amateur mathematician”



Isaac Barrow
1630-1677

Lucasian Professor of
Mathematics at
Cambridge University
and
mentor to Isaac Newton



L A
G E O M E T R I E.
LIVRE PREMIER.

*Des problemes qu'on peut construire sans
y employer que des cercles & des
lignes droites.*

TOus les Problemes de Geometrie se
peuvent facilement reduire a tels termes,
qu'il n'est besoin par après que de connoi-
stre la longueur de quelques lignes droites,
pour les construire.

Et comme toute l'Arithmetique n'est composée, que
de quatre ou cinq operations, qui sont l'Addition, la
Soustraction, la Multiplication, la Diuision, & l'Extra-
ction des racines, qu'on peut prendre pour vne espece
de Diuision : Ainsi n'at-on autre chose a faire en Geo-
metrie touchant les lignes qu'on cherche, pour les pre-
parer a estre conuës, que leur en adiouter d'autres, ou
en oster, Oubien en ayant vne, que ie nommeray l'vnité
pour la rapporter d'autant mieux aux nombres, & qui
peut ordinairement estre prise a discretion, puis en ayant
encore deux autres, en trouuer vne quatriesme, qui soit
à l'vne de ces deux, comme l'autre est a l'vnité, ce qui est
le mesme que la Multiplication; oubien en trouuer vne
quatriesme, qui soit a l'vne de ces deux, comme l'vnité
est

Commẽ
le calcul
d'Ari-
thmeti-
que se
rapporte
aux ope-
rations de
Geome-
trie.

Blaise Pascal

1623-1662

French mathematician
physicist and religious
philosophe





John Wallis 1616-1703

English Mathematician



Johann Hudde

1628 - 1704

Dutch mathematician and
a student of von Schooten

He developed an ingenious
method to find multiple roots
of an algebraic equation



Gottfried Wilhem Leibniz
1646-1716



Gottfried Wilhelm
Leibniz

1646-1716



Gottfried Wilhelm
Leibniz

1646-1716



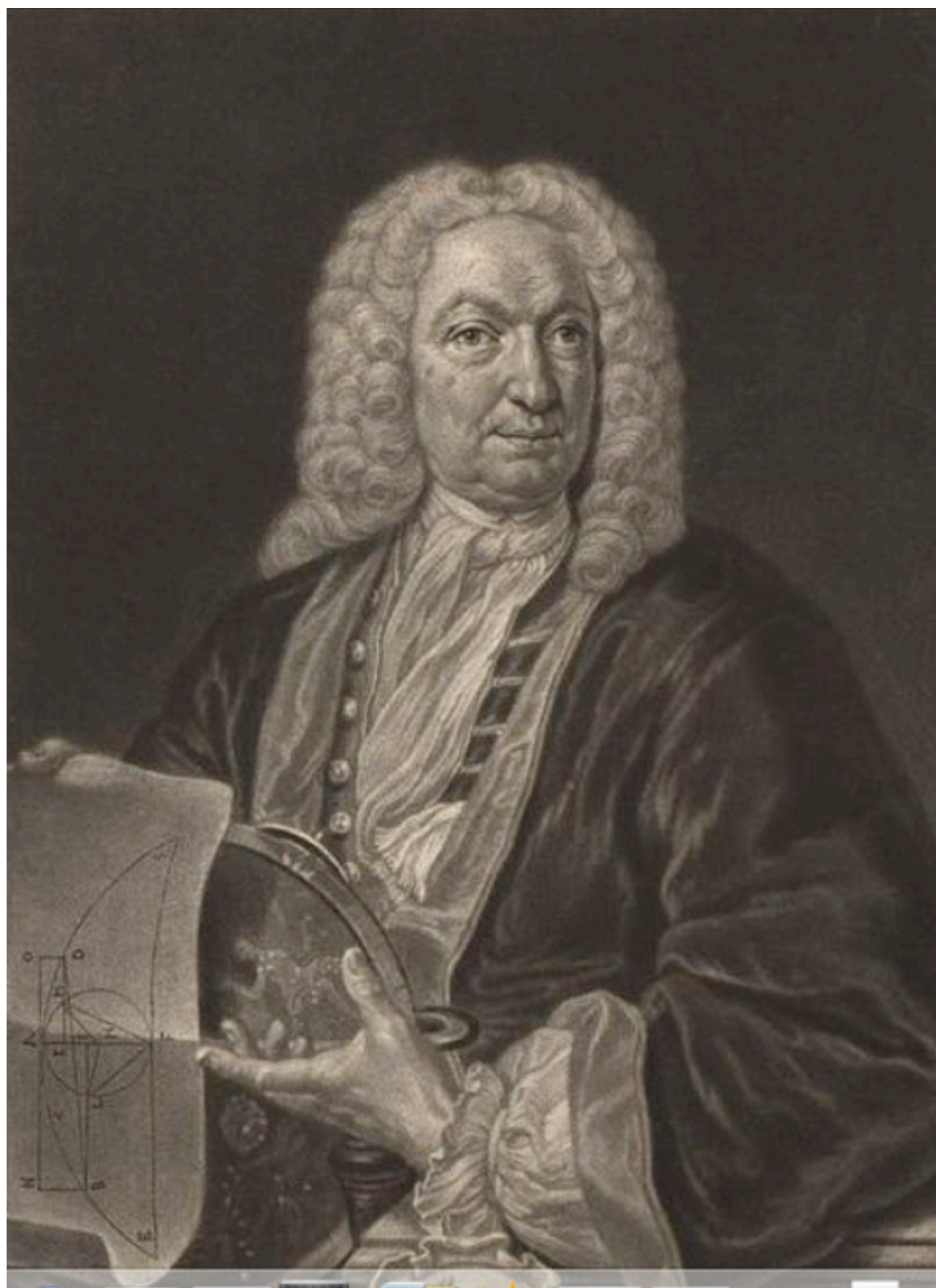
Pierre Varignon

1654-1722

Professor of mathematics
at the College Mazarin in Paris
in 1688 and member
of the Academie Royale des
Sciences

Pierre Varignon
Professeur Royal de Mathématiques
à l'Académie Royale des Sciences
à Caen l'an 1654 mort à
Paris 1722

Par ses Scavants Efforts, de ses veilles heureuses,
Il sembla rendre désormais.



Johann Bernoulli

1647-1748

Response de Bernoulli to
Hermann, from Basel
October 7, 1710

Memoires de l'Academie
Royale des Sciences



Johann Bernoulli
1667-1748

Jacob Bernoulli 1654-1705





Leonard Euler
1707-1709

Leonhard Euler

1707 -1783

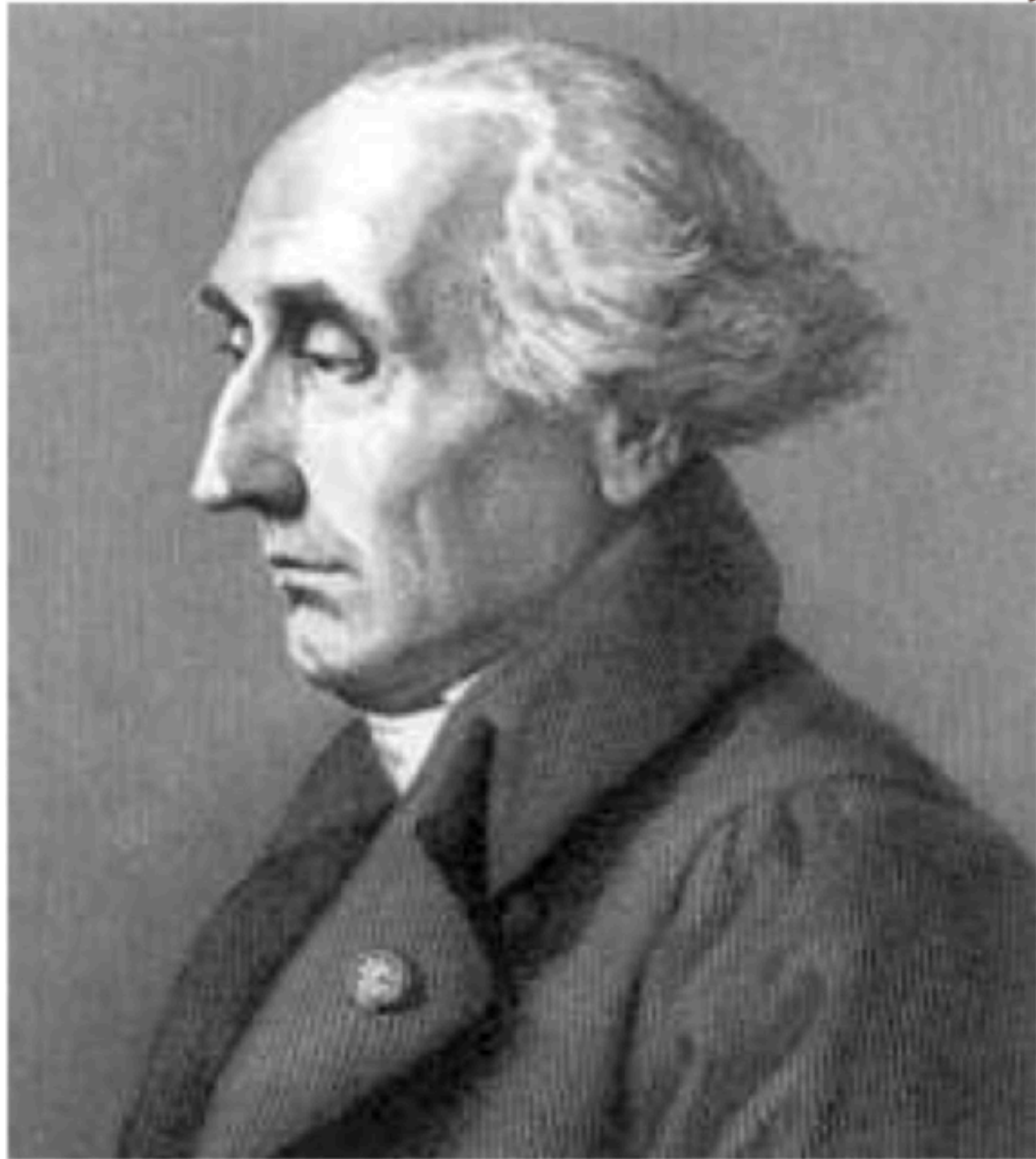


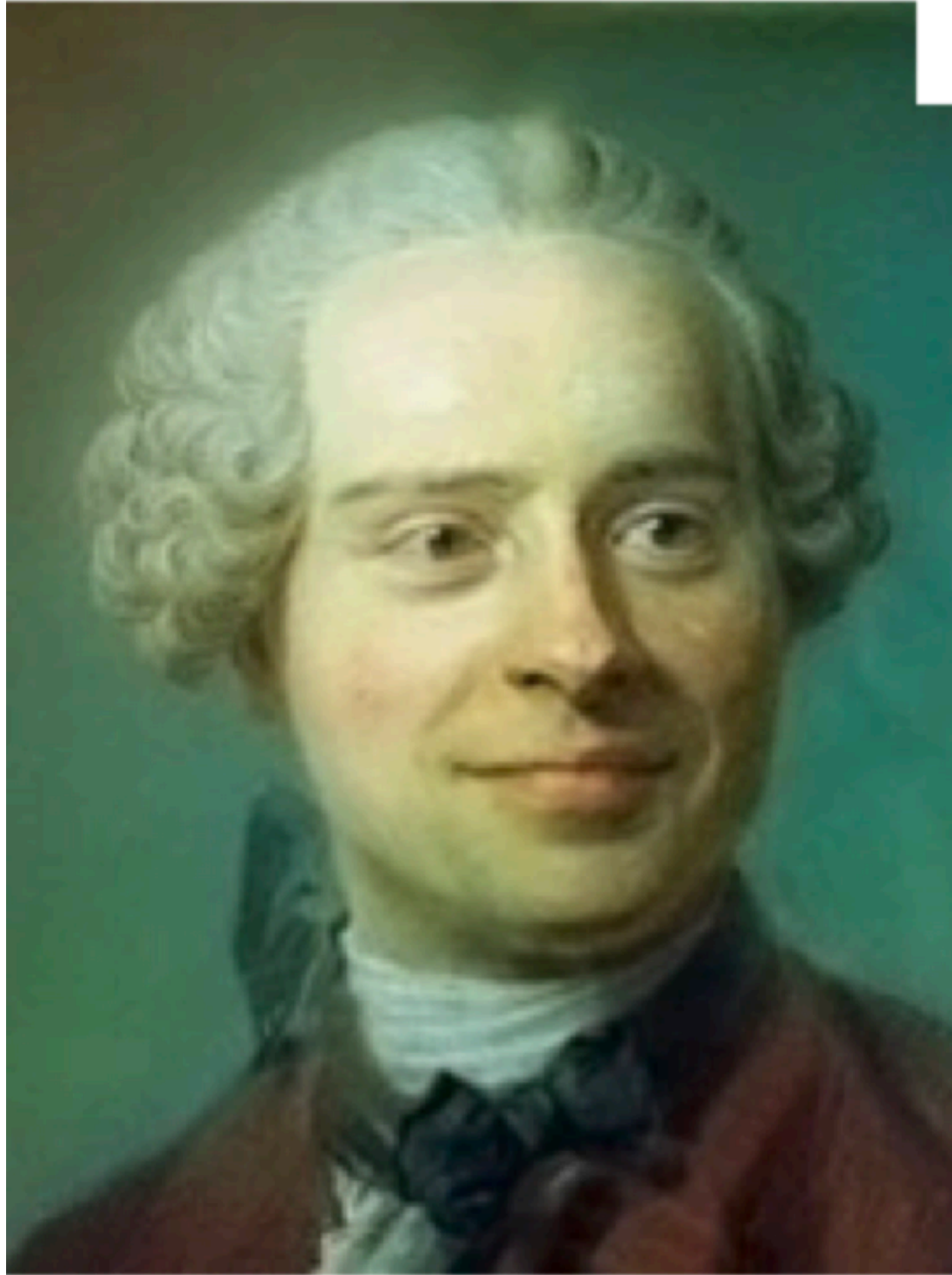
Letters to a German
Princess on Different
Subjects in Physics
and Philosophy



Joseph-Louis Lagrange

1736-1813





Jean le Rond D'Alembert

1717-1783



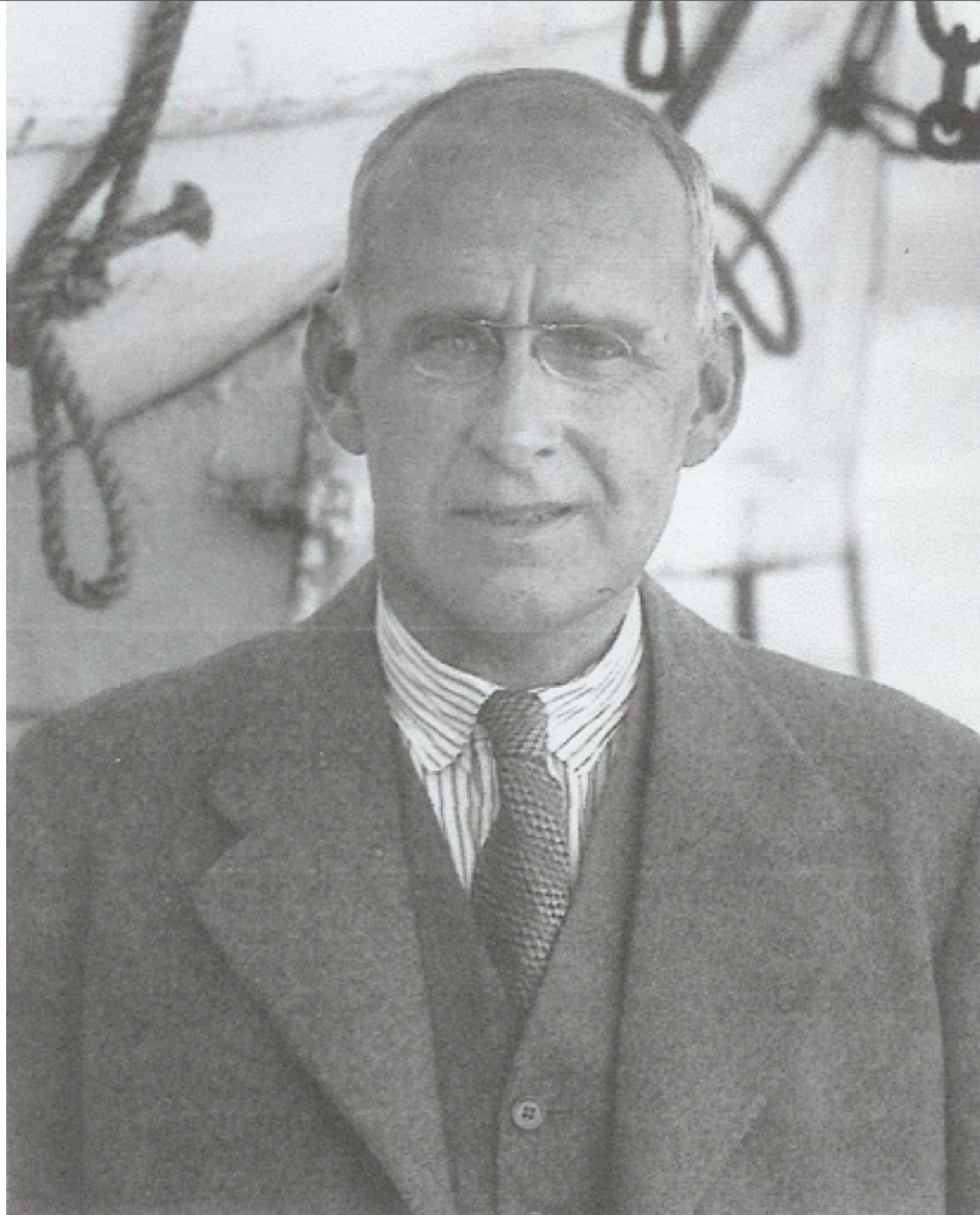
Friedrich
Wilhelm Bessel

1784- 1846

Director of the
Konigsberg
Observatory

Sirius dark
companion
1844

Astrophysicist

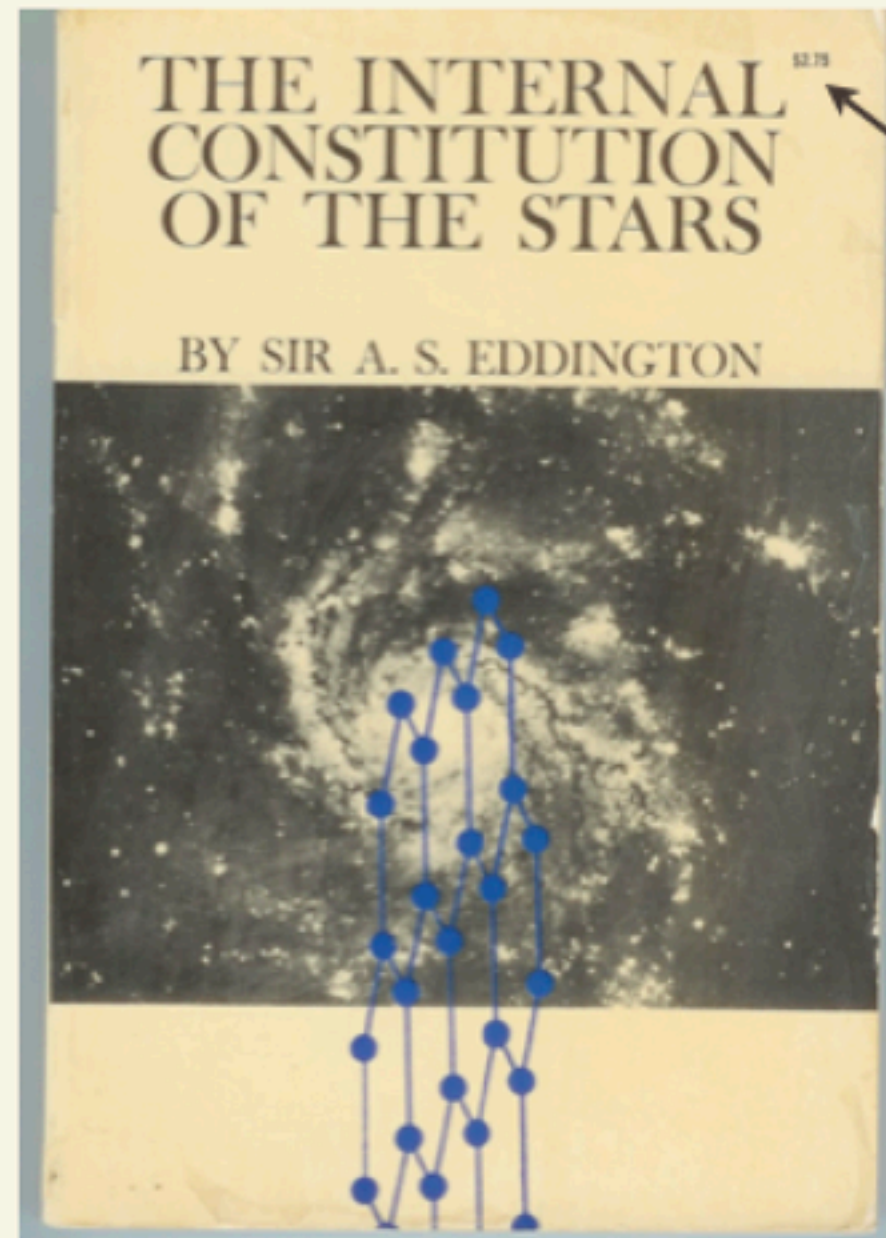
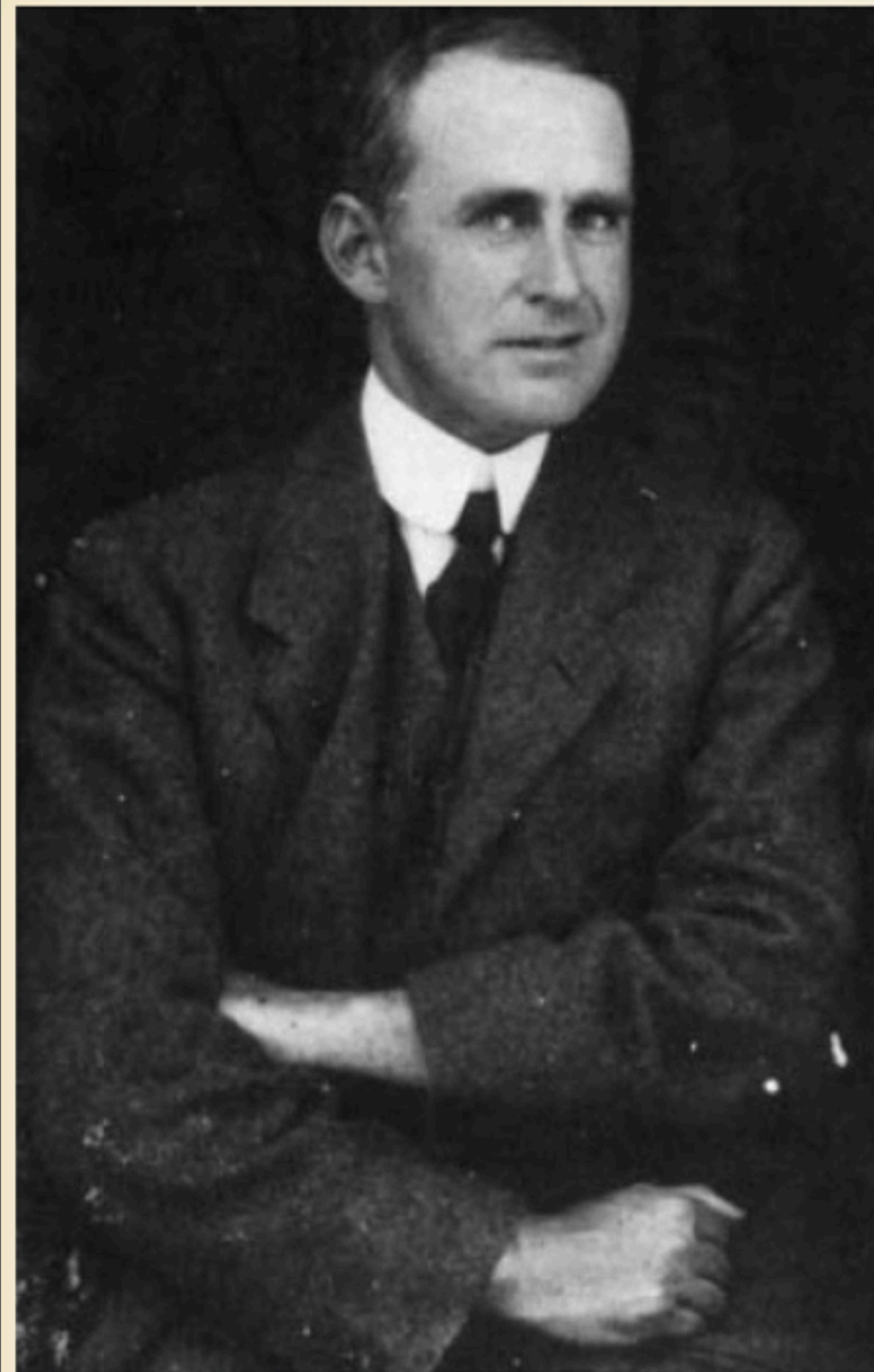


Arthur S.
Eddington

1882-1944

Arthur S. Eddington

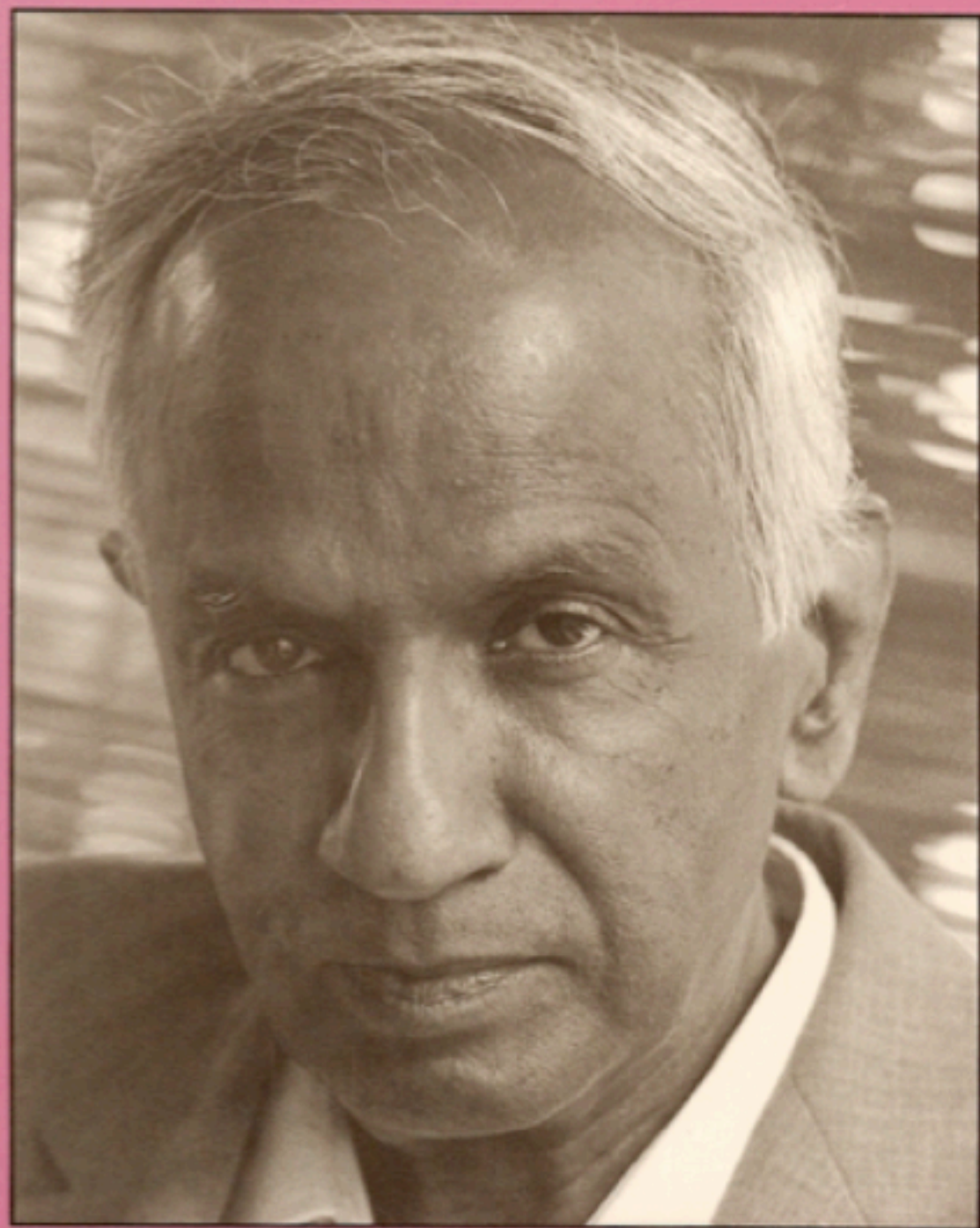
1882-1944



In 1920, Eddington pointed to the fusion of 4 hydrogen atoms into a Helium atom as the likely energy source of stars.

CHANDRA

A Biography of S. Chandrasekhar



Kameshwar C. Wali

*Obsession, Friendship, and Betrayal
in the Quest for Black Holes*



ARTHUR I. MILLER



Edward A.
Milne

1896-1950

E.A. MILNE
1929

Ralph Fowler

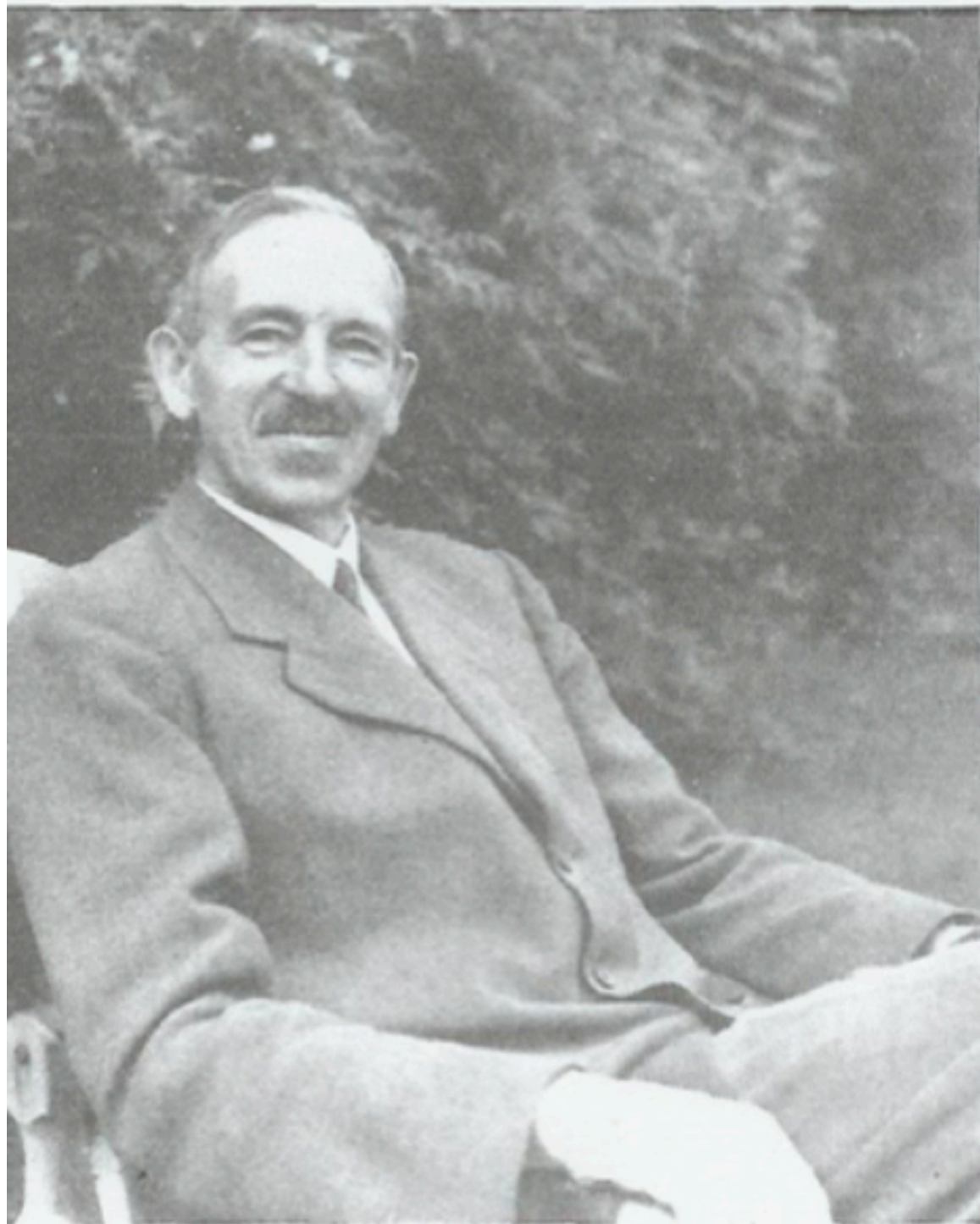
1889-1947

“On dense Matter”

Monthly Notices of the
Royal Astronomical Society

87, 115-122 (1926)

“It may be accepted now as
certain that classical statistical
mechanics is not applicable at
extreme densities, even to ideal
material composed of
extensionless mass points and
that the form used here is fairly
certain the correct substitute”



by Muspratt, Post-office Terrace, Cambridge

RALPH HOWARD FOWLER

Literature



Galileo, The Assayer 1623

PHILOSOPHIÆ

James NATURALIS Alexander

PRINCIPIA

MATHEMATICA.

AUCTORE

ISAACO NEWTONO,

EQVITE AVRATO.

EDITIO ULTIMA

AUCTIOR ET EMENDATIO.



AMSTÆLODAMI

SUMPTIBUS SOCIETATIS,

MDCCXIV.

Never at Rest

A Biography of
Isaac Newton



RICHARD S. WESTFALL

MICROGRAPHIA:

OR SOME
Physiological Descriptions
OF

MINUTE BODIES

MADE BY
MAGNIFYING GLASSES.

WITH
OBSERVATIONS and INQUIRIES thereupon.

By *R. HOOKE*, Fellow of the ROYAL SOCIETY.

*Non possis oculo quantum contendere Linceus,
Non tamen idcirco contemnas Lippus inungi.* Horat. Ep. Lib. 1.



LONDON, Printed for *John Martyn*, Printer to the ROYAL
SOCIETY, and are to be sold at his Shop at the Bell a little
without Temple Barr. MDC LXVII.

Philosophical EXPERIMENTS AND OBSERVATIONS

Of the late Eminent

Dr. *ROBERT HOOKE*,
S. R. S.
And Geom. Prof. *Gresh.*

AND

Other Eminent VIRTUOSO's in his Time.

With COPPER PLATES.

Publish'd by W. DERHAM, F. R. S.



LONDON:

Printed by W. and J. INNES, Printers to the
ROYAL SOCIETY, at the West End of *St. Paul's*.

MDCCXXVI.

not appear so rounded, and lying above the Paper, as I want, as it ought to do) that is, it was for the most part pretty oval, and ways, resembling like an Egg, but the other way it was a little flared out towards the sides. Diverse of these Eggs, as is common to most others, I found to be barren, or sterile, for they never afforded any young ones. And these I usually found much whiter than the other that were prolific. The Eggs of other kinds of *Ovipara* Insects I have found to be perfectly round every way, like to many Globules; of this sort I have observ'd some few of *Lepidura* Eggs; and thinking the last former to include a very large and curious pattern, I brought it to a Box, intending to examine it gradually with my *Microscope*, I found within a day or two after I had laid the Box, almost all the inner surface of the Box cover'd over with an infinite of exactly round Eggs, which were stuck very thick to the sides of it, and in so exactly regular and close an order, that made me call to mind my *Pythagoras*, which I had formerly thought on for the making out of all the regular Figures of Salt, which I have elsewhere listed; for here I found all of them rang'd into a most exact *triangular* order, much after the manner as the *Hexagons* are plac'd on the eye of a Fly; all which Eggs I found after a little time to be hatch'd, and out of them to come a multitude of small *Worms*, very much resembling young *Silk-worms*, leaving all their thin hollow shells behind them, sticking on the Box in their original posture; these I found with the *Microscope* to have much such a resemblance to the *Silk-worms* Eggs, but could not perceive them hatch'd. And indeed, there is as great a variety in the Shape of the Eggs of *Ovipara* Insects as among those of Birds.

Of these Eggs, a large and lusty Fly will at one time lay near five or six hundred, so that the Increase of such kind of Insects must needs be very prodigious, were they not pray'd on by multitudes of Birds, and destroy'd by Frogs and Rats; and hence 'tis that these *Creeping* *Crawlers* the *Trachea* are infested with such multitudes of Locusts, and such other Vermin.

Observ. XLII. Of a blue Fly.

THE kind of Fly, whereof a *Microscopical Picture* is deliver'd in the first Figure of the 26. *Table*, is a very beautiful creature, and he many things about it very notable; diverse of which I have already partly describ'd, namely, the feet, wings, eyes, and head, in the preceding Observations.

And though the head before describ'd be that of a grey *House-fly*, yet for the main it is very agreeable to this. The things wherein they differ most, will be easily enough found by the following particulars:

First, the chambers of eyes of this Fly, are very much smaller than those of the *House-fly*, in proportion to the head.



The Posthumous
WORKS
OF
ROBERT HOOKE, M.D. S.R.S.
Geom. Prof. Gresh. &c.
Containing his
Cutlerian Lectures,
AND OTHER
DISCOURSES,
Read at the MEETINGS of the Illustrious
ROYAL SOCIETY.

IN WHICH

- I. The present Deficiency of NATURAL PHILOSOPHY is discoursed of, with the Methods of rendering it more certain and beneficial.
- II. The Nature, Motion and Effects of LIGHT are treated of, particularly that of the *Sun* and *Comets*.
- III. An Hypothetical Explication of MEMORY; how the Organs made use of by the Mind in its Operation may be Mechanically understood.
- IV. An Hypothesis and Explication of the cause of GRAVITY, OF GRAVITATION, MAGNETISM, &c.
- V. Discourses of EARTHQUAKES, their *Causes* and *Effects*, and Histories of several; to which are annexed, *Physical Explications* of several of the Fables in *Ovid's Metamorphoses*, very different from other Mythologicall Interpreters.
- VI. Lectures for improving NAVIGATION and ASTRONOMY, with the Descriptions of several new and useful *Instruments* and *Contrivances*; the whole full of curious Disquisitions and Experiments.

Illustrated with **SCULPTURES.**

To these DISCOURSES is prefixt the AUTHOR'S LIFE, giving an Account of his Studies and Employments, with an Enumeration of the many Experiments, Instruments, Contrivances and Inventions, by him made and produc'd as Curator of Experiments to the *Royal Society*.

PUBLISH'D
By **RICHARD WALLER**, R. S. Secr.

LONDON:
Printed by **SAM. SMITH** and **BENI. WALFORD**, (Printers to the Royal Society) at the *Printer's Arms* in St. Paul's Church-yard. 1705.

Robert Hooke
1635 - 1703

A
General Scheme, or Idea
Of the PRESENT STATE of
Natural Philosophy,
AND
How its DEFECTS may be Remedied
By a Methodical Proceeding in the making
EXPERIMENTS
AND COLLECTING
OBSERVATIONS.
WHEREBY
To Compile a NATURAL HISTORY, as
the Solid Basis for the Superstructure of True
PHILOSOPHY.

A C O U R S E O F

Mechanical, Magnetical, Optical, Hydrostatical,

Horiz. AND *Galvan.*
Pneumatical EXPERIMENTS.

To be perform'd by FRANCIS HAUKSBEE; and the Explanatory
Lectures read by WILLIAM WHISTON, M. A.

M E C H A N I C K S.

1st DAY. **S**IR ISAAC NEWTON's Three
Laws of Motion, or Nature, demon-
strated by Experiments.

That the Velocity of Falling Bodies is as the
Times of Falling, and the Lines of Descent in the
Duplicate Proportion of those Times.

An Instrument to measure the Force of Falling
Bodies.

Experiments concerning the Sliding, Rolling, and
Falling of Bodies.

That Bodies will ascend as high, as whence they
fall by the last Velocity impress'd, when all Obsta-
cles are removed.

That Bodies by a compound Force move in a Di-
agonal Line.

2d.—The Balance and Steelyard, with all their
Properties and Uses shewn and explain'd.

The Method of estimating the *Momentum*, or
Quantity of Motion in any given Body.

The general Principle of Mechanicks established
upon this Method.

Experiments to demonstrate the different Effects
of the same Weight or Power acting in different
Directions at the same Point of any Engine.

The Resolution of Forces into those of other Di-
rections.

All the various Kinds of Levers explain'd.

3d.—All the Phenomena of Pulleys, both single
and in all their possible Combinations explain'd.

The Power of the Wheel or Axis in Peritrochio
explain'd.

The Wedge, with the Method of computing its
Force, deduced from Experiments.

The Screw, with the manner of computing its
Force.

A Compound Engine.

4th.—An Experiment of Lifting a Weight by a
Chain of Inflated Bladders, with its Application to
Muscular Motion.

Galileo's Demonstration concerning the Strength of
the Bones, Timber, &c. reduced to Experiment.

The Method of computing the Force of the Air
on the Sails of Windmills, and of Ships; and of Wa-
ter on Water-Wheels, and on the Rudder of a Ship.

Experiments to shew the proportional Advantages
of large and small Wheels, in all Sorts of Carriages,
as Coaches, Waggon, Carts, &c.

5th.—An Experiment to shew, that the lateral
Motion compounded with the perpendicular Proje-
ction, does not alter the Line of Ascent or Descent
in the projected Body.

The most considerable Objections against the Mo-
tion of the Earth, answered from this Experi-
ment.

That

Francis Hauksbee
1660-1713

At Newton's invitation he
succeeded Hooke and Papin
in performing experimental
demonstrations at the
Royal Society.

In 1716 his book was
translated into Italian
under the title
"Experience *fisico-
mecchaniche*", establishing a
linke between the Galilean
tradition and Newton's
thought.

Mathematical
ELEMENTS
OF
Natural Philosophy
CONFIRMED BY
EXPERIMENTS,
OR AN
INTRODUCTION
TO
Sir Isaac Newton's Philosophy.

Written in LATIN,
By **WILLIAM-JAMES'S GRAVESANDE**,
Doctor of Laws and Philosophy,
Professor of Mathematics and Astronomy at *Leyden*,
and Fellow of the Royal Society of *London*.

Translated into ENGLISH
By **J. T. DESAGULIERS**, LL. D.
*Fellow of the Royal Society, and Chaplain to his Grace
the Duke of CHANDOS.*

The SECOND EDITION, carefully review'd and cor-
rected by the Translator.

L O N D O N:
Printed for **J. SENEX**, at the Globe in *Salisbury-Court*,
and **W. TAYLOR**, at the Ship and *Black-Swan* in
Pater-Noster-Row. **MDCCLXXI.**

In order to render the Study of Natural Philo-
sophy as easy and agreeable as possible, I have
thought fit to illustrate every Thing by Experiments,
and to set the very Mathematical Conclusions be-
fore the Readers Eyes by this Method.

He that sets forth the Elements of a Science, does
not promise the learned World any Thing new in the
main. Therefore I thought it needless, to point out
where what is here contain'd is to be found. I have
made my Property of whatever served my Purpose;
and I thought giving notice of it once for all, was
sufficient to avoid the suspicion of Theft. I had
rather lose the Honour of a few Discoveries, di-
spersed here and there in this Treatise, than rob
any one of theirs. Let who will then take to him-
self what he thinks his own: I lay claim to nothing.

As to the Machines which serve for making the
Experiments, I have taken care to imitate several
from other Authors, have altered and improved others,
and added many new ones of my own Invention. And
no wonder I should be forced to that Necessity, having
made Experiments upon many Things never tried per-
haps by any one before. For Mathematicians think
Experiments superfluous where Mathematical Demon-
strations will take Place: But as all Mathematical
Demonstrations

Voltaire 1694-1778



THE
ELEMENTS
OF
Sir ISAAC NEWTON'S
PHILOSOPHY.

By Mr: VOLTAIRE.

Translated from the FRENCH.

Revised and Corrected

By J O H N H A N N A, M. A.

Teacher of the Mathematicks.

With Explication of some Words in Alphabetical
Order.

*Pulchre sibi disputare videntur, cum quod evertere
non possunt, tanquam ridiculum contemnunt.*

Horroccius.

L O N D O N :

Printed for STEPHEN AUSTEN at the
Angel and Bible in St. Paul's Church-Yard.

Francesco Algarotti

1712 - 1764



Friend of Voltaire and Emilie du
Chatelet

Sir ISAAC NEWTON'S
PHILOSOPHY

Explain'd

For the Use of the LADIES.

In SIX DIALOGUES

ON

LIGHT and COLOURS.

From the *Italian* of Sig. *Algarotti*.

VOLUME I.

Quæ legat ipsa Lycoris. VIRG. Ec. x.

LONDON:

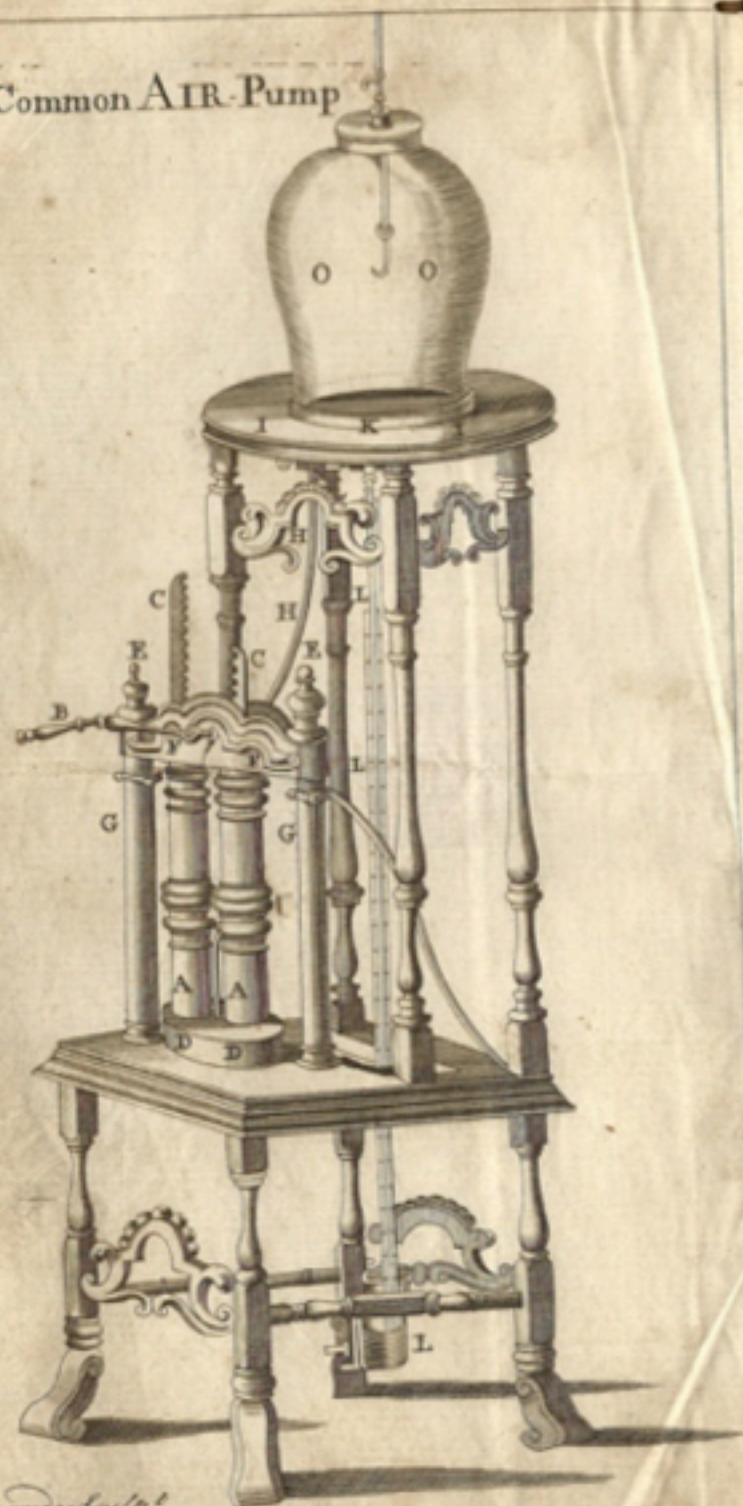
Printed for E. CAVE, at St. John's-Gate,
MDCCXXXIX.

1739

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Listed on the Index librorum prohibitorum

Common AIR-Pump



D. Pomaroe Sculp.

A
COURSE

Desig^d — OF *Math*
Experimental Philosophy;

Lecturing — BEING *July 22 - 1773*
AN INTRODUCTION to the true
PHILOSOPHY

OF
Sir Isaac Newton.

Containing,
MECHANICS, HYDROSTATICS,
PNEUMATICS, OPTICS, and
ASTRONOMY.

To which is added,
The Use of the GLOBES,
Done in an easy and familiar Manner for the
Use of young Gentlemen.

By ROBERT GIBSON,
Teacher of Mathematics.

DUBLIN:

Printed for the Author, and OLI. NELSON,
at Milton's-Head in Skinner-Row, 1755.

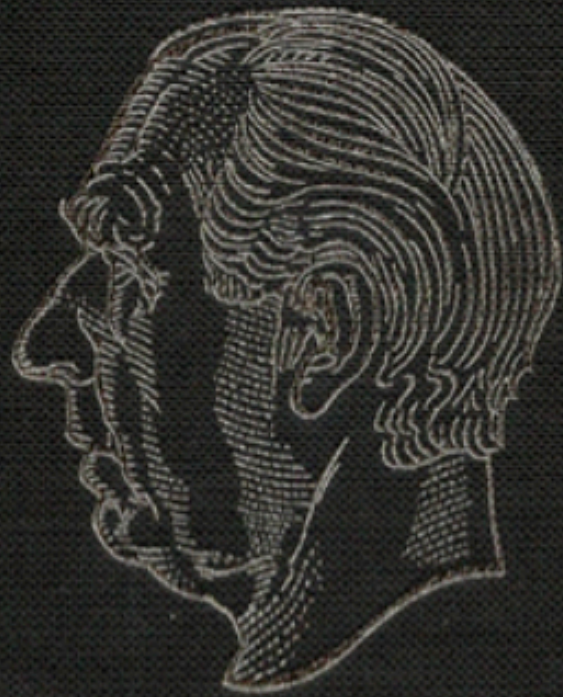
In drawing up this course, I have not scrupled to take whatever I judged might best answer
my Purposes from the best authors, Robert Gibson, Dublin May 10, 1755

Niels Bohr and the Quantum Atom

*The Bohr Model of Atomic
Structure 1913–1925*

Helge Kragh





Niels Bohr
Collected
Works
13 volumes

NIELS BOHR'S TIMES,

IN
PHYSICS,
PHILOSOPHY,
AND POLITY

ABRAHAM
PAIS



end

Otto von Guericke (1602-1686)





Yakov Ilich Frenkel
1894-1952

“Application of the Pauli-Fermi
electron gas theory to the
problem of cohesive forces”

Zeitschrift fur Physik
47, 819 (1928)

Zeldovich and Novikov wrote: “Frenkel and Landau
made a large contribution to the theory of white
dwarfs” Pravda, March 9, 1975



Edmund C. Stoner

1899 -1966

The distribution of
electrons among
atomic levels

▣ Philosophical Magazine 48 ▣
(1924) 719-736

Communicated by R.H. Fowler

“If electrons in the atom are distributed according to the present scheme . . . the interesting point is suggested there is then one electron in each possible equally probably state.”



F. Madgwick, B. N. Banerji, H. D. Smyth, N. Ahmad, W. I. Gibson, L. L. Whyte, P. Kapitza,

A. C. Chakravarti, P. Mercier, J. Crackston, H. Robinson, Miss Taylor, E. S. Bieler, J. K. Roberts, P. M. S. Blackett, E. C. Stoner,



Wolfgang Pauli

1900-1958



JW Nicholson

John William Nicholson
(1888-1951)

Cambridge
mathematician and
astronomer, classmate
and close friend of
Arthur Eddington

Month. Not. Roy. Astr. Soc.
lxxii, pp. 49, 139, 677, 693, 729
(1912) quoted by Bohr



David Bohm
1917-1992

Hidden variable
interpretation of quantum
mechanics,
Bohmian Mechanics

Phys. Rev. 85 (1952)
166-179, 180-193

DISCORSI
E
DIMOSTRAZIONI
MATEMATICHE,
intorno à due nuoue scienze

Attenenti alla
MECANICA & i MOVIMENTI LOCALI,
del Signor

GALILEO GALILEI LINCEO,
Filosofo e Matematico primario del Serenissimo
Grand Duca di Toscana.

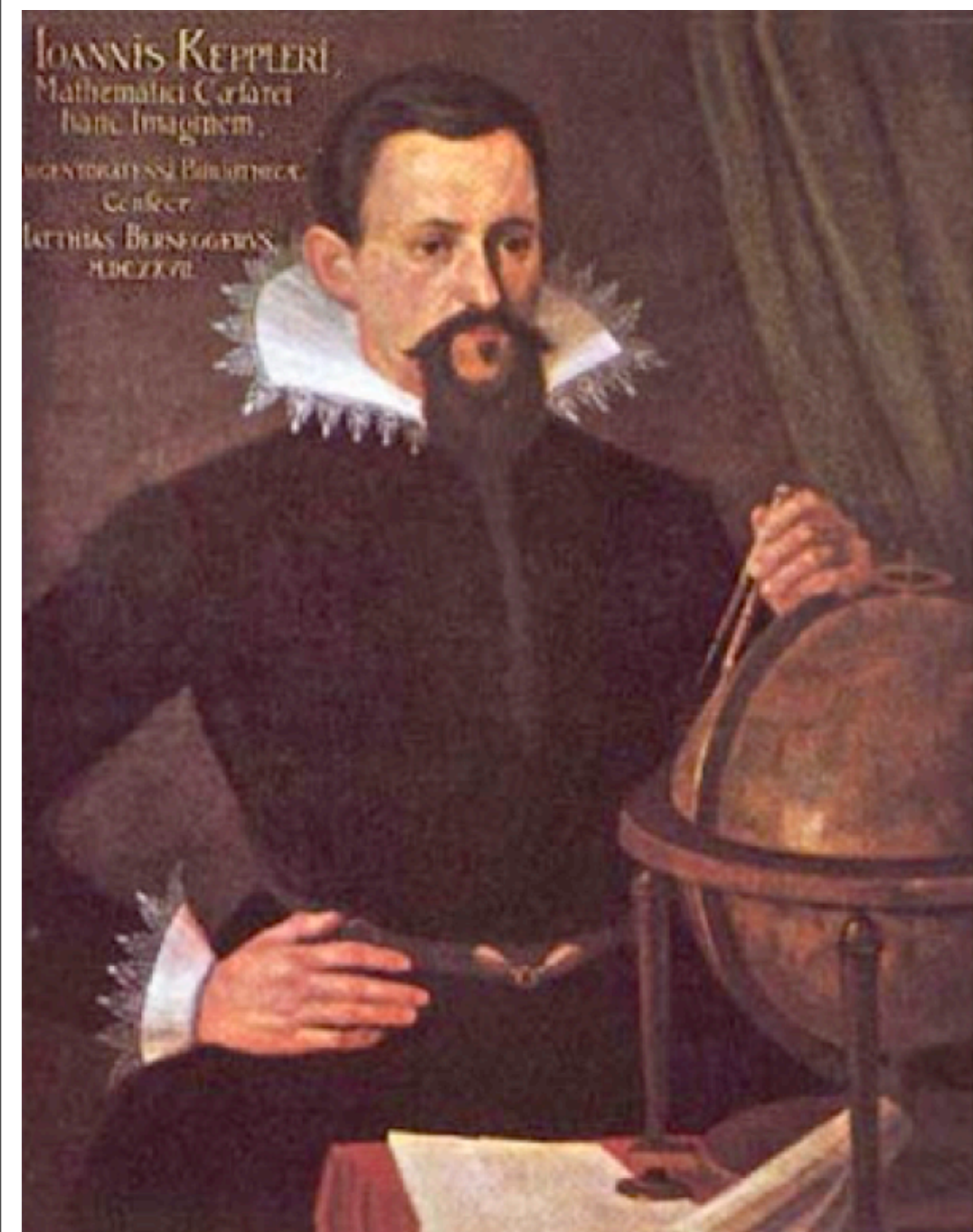
Con una Appendice del centro di gravità d'alcuni Solidi.



IN LEIDA,
Appresso gli Elsevirii. M. D. C. XXXVIII.

“Discourse
and
Mathematical
Demonstration
concerning two new
Sciences”

Galileo Galilei (1638)



Johannes Kepler
1571-1630

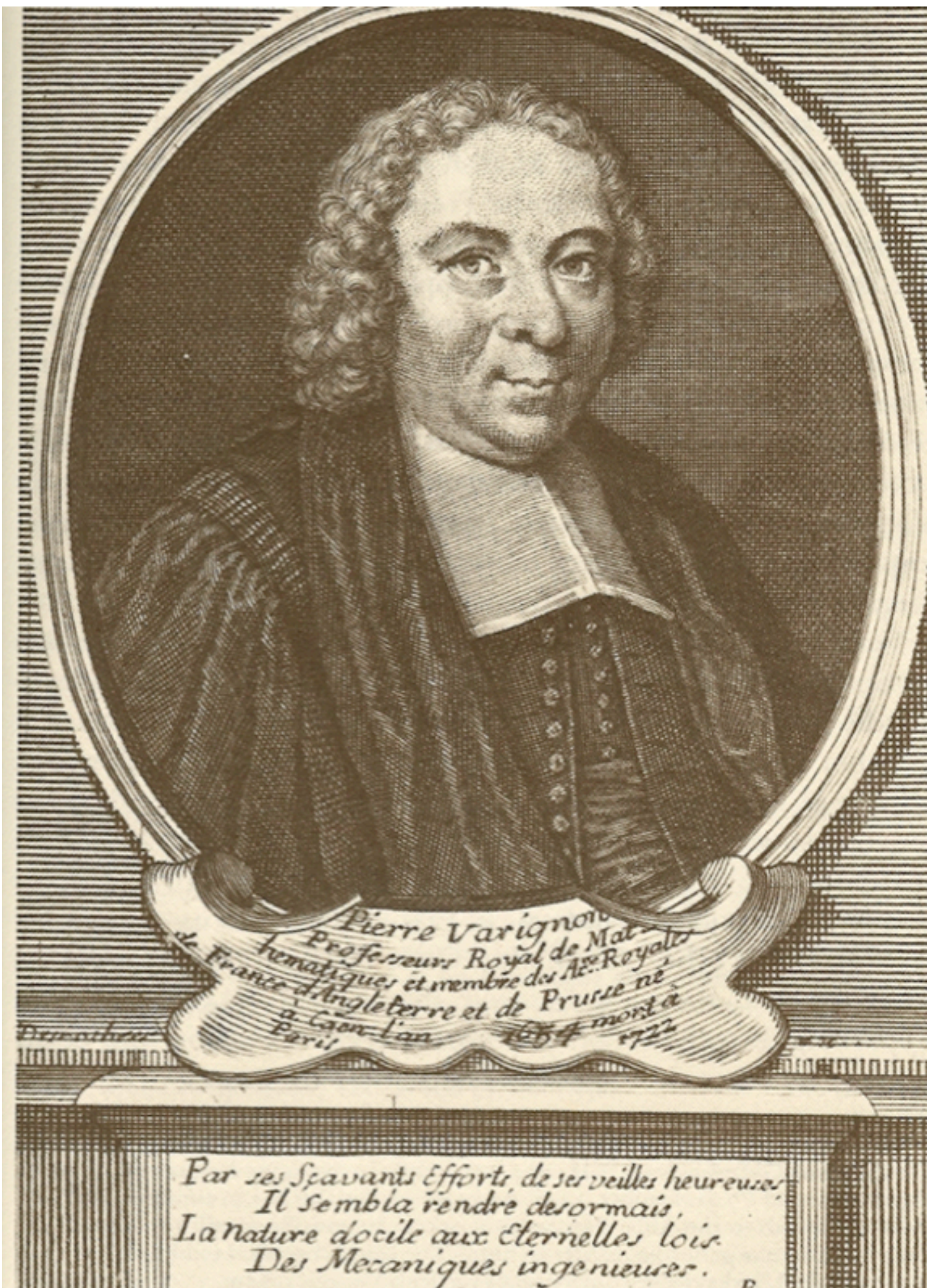
D. ISAACVS NEWTON EQVES
REG. SOCIETATIS PRESES. AN.^o 1703.



Isaac Newton

1642-1727

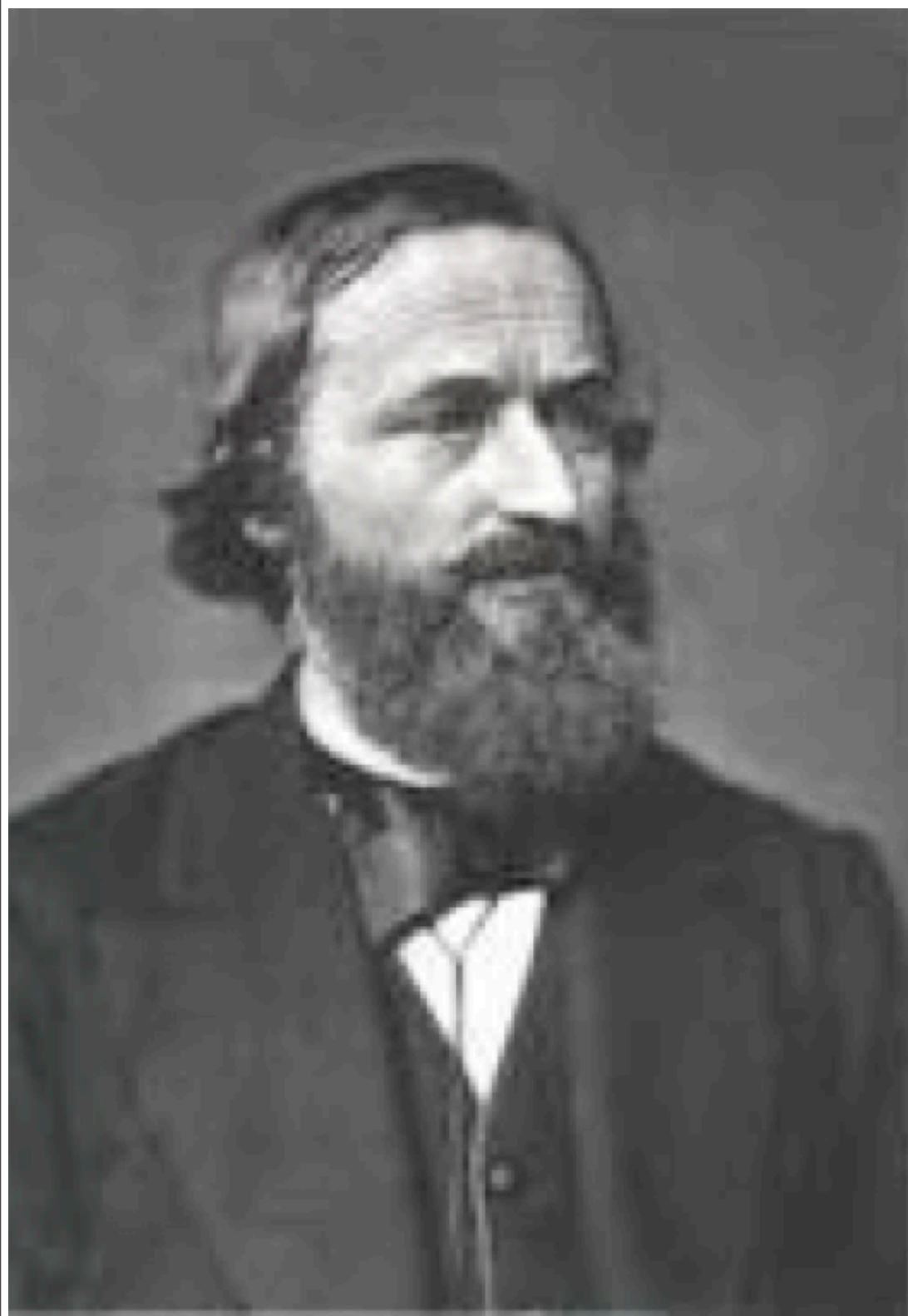
Portrait by Charles Jervas 1703



Pierre Varignon

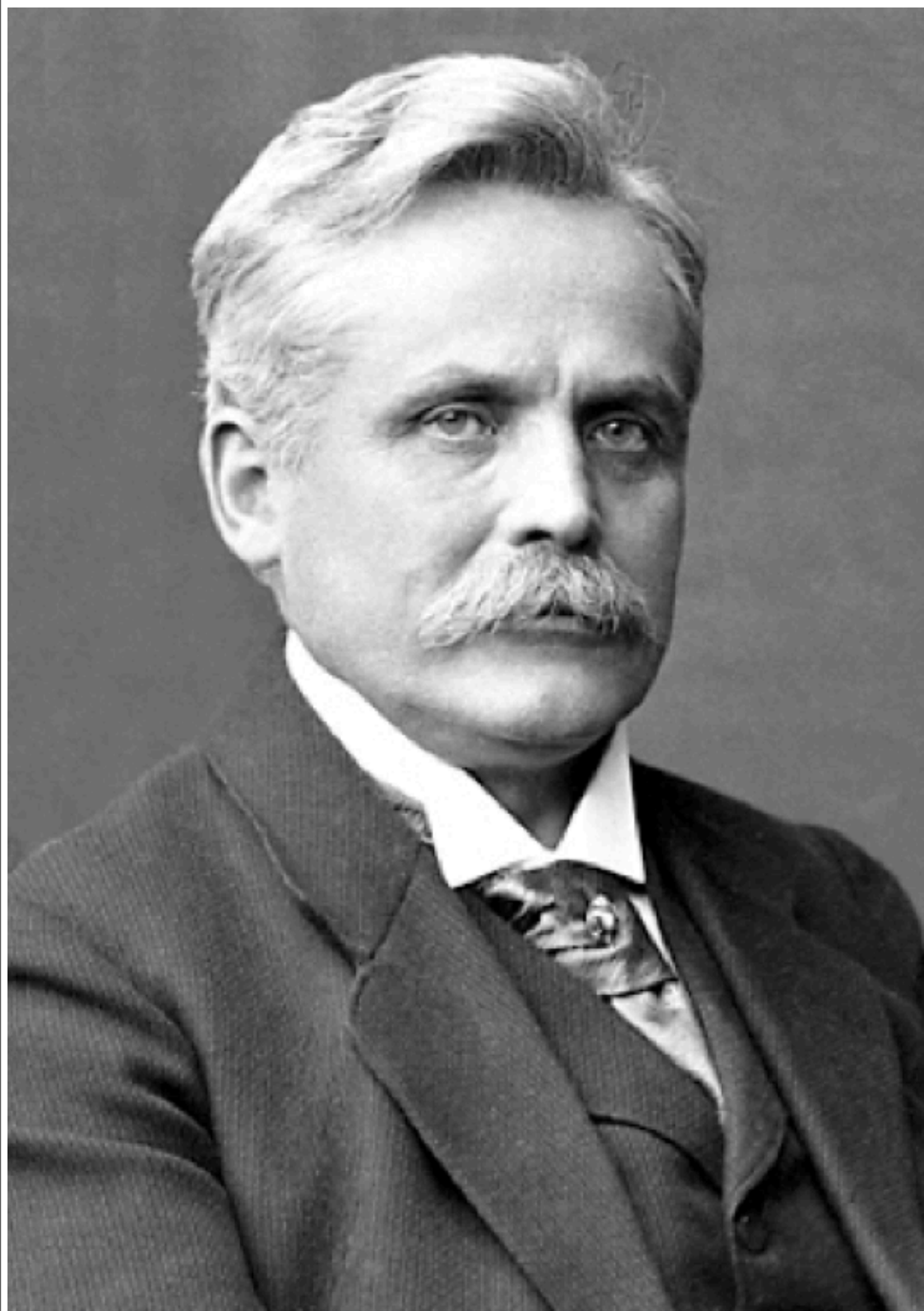
1654 - 1722

Par ses Scavants Efforts, de ses veilles heureuses,
Il sembla rendre desormais,
La nature docile aux Éternelles lois.
Des Mécaniques ingénieuses.



GUSTAV KIRCHOFF
(1824-1887)

**UNIVERSALITY OF
THERMAL RADIATION
SPECTRUM**



WILHELM WIEN
(1864-1928)

Wien's displacement law:
At maximum intensity, the
wavelength λ of black-body radiation
 $\lambda = b/T$
where b is a constant.

$T = 6000 \text{ K}$ $\lambda = 2.898 \text{ mm}$, green
 $T = 300 \text{ K}$ $\lambda = 9660 \text{ mm}$, infrared



IN 189?
HEINRICH RUBENS
AND
FERDINAND
KURLBAUM
OBTAINED
NEW BLACK BODY
RADIATION
DATA AT HIGHER
TEMPERATURE

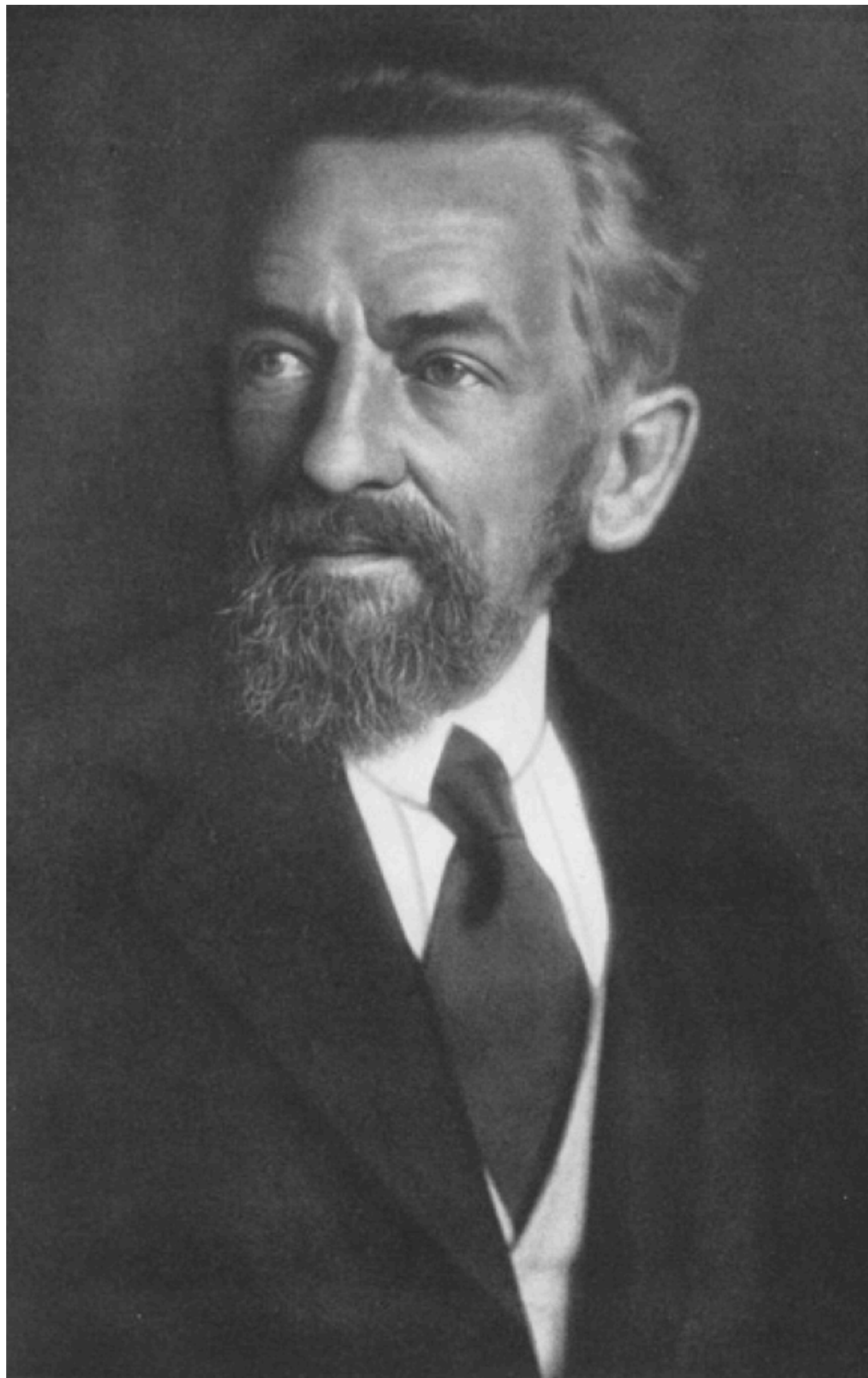


FERDINAND KURLBAUM
(1857-1927)



JOSEF STEFAN
(1835 - 1893)

$$I \propto T^4 \quad 1879$$



OTTO LUMMER
(1860 - 1925)



Wilhelm Anderson

1880-1940

“About the limiting
density of matter and
energy”

Zeitschrift für Physik 56
(1929) 851-856



ERNST PRINGSHEIM
(1859-1917)

